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Pelvic floor biometry in asymptomatic primiparous women compared with nulliparous women: a single-center study in Southern China

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Abstract

Objective: This study aimed to investigate pelvic floor biometry of asymptomatic primiparous women compared with nulliparous women by using four-dimensional transperineal ultrasound (4D TPUS).

Methods: From July 2015 to February 2017, 722 women were enrolled and divided into the nulliparous group (n = 292), the vaginal delivery group (n = 272), and the elective cesarean section group (n = 158). The ultrasound parameters of 4D TPUS were compared among the groups.

Results: The vaginal delivery group had a significantly greater bladder neck descent ($\eta^2 = 0.04$), retrovesical angles on Valsalva maneuver ($\eta^2 = 0.01$), urethral rotation ($\eta^2 = 0.01$), levator hiatus area on Valsalva maneuver ($\eta^2 = 0.02$), urethral inclination angle ($\eta^2 = 0.02$), and funneling of the proximal urethra ($\eta^2 = 0.11$) than the other two groups. Comparison of the two modes of delivery (vaginal delivery and cesarean section) also showed significant differences in the above-mentioned ultrasound parameters.

Conclusion: There are significant differences in pelvic floor biometry between asymptomatic primiparous women and nulliparous women, as well as between women with vaginal delivery and those with elective cesarean section.

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Keywords

Vaginal delivery, four-dimensional ultrasound, pelvic floor, primiparous, nulliparous, cesarean section, Valsalva maneuver, bladder neck descent

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Introduction

Pregnancy and childbirth are important causes of changes in pelvic floor structure and are risk factors for development of pelvic floor disorders (PFDs), such as urinary incontinence and pelvic organ prolapse.[1] A previous study reported that 3.9% of primiparous women with spontaneous vaginal delivery and 3.6% of those with elective cesarean section suffered from stress urinary incontinence within 1 year after delivery.[2] However, Viktrup et al.[3] reported that among asymptomatic primiparous women (without initial symptoms at the first 3 months puerperium), 30% of cases developed stress urinary incontinence at 12 years after the first delivery. This result suggests that in spite of no initial symptoms, pregnancy and childbirth may still cause changes in the structure and function of the pelvic floor. Most previous reports focused on evaluating the change in pelvic floor structures of primiparous women.[4–6] However, little is known about structural changes in the pelvic floor of asymptomatic primiparous women. Identifying asymptomatic changes in the pelvic floor of primiparous women may help lead to preventive interventions before the second childbirth to reduce the damage caused by the second childbirth.

Over the past 2 decades, three-dimensional (3D) and four-dimensional (4D) transperineal ultrasound (TPUS) imaging have been widely used in pelvic floor assessment.[7] Four-dimensional TPUS can achieve real-time acquisition of 3D ultrasound data and it provides a global view of the entire pelvic floor. Furthermore, 4D TPUS can be used to investigate female pelvic organ prolapse, urinary and fecal incontinence, and defecation disorders, providing immediate objective confirmation of clinical findings.[8] This study aimed to investigate the pelvic floor biometry of asymptomatic primiparous women compared with nulliparous women.

Methods

Participants

We performed a prospective study from July 2015 to February 2017. A total of 883 women were recruited from the Department of Gynecology and Obstetrics, The Third Affiliated Hospital of Sun Yat-Sen University. The inclusion criteria for the nulliparous group were as follows: (1) age ≥18 years; (2) nulliparous; (3) without symptoms of PFDs, chronic cough, and long-term constipation; and (4) no evidence of pelvic organ prolapse on a clinical gynecological examination. The inclusion criteria for the primiparous group were as follows: (1) age ≥18 years; (2) primiparity; (3) delivery of a single term infant with a birth weight between 2500 and 4000 g, without the use of forceps or a vacuum; (4) elapsed time of 6 to 8 weeks since delivery;[9] (5) without symptoms of PFDs, chronic cough, and long-term constipation; and (6) no evidence of pelvic organ prolapse on a clinical gynecological examination. The exclusion criteria were as follows: (1) pelvic mass on conventional ultrasound >3 cm (including uterine fibroids, ovarian neoplasms, and fallopian tube neoplasms); and (2) inability to receive an examination.

Finally, a total of 722 women were enrolled in the study, and they were divided into the nulliparous group, the vaginal delivery group, and the elective cesarean section group (Figure 1).

This study was approved by the institutional review board of The Third Affiliated Hospital of Sun Yat-Sen University (SYSU[2015]2-14). All women provided informed consent before being enrolled in this study.

Four-dimensional ultrasound

Four-dimensional transperineal ultrasound was performed using a GE Voluson E8 ultrasound device (GE Kretz Ultrasound, Zipf, Austria), which was compatible with a RAB4-8L curved array volume transducer, with a frequency range of 4 to 8 MHz.

For an ultrasound examination, women were placed in the supine position with the bladder nearly empty to maximize pelvic organ descent. The examination was also performed with women in the supine position (after voiding) at rest and on maximum Valsalva maneuver. Mid-sagittal and axial plane views were obtained by placing a transducer on the perineum. The resulting images included the symphysis pubis, urethra and bladder neck, vagina, cervix, rectum, and anal canal. Each woman was asked to push at her maximum force for at least 5 seconds to produce maximum pelvic organ descent. All data were integrated for further analysis.

According to the Pelvic floor Ultrasound Basic settings and procedures by the International Urogynecological Association,[1] the following ultrasound parameters were measured: (1) using the inferoposterior margin of the symphysis pubis[10] as a reference point, the bladder neck position at rest and on Valsalva maneuver was measured (Figure 2); (2) retrovesical angles at rest

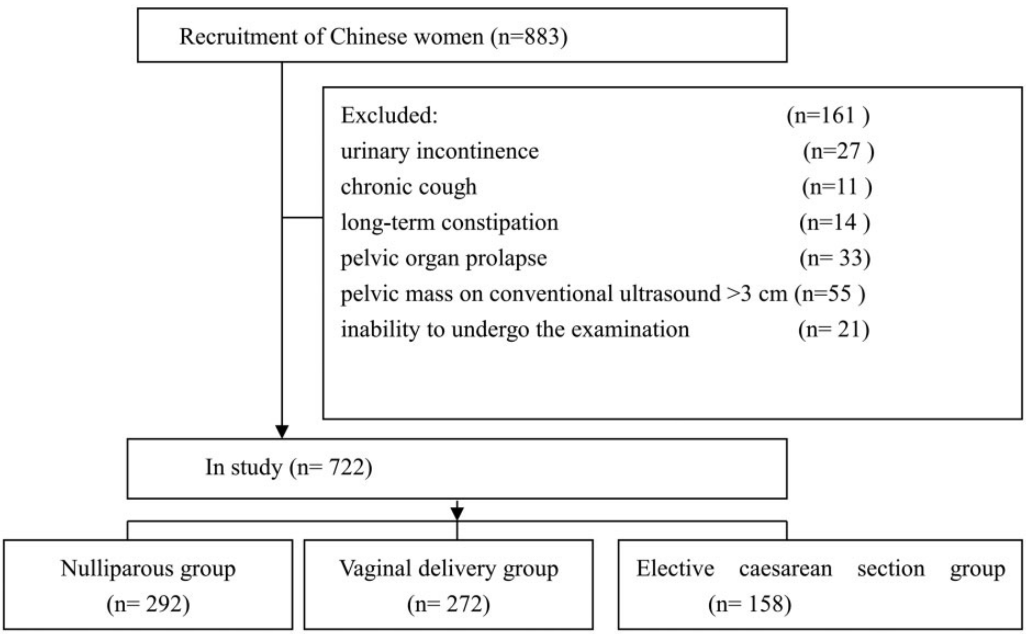

Figure 1. Flow chart of enrollment and grouping of the participants.

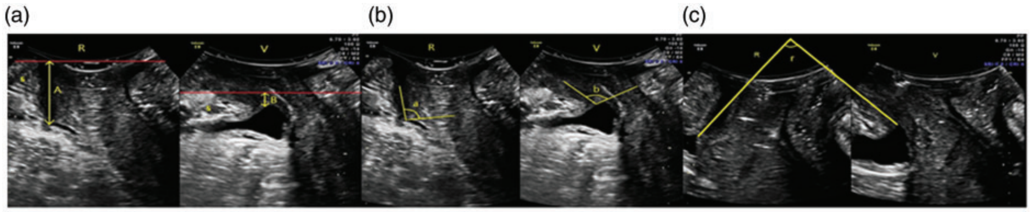

Figure 2. Ultrasound showing the mid-sagittal view of the bladder neck position (a), retrovesical angle (b), and urethral rotation (c). The difference between the bladder neck position at rest (line A) and bladder neck position on Valsalva maneuver (line B) was termed bladder neck descent. R: at rest, V: on Valsalva maneuver.

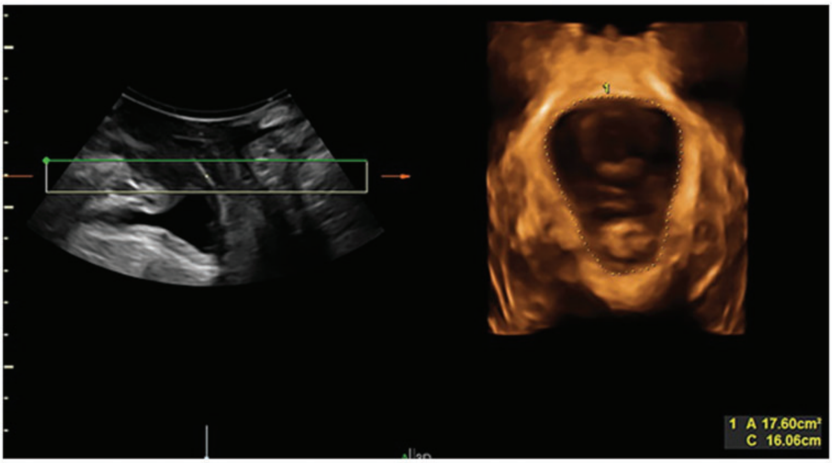

Figure 3. Ultrasound showing the levator hiatus area on Valsalva maneuver in the axial plane. The dotted line represents the levator hiatus.

and on Valsalva maneuver (Figure 2); (3) bladder neck descent; (4) urethral rotation (Figure 2); (5) levator hiatus area on maximum Valsalva maneuver (Figure 3); and (6) funneling of the proximal urethra on Valsalva maneuver (Figure 4).

The bladder neck position at rest and on Valsalva maneuver, retrovesical angles at rest and on Valsalva maneuver, bladder neck descent, urethral rotation, and funneling of the proximal urethra were measured in the mid-sagittal plane. The levator hiatus area on maximum Valsalva maneuver was measured in the axial plane at the narrowest part of

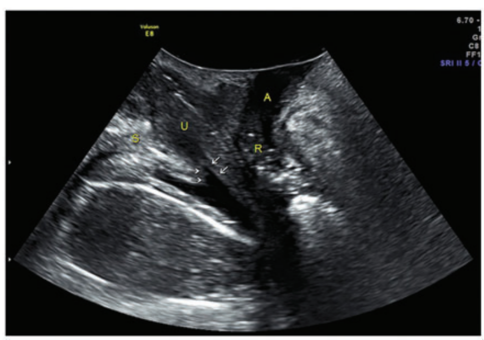

Figure 4. Ultrasound showing funneling of the proximal urethra in the mid-sagittal plane. The arrows indicate funneling. A: anal canal, R: rectum, U: urethra, S: symphysis pubis.

the levator hiatus. Of these parameters, the bladder neck position at rest and on Valsalva maneuver, retrovesical angles at rest and on Valsalva maneuver, and levator hiatus area on maximum Valsalva maneuver were measured values. Bladder neck descent and urethral rotation were calculated values. The bladder neck–symphysis pubis distance was the distance between the bladder neck and the lowest margin of the symphysis pubis. Bladder neck descent was the difference in bladder neck–symphysis pubis distance value between rest and the Valsalva position. Urethral rotation was the change in angle from the proximal urethra to the central symphyseal axis, which was measured between rest and the Valsalva position.

Statistical analysis

The minimum required sample size was estimated by software G*Power version 3.1 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). The effect size was conservatively set at 0.3, the type I error (alpha) was 0.05, power was 0.80, and the number of independent groups was three. After calculation, a minimum required sample size of all participants was 111. Missing data were only observed in variable bladder neck descent in the nulliparous group, and the missing data rate was 1.80% (13/722). There were no significant differences in general characteristics (age and body mass index) between participants with and those without missing data in bladder neck descent.

Continuous variables are expressed as mean $\pm$ standard deviation, and the only categorical variable, funneling of the proximal urethra, is shown as number and percentage. Both parametric and non-parametric inferential statistics were used in this study depending on normality assumption of data. The normality of all continuous data were assessed by the Kolmogorov–Smirnov test. If normality of continuous variables was not assumed, the data are presented as median and interquartile range (IQR). For comparisons of all three groups (nulliparous, vaginal delivery, elective cesarean section), one-way ANOVA and Fisher's least significant difference as post-hoc comparisons were used. The Kruskal–Wallis test was used as a corresponding non-parametric method. For comparison between two groups (nulliparous and primiparous), the Student's independent t-test or Mann–Whitney U test as a non-parametric method was used. To further investigate the association of independent variables with birth experience or mode of delivery, logistic regression and the c-statistic (i.e., area under the curve [AUC]) are reported. Variables that were significant in both logistic regression and AUC results were considered as independent factors associated with the mode of delivery. $P < 0.05$ indicates significance for two-tailed tests. All analyses were performed using IBM SPSS version 20 (IBM Corp., Armonk, NY, USA).

Results

Participants

A total of 722 eligible participants (mean age: 28.02 ± 4.34 years) were enrolled in the study, including 292 nulliparous women and 430 primiparous women (272 with vaginal delivery and 158 with elective cesarean section). Further comparisons, participants were compared among three groups (nulliparous, vaginal delivery, and elective cesarean section) and two groups (nulliparous and primiparous). That primiparous group had a significantly older age and higher body mass index than the nulliparous group (both $P < 0.001$, Table 1). Age was significantly older in primiparous women with cesarean section

Table 1. General characteristics of nulliparous and primiparous women.

Parameters	Nulliparous (n = 292)	Primiparous (n = 430)	Total (n = 722)	P	Cohen's d
Age, years (range)	26 (24–29)	28 (26–32)	28 (25–31)	<0.001	0.53
BMI, kg/m^2 (range)	20.12 (18.50–21.48)	21.72 (20.01–23.45)	20.95 (19.38–22.97)	<0.001	0.65

BMI: body mass index. The Mann–Whitney U test was used for analysis.

Table 2. General characteristics of the three groups.

Parameters	Nulliparous women (n = 292)	Vaginal delivery (n = 272)	Elective cesarean section (n = 158)	Total (n = 722)	P	η^2
Age, years (range)	26 (24–29)	28 (26–31)*	29 (27–32)*†	28 (25–31)	<0.001	0.06
BMI, kg/m^2 (range)	20.12 (18.50–21.48)	21.63 (19.75–23.42)*	22.03 (20.40–23.85)*	20.95 (19.38–22.97)	<0.001	0.10

BMI, body mass index. The Kruskal–Wallis test and Dunn's test as post-hoc comparison were used. The effect size was measured by η^2.
*$P < 0.05$ compared with the nulliparous group; †$P < 0.05$ compared with the vaginal delivery group.

than in those with vaginal delivery ($P < 0.001$, Table 2).

Comparison of ultrasound parameters among the three groups

Ultrasound findings were compared among the three groups. The bladder neck position at rest was significantly higher above the symphysis pubis in the nulliparous group than in the other two groups ($P < 0.001$, Table 3). The bladder neck position on Valsalva was significantly different among the three groups, (nulliparous > elective cesarean section > vaginal delivery, all $P < 0.05$). Bladder neck descent, retrovesical angles on Valsalva, urethral rotation, levator hiatus area on Valsalva, urethral inclination angle, and funneling of the proximal urethra were significantly greater in the vaginal delivery group than in the other two groups (all $P < 0.05$). However, none of these variables were significantly different between the nulliparous and elective cesarean section groups.

Comparisons of ultrasound parameters between the nulliparous and primiparous groups

To identify the changes in ultrasound parameters of primiparous women, ultrasound findings were compared between the nulliparous and primiparous groups. The nulliparous group had significantly greater bladder neck position at rest and bladder neck position on Valsalva than the primiparous group (both $P < 0.001$, Table 4). The primiparous group had significantly greater bladder neck descent, retrovesical angles on Valsalva, levator hiatus area on Valsalva, and incidence of funneling of the proximal urethra compared with the nulliparous group (all $P < 0.05$).

Associations of independent variables with birth experience or mode of delivery

Logistic regression and receiver operating characteristic (ROC) analysis were

Table 3. Ultrasound parameters of the three groups.

Parameters	Nulliparous women (n = 292)	Vaginal delivery (n = 272)	Elective cesarean section (n = 158)	Total (n = 722)	P	η^2
Bladder neck position at rest (mm)	30.35 ± 3.32	28.71 ± 3.36*	28.08 ± 3.60*	29.24 ± 3.52	<0.001	0.07
Retrovesical angles at rest (degree)	116.39 ± 16.90	119.18 ± 17.16	118.62 ± 20.12	117.93 ± 17.77	0.167	0.01
Bladder neck position on Valsalva (mm)	13.00 ± 8.19	9.12 ± 6.54*	11.08 ± 6.81*†	11.12 ± 7.49	<0.001	0.05
Bladder neck descent (mm)	16.55 ± 7.75	19.59 ± 6.66*	17.00 ± 6.50†	17.82 ± 7.20	<0.001	0.04
Retrovesical angles on Valsalva (degree)	132.19 ± 23.19	138.15 ± 23.93*	133.18 ± 26.38†	134.65 ± 24.32	0.001	0.01
Urethral rotation (degree)	37.19 ± 20.61	41.66 ± 18.86*	35.26 ± 17.37†	38.45 ± 19.43	0.001	0.02
Levator hiatus area on Valsalva (cm^2)	18.09 ± 6.24	19.70 ± 5.26*	18.19 ± 4.62†	18.72 ± 5.60	<0.001	0.02
Urethral inclination angle at rest (degree)	20.10 (15.40–26.90)	17.60 (12.80–28.68)	18.55 (14.15–28.98)	19.15 (13.90–27.73)	0.132	0.001
Urethral inclination angle (degree)	14.85 (0–30.65)	21 (9.70–35.63)*	13.25 (0–23.75)†	16.55 (0–31.50)	<0.001	0.02
Funneling of the proximal urethra					0.012	0.11[a]
No	279 (95.55)	242 (88.97)	147 (93.04)	668 (92.52)		
Yes	13 (4.45)	30 (11.03)	11 (6.96)	54 (7.48)		

Values shown are mean ± standard deviation, median (range), or n (%). For continuous data with a normal distribution, one-way ANOVA and Fisher's least significant difference were used for post-hoc comparison. For data with a non-normal distribution, the Kruskal–Wallis test and Dunn's test were used for post-hoc comparison. The effect size was measured by η^2.

*$P < 0.05$ compared with the nulliparous group; †$P < 0.05$ compared with the vaginal delivery group.

[a]The effect size of the chi-square test was measured by Cramer's V.

Table 4. Ultrasound parameters of the nulliparous and primiparous groups.

Parameters	Nulliparous group (n = 292)	Primiparous group (n = 430)	Total (n = 722)	P	Cohen's d
Bladder neck position at rest (mm)	30.35 ± 3.32	28.48 ± 3.46	29.24 ± 3.52	<0.001	0.55
Retrovesical angles at rest (degree)	116.39 ± 16.90	118.97 ± 18.28	117.93 ± 17.77	0.096	0.15
Bladder neck position on Valsalva (mm)	13.00 ± 8.19	9.84 ± 6.70	11.12 ± 7.49	<0.001	0.43
Bladder neck descent (mm)	16.55 ± 7.75	18.64 ± 6.71	17.82 ± 7.20	<0.001	0.29
Retrovesical angles on Valsalva (degree)	132.19 ± 23.19	136.33 ± 24.94	134.65 ± 24.32	0.005	0.17
Urethral rotation (degree)	37.19 ± 20.61	39.31 ± 18.57	38.45 ± 19.43	0.111	0.11
Levator hiatus area on Valsalva (cm^2)	18.09 ± 6.24	19.14 ± 5.08	18.72 ± 5.60	<0.001	0.19
Urethral inclination angle at rest (degree)	20.10 (15.40–26.90)	17.85 (12.98–28.73)	19.15 (13.90–27.73)	0.089	0.03
Urethral inclination angle (degree)	14.85 (0–30.65)	17.90 (5.68–32)	16.55 (0–31.50)	0.086	0.13
Funneling of the proximal urethra				0.011	0.10[a]
No	279 (95.55)	389 (90.47)	668 (92.52)		
Yes	13 (4.45)	41 (9.53)	54 (7.48)		

Values shown are mean ± standard deviation, median (range), or n (%). For continuous data with a normal distribution, the Student's independent t-test was used. For data with a non-normal distribution, the Mann–Whitney U test was used.

[a]The effect size of the chi-square test was measured by Cramer's V.

performed to identify the independent ultrasound parameters associated with birth experience. Five parameters, including the bladder neck position at rest, bladder neck position on Valsalva, bladder neck descent, retrovesical angles on Valsalva, and levator hiatus area on Valsalva, were significantly associated with birth experience (logistic regression, all $P < 0.05$; ROC analysis, all $P < 0.01$; AUC range: 0.573–0.653) (Table 5).

Independent ultrasound parameters that were associated with the mode of delivery were also analyzed. The bladder neck position on Valsalva, bladder neck descent, retrovesical angles on Valsalva, urethral rotation, levator hiatus area on Valsalva, and urethral inclination angle were significantly associated with the mode of delivery (logistic regression, all $P < 0.05$; ROC analysis, all $P < 0.05$; AUC range: 0.564–0.625) (Table 6).

Discussion and conclusions

In this study, we used 4D TPUS to investigate pelvic floor biometry of asymptomatic primiparous women compared with nulliparous women. We found that the bladder neck position at rest or on Valsalva maneuver was significantly greater in the nulliparous group than in the other two groups. The vaginal delivery group had a significantly greater bladder neck descent, retrovesical angles on Valsalva, urethral rotation, levator hiatus area on Valsalva, urethral inclination angle, and funneling of the proximal urethra than the other

Table 5. Logistic regression and ROC analysis of independent variables associated with birth experience.

		Logistic regression		ROC analysis	
Parameters	Indicator	OR (95% CI)	P	AUC (95% CI)	P
Bladder neck position at rest (mm)	Nulliparous	1.18 (1.12–1.24)	<0.001	0.652 (0.611–0.693)	<0.001
Retrovesical angles at rest (degree)	Primiparous	1.01 (1.00–1.02)	0.056	0.540 (0.498–0.583)	0.069
Bladder neck position on Valsalva (mm)	Nulliparous	1.06 (1.04–1.08)	<0.001	0.653 (0.611–0.694)	<0.001
Bladder neck descent (mm)	Primiparous	1.04 (1.02–1.06)	<0.001	0.583 (0.539–0.627)	<0.001
Retrovesical angles on Valsalva (degree)	Primiparous	1.01 (1.00–1.01)	0.025	0.573 (0.530–0.616)	0.001
Urethral rotation (degree)	Primiparous	1.01 (1.00–1.01)	0.151	0.555 (0.511–0.598)	0.014
Levator hiatus area on Valsalva (cm^2)	Primiparous	1.03 (1.01–1.06)	0.014	0.594 (0.549–0.639)	<0.001
Urethral inclination angle at rest (degree)	Nulliparous	1.00 (0.99–1.01)	0.688	0.543 (0.501–0.586)	0.051
Urethral inclination angle (degree)	Primiparous	1.01 (1.00–1.01)	0.096	0.560 (0.516–0.603)	0.007
Funneling of the proximal urethra (yes)	Primiparous	2.26 (1.19–4.30)	0.013	–	–

ROC: receiver operating characteristic, OR: odds ratio, CI: confidence interval, AUC: area under the curve. Logistic regression analysis and ROC analysis were used. The estimated OR itself is already a unstandardized effect size.

Table 6. Logistic regression and ROC analysis of independent variables associated with the mode of delivery.

		Logistic regression		ROC analysis	
Parameters	Indicator	OR (95% CI)	P	AUC (95% CI)	P
Bladder neck position at rest (mm)	Vaginal delivery	1.05 (1.00–1.12)	0.069	0.555 (0.498–0.612)	0.057
Retrovesical angles at rest (degree)	Vaginal delivery	1.00 (0.99–1.01)	0.760	0.525 (0.468–0.581)	0.392
Bladder neck position on Valsalva (mm)	ECS	1.05 (1.01–1.08)	0.004	0.584 (0.528–0.640)	0.004
Bladder neck descent (mm)	Vaginal delivery	1.06 (1.03–1.09)	<0.001	0.607 (0.552–0.662)	<0.001
Retrovesical angles on Valsalva (degree)	Vaginal delivery	1.01 (1.00–1.02)	0.048	0.564 (0.506–0.621)	0.027
Urethral rotation (degree)	Vaginal delivery	1.02 (1.01–1.03)	<0.001	0.597 (0.542–0.652)	<0.001
Levator hiatus area on Valsalva (cm^2)	Vaginal delivery	1.06 (1.02–1.11)	0.003	0.575 (0.519–0.632)	0.009
Urethral inclination angle at rest (degree)	ECS	1.01 (0.99–1.02)	0.385	0.532 (0.476–0.587)	0.275
Urethral inclination angle (degree)	Vaginal delivery	1.02 (1.01–1.03)	<0.001	0.625 (0.570–0.679)	<0.001
Funneling of the proximal urethra (yes)	Vaginal delivery	1.66 (0.81–3.41)	0.170	–	–

ROC: receiver operating characteristic, OR: odds ratio, CI: confidence interval, AUC: area under the curve, ECS: elective cesarean section. Logistic regression analysis and ROC analysis were used. The estimated odds ratio itself is already an unstandardized effect size.

two groups. Comparison between the two modes of delivery also showed significant differences in the above-mentioned ultrasound parameters. Furthermore, the significance in ultrasound parameters among groups was confirmed by logistic regression analysis.

Biometric measurements are crucial for detecting early pathological changes in PFDs. Bladder neck descent, cervical descent, rectal descent, and urethral rotation have typically been used to assess pelvic organ descent in postpartum women.[11] In our study, the bladder neck position was significantly lower in primiparous women than in nulliparous women, and this difference was greater on Valsalva maneuver. We also found a difference in bladder neck position between the vaginal delivery and elective cesarean group at rest and on Valsalva maneuver. As a result, bladder neck descent was greater in the vaginal delivery group than in the nulliparous and elective cesarean section groups. Bladder neck descent is a measure of bladder neck mobility and is associated with stress urinary incontinence for a long time.[10,12] Greater bladder neck descent in the primiparous group suggested that, despite being without initial symptoms, primiparous women with vaginal delivery may have a higher risk for developing stress urinary incontinence compared with those with elective cesarean section.

Consistent with our observation, Dietz reported negative effects of vaginal delivery on fascial support of all three pelvic compartments compared with cesarean section.[13]

The retrovesical angle is associated with functional integrity of both of the proximal urethral supports.[14] Pregazzi et al.[15] suggested that the retrovesical angle plays a significant role in maintaining female continence. Previous studies have shown that patients with stress urinary incontinence have a significantly greater retrovesical angle at rest and in the Valsalva position compared with healthy controls.[14,16] In the present study, there was no significant difference in the retrovesical angle at rest among the three groups. However, the retrovesical angle on Valsalva maneuver in the vaginal delivery group was significantly greater than that in the nulliparous and elective cesarean section groups. No significant difference in retrovesical angle on Valsalva maneuver was found between the nulliparous and elective cesarean section groups. This result suggested that vaginal delivery increased the retrovesical angle on Valsalva, which may increase the risk for developing urinary incontinence in asymptomatic primiparous women. In line with our observation, Costantini et al.[17] and Shahin et al.[18] also found that the urethro-pelvic angle was greater in primiparous than in nulliparous Caucasian women at rest and during coughing. In our study, the urethral rotation angle was significantly larger in the vaginal delivery group than in the other two groups. This finding is mainly consistent with the report of Dietz and Bennett who found that the urethral rotation angle was significantly different between nulliparous and postpartum women.[19]

The levator hiatus is the largest hiatus in women, and distension of the levator hiatus is associated with pelvic organ prolapse.[20] In the current study, the levator hiatus area on Valsalva maneuver in the vaginal delivery group was significantly larger than that in the nulliparous group. This finding indicated that vaginal delivery is one of the most important factors that induces distension of the levator hiatus. Our observation is in line with Chan et al.'s[21] and Abdool et al.'s[22] reports that hiatal distension was greater after vaginal delivery. Funneling of the proximal urethra is associated with female stress urinary incontinence.[23] Our study showed that there was funneling of the proximal urethra in primiparous and nulliparous women, which is consistent with Huang and Yang's study.[24] However, the incidence of proximal urethra funneling was higher in the vaginal delivery group than in the nulliparous group. This finding suggests that vaginal delivery induces formation of funneling of the proximal urethra in primiparous women, which may elevate the risk for developing stress urinary incontinence.

The main strength of this study is the large dataset that included more than 700 women, which allowed us to successfully establish the limits of normality of the pelvic floor in healthy women. However, there are still some limitations of this study. First, we only performed biometric measurements at 6 to 8 weeks postpartum. Therefore, the long-term effect of childbirth on pelvic floor function in asymptomatic primiparous women remains to be evaluated. Recovery of structures in vaginal delivery or cesarean delivery may be different. Therefore, a second assessment should be performed at 7 months postpartum to compare the recovery of structures between these groups. Additionally, nulliparous and primiparous subjects were two separate cohorts rather than the same cohort evaluated at nulliparous and postpartum stages. Moreover, because this was a single-center study in South China, the findings of this study should be validated by an external cohort or a multicenter study. In the future, a well-designed, prospective trial should be conducted to further validate the findings of this study.

In summary, our study suggests that there are significant differences in pelvic floor biometry between asymptomatic primiparous and nulliparous women, including an increased bladder neck descent and retrovesical angle, as well as distension of the levator hiatus on Valsalva maneuver in primiparous women. There are also significant differences in pelvic floor biometry between women with vaginal delivery and elective cesarean section.

Abbreviations

AUC: area under the curve, BMI: body mass index, PFD: pelvic floor disorder, 3D: three-dimensional, 4D: four-dimensional, TPUS: transperineal ultrasound, ROC: receiver operating characteristic

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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