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Impact of prepregnancy body mass index on pregnancy outcomes, incidence of urinary incontinence and quality of life during pregnancy - An observational cohort study

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ABSTRACT

Background: To evaluate the effects of prepregnancy body mass index (BMI) on pregnancy outcomes, prevalence of urinary incontinence, and quality of life.
Methods: The observational cohort included 2210 pregnant women who were divided into 4 groups according to their prepregnancy BMI: underweight (<18.5), normal weight (18.5–24.9), overweight (25–29.9), and obese (≥30). Data were analyzed for pregnancy outcomes, prevalence of urinary incontinence during pregnancy, scores of the Short Form 12 health survey (SF-12) and changes in sexual function.
Results: Compared with normal weight, overweight and obesity were associated with advanced maternal age, low education level, multiparity, preterm delivery, cesarean section, gestational weight gain above the Institute of Medicine (IOM) guidelines, preeclampsia, gestational diabetes, macrosomia and large fetal head circumference. After adjusting for confounding factors, women with overweight and obesity were more likely to have adverse maternal outcomes (gestational weight gain above the IOM guidelines, preeclampsia and gestational diabetes) and fetal outcomes (large fetal head circumference and macrosomia) compared to normal weight women. Overweight and obese women (BMI ≥ 25) were more likely to have urinary incontinence than normal weight and underweight women. There were no significant differences in SF-12 scores among the 4 BMI groups, but more than 90% of pregnant women had reduced or no sexual activities regardless of BMI.

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Conclusions: Maternal prepregnancy overweight and obesity are associated with greater risks of preeclampsia, gestational diabetes, macrosomia and urinary incontinence. Health care providers should inform women to start their pregnancy at a BMI in the normal weight category.

At a glance of commentary

Scientific background on the subject

High body mass index (BMI) before pregnancy can cause adverse outcomes for pregnant women and fetuses, such as gestational diabetes mellitus (DM), preeclampsia, macrosomia etc., but few information is available regarding changes in the health-related quality of life and (QoL) and urinary incontinence (UI).

What this study adds to the field

Prepregnancy overweight and obesity are associated with greater risks of preeclampsia, gestational diabetes, macrosomia, and urinary incontinence. There were no significant differences in QoL using SF-12 scores between different groups of prepregnancy BMI. Health care providers should inform women to start their pregnancy at a BMI in the normal category.

The obesity epidemic is a public health problem in both developed and developing countries. The World Health Organization (WHO) notes that 1.9 billion people worldwide are overweight [1]. In Western countries, the reported prevalence of overweight or obesity in pregnant women is 11–40% [2–4], and in Asian countries, it is 8–24% [5–7]. Previous studies have shown that obesity during pregnancy and a high body mass index (BMI) before pregnancy can cause adverse outcomes for pregnant women and fetuses, such as gestational diabetes mellitus (DM), preeclampsia, cesarean section (CS), postpartum hemorrhage, preterm delivery, a large fetus for gestational age, and even fetal death [4,6,8,9]. The WHO recommends that weight gain during pregnancy should be based on Institute of Medicine (IOM) guidelines [10], but less than half of pregnant women experience weight gain that is within the recommended range [5,11,12]. In the past, most studies focused on the influence of prepregnancy BMI and gestational weight gain on pregnancy outcomes [4–6,8,11–14], but little information is available regarding changes in the health-related quality of life (QoL) [15]. Urinary incontinence (UI), a common condition in pregnancy, can disturb the quality of life of pregnant women. The prevalence of UI during pregnancy is as high as 18.6–75% [16–18]. Pregnancy and birth trauma are thought to be associated with the development of UI [16–18]. Obesity is a major risk factor for stress UI in women [16–18], but the cause of UI during pregnancy remains unclear. In addition to UI, weight gain and changes in sexual function during pregnancy may have a significant impact on women's QoL. The purpose of this study was to evaluate the effects of prepregnancy BMI on pregnancy outcomes, the prevalence of UI, and health-related QoL.

Materials and methods

This observational cohort included 2210 pregnant women with singleton pregnancies who were delivered at our institution, a tertiary hospital, between January 2014 and May 2015. The exclusion criteria were multiple pregnancy, delivery before 28 gestational weeks and first visit after the first trimester. The Ethics Committee of our institute approved the study protocol (No. 201800906B0C501). We retrospectively reviewed the electronic medical records for each subject, and the following data were extracted: (1) maternal demographics and reproductive characteristics including age, parity, body weight (prepregnancy and at delivery), gestational weight gain, BMI at prepregnancy and delivery, complications during pregnancy (preeclampsia and/or gestational DM), membrane rupture, labor augmentation, labor courses, third- and fourth-degree perineal lacerations, instrument-assisted vaginal delivery and cesarean delivery. Indications for CS included uterine scarring, abnormal presentation of fetus, placenta previa, placental abruption, cephalopelvic disproportion, emergency CS comprising arrest of dilatation or descent, and fetal distress. (2) Fetal characteristics and outcomes including gestational weeks, newborn birth weight, sex, head circumference and Apgar score at one minute and five minutes. Preterm delivery was defined as the birth of a newborn before 37 weeks of gestation. Macrosomia was defined as birth weight greater than 4000 gm. A baby who scored 7 or above on the Apgar test was considered in good health. (3) Data on UI during pregnancy, Short Form 12 health survey (SF-12) scores [19], and the results from a sexual questionnaire [20] were collected.

Written or oral informed consent was obtained from all women. During the study period, the recruited women were questioned by nurses in the obstetric wards on postpartum day 2, whether they had experienced urinary leakage in their daily life at least once a month during pregnancy, using the Liang et al. LUTS (lower urinary tract symptoms) questionnaire [21]. The SF-12 and sexual function questionnaire were completed with face-to-face interviews simultaneously. The SF-12 is a generic health-related quality of life survey that includes physical composition summary (PCS) and a psychosocial summary (MCS) scores that assesses physical and mental function, respectively [19]. These two summary scores range from 0 to 100, with higher scores indicating a better quality of life. The sexual questionnaire used in this study contained 4 questions rated on a severity scale of 0–3, with a total score below 6 indicating poor sexual activity [20]. All women were asked to reply to questions that evaluated the frequency of sexual activity, willingness to participate in sexual activity, satisfaction from sexual activity and dyspareunia.

Table 1 Characteristics of women who delivered after 28 weeks of gestation.

Variable	Prepregnancy BMI								p value
	≤18.5		18.5–24.9		25–29.9		≥30		
	(n = 223)		(n = 1591)		(n = 305)		(n = 91)		
	n	%	n	%	n	%	n	%	
Age (y/o)									<0.0001[a]
20–24	18	8.1	50	3.2	8	2.6	4	4.4	
25–29	64	28.7	336	21.1	44	14.4	12	13.2	
30–34	91	40.8	708	44.5	113	37.1	35	38.4	
35–39	43	19.3	435	27.3	123	40.3	32	35.2	
≥40	7	3.1	62	3.9	17	5.6	8	8.8	
Education (y)									0.0043[a]
>12	172	77.1	1286	80.8	232	76.1	61	67.0	
≤12	51	22.9	305	19.2	73	23.9	30	33.0	
Parity									<0.0001[a]
1	127	57.0	826	51.9	128	42.0	33	36.3	
2	82	36.8	613	38.5	127	41.6	41	45.0	
3	11	4.9	125	7.9	48	15.7	15	16.5	
≥4	3	1.3	27	1.7	2	0.7	2	2.2	
IOM weight gain									<0.0001[a]
Normal	83	37.2	677	42.6	131	42.9	36	39.6	
Below	134	60.1	745	46.8	50	16.4	12	13.2	
Above	6	2.7	169	10.6	124	40.7	43	47.2	
TBWI (kg)	11.88 ± 3.16		11.92 ± 3.57		10.72 ± 3.88		9.14 ± 3.56		<0.0001[b]
PCS of SF12	36.86 ± 7.96		36.96 ± 7.82		37.22 ± 8.01		38.39 ± 8.23		0.1439[b]
MCS of SF12	52.52 ± 9.07		51.20 ± 9.52		50.42 ± 10.79		51.53 ± 8.80		0.0868[b]
Sexual score	1.42 ± 2.00		1.22 ± 1.92		1.16 ± 1.93		1.03 ± 1.76		0.0866[b]

[a] Chi-square test.
[b] ANOVA test.
Abbreviations: BMI: body mass index; IOM: Institute of Medicine guideline; TBWI: total body weight increase; PCS: physical component summary score; MCS: mental component summary score; SF-12: short form-12 health questionnaire.

Information on prepregnancy body weight and a BMI calculation was collected via a maternal self-report at the first visit. Women were divided into 4 groups based on their prepregnancy BMIs according to classifications defined by the WHO [22]: underweight (BMI less than 18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), and obese (30 kg/m^2 or higher). In addition, women were categorized into 3 groups based on prepregnancy BMI and gestational weight gain related to the 2009 IOM recommendations [10]: 1. weight gain below the IOM guidelines, 2. weight gain within the IOM guidelines, and 3. weight gain above the IOM guidelines. The IOM's recommendation for gestational weight gain is 12.5–18 kg, 11.5–16 kg, 7–11.5 kg and 5–9 kg, for underweight, normal weight, overweight and obesity, respectively.

Statistical analyses

Descriptive statistics are presented as the means with standard deviations and percentages for continuous and categorical variables using Pearson's chi-square tests and t-tests and analysis of variance (ANOVA), respectively. As the pregnancy BMIs were categorized into four groups, including BMI < 18.5 kg/m^2, 18.5–24.9 kg/m^2, 25–29.9 kg/m^2, and ≥30 kg/m^2, we first conducted a proportional odds logistic regression to examine the fitting of the proportional odds assumption and found that the p value was larger than 0.05. Second, to evaluate the interrelation between prepregnancy BMI and pregnancy risk, generalized logistic regression with univariate and multivariable models was employed to analyze whether the data violated this assumption with a p value less than 0.05. The variables parity, length of gestation, and the history of medical illness were considered potential confounding factors and adjusted based on model selection. After taking the maternal age into consideration, the stepwise approach, using both the addition and removal for other variables with a p value larger than 0.05, was adopted to select the parsimonious models for each multivariable logistic regression. The odds ratio (OR) and adjusted odds ratio (aOR) with a 95% confidence intervals (CI) were calculated for each variable. All statistical significance levels were defined as p values less than 0.05. All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Clinical characteristics based on maternal prepregnancy BMI are presented in Table 1. The cohort consisted of 10.1% underweight, 72% normal weight, 13.8% overweight and 4.1% obese women. Women with an increased prepregnancy BMI were older, had lower education levels, and had higher rates of multiparous and gestational weight gain above the IOM guidelines than women with normal prepregnancy BMIs. The PCS score was slightly increased with an increase in prepregnancy BMI, but the MCS score behaved inversely; however, neither score reached statistical significance. The sexual function score was also slightly decreased with an increase in prepregnancy BMI but without statistical significance.

Table 2 Univariate and multiple logistic regression for maternal and fetal outcomes associated with prepregnancy BMIs.

Variable	Classification	Prepregnancy BMI					
		≤18.5 vs. 18.5–24.9		25–29.9 vs. 18.5–24.9		≥30 vs. 18.5–24.9	
		OR (95% CI)	aOR# (95% CI)	OR (95% CI)	aOR# (95% CI)	OR (95% CI)	aOR# (95% CI)
Maternal							
Age (y/o)	≥35 vs. <35	0.64 (0.46, 0.89)*	0.69 (0.48, 1.00)*	1.87 (1.46, 2.40)**	2.02 (1.49, 2.76)**	1.73 (1.13, 2.65)*	1.32 (0.69, 2.52)
Education (y)	≤12 vs. >12	1.25 (0.89, 1.75)	1.58 (1.08, 2.30)*	1.33 (0.99, 1.78)	–	2.07 (1.32, 3.27)*	–
Parity	Primi- vs. Multiparity	1.23 (0.92, 1.63)	1.56 (1.13, 2.15)*	0.67 (0.52, 0.86)*	0.55 (0.41, 0.75)*	0.53 (0.34, 0.82)*	0.24 (0.12, 0.48)**
Preterm (weeks)	<37 vs. ≥37	1.33 (0.87, 2.01)	8.23 (4.72, 14.36)**	1.59 (1.13, 2.25)*	0.17 (0.10, 0.30)**	2.10 (1.23, 3.61)*	0.03 (0.01, 0.09)**
Mode of delivery	Instrumental vs. vaginal	1.13 (0.50, 2.54)	–	0.96 (0.43, 2.17)*	–	0.52 (0.07, 3.87)*	–
	CS vs. vaginal	0.85 (0.60, 1.21)	–	1.60 (1.23, 2.10)*	–	2.32 (1.50, 3.59)*	–
IOM	Below vs. Normal	1.47 (1.10, 1.97)**	1.24 (0.90, 1.71)*	0.35 (0.25, 0.49)**	0.36 (0.25, 0.52)**	0.30 (0.16, 0.59)**	0.29 (0.13, 0.68)**
	Above vs. Normal	0.29 (0.12, 0.68)**	0.34 (0.14, 0.81)*	3.79 (2.82, 5.11)**	2.84 (2.01, 4.01)**	4.79 (2.98, 7.69)**	2.60 (1.30, 5.21)**
Preeclampsia	Yes vs. No	0.39 (0.09, 1.64)	–	3.19 (1.84, 5.55)**	–	10.65 (5.77, 19.65)**	3.65 (1.41, 9.44)*
Gestational DM	Yes vs. No	0.34 (0.11, 1.08)	–	2.79 (1.78, 4.38)**	3.39 (1.95, 5.91)**	6.51 (3.70, 11.46)**	6.83 (2.69, 17.33)**
Emergent CS	Yes vs. No	0.99 (0.50, 1.95)	–	1.17 (0.67, 2.04)	–	2.03 (0.95, 4.36)	–
Severe perineal laceration	Yes vs. No	0.91 (0.63, 1.33)	–	0.76 (0.53, 1.10)*	–	0.84 (0.44, 1.60)	–
Urine leakage	Yes vs. No	1.02 (0.77, 1.35)	–	0.98 (0.77, 1.26)	–	0.92 (0.60, 1.40)	–
Sexual score	<6 vs. ≥6	0.83 (0.49, 1.39)	–	1.04 (0.63, 1.70)	–	1.24 (0.49, 3.13)	–
Fetal							
Gender	Male vs. Female	1.04 (0.78, 1.37)	–	1.18 (0.92, 1.51)	–	1.19 (0.78, 1.82)	–
LBW (gm)	<2500 vs. ≥2500	1.65 (1.09, 2.50)*	–	1.03 (0.67, 1.58)	–	0.98 (0.47, 2.07)	–
Macrosomia (gm)	≥4000 vs. < 4000	0.75 (0.17, 3.24)	–	2.81 (1.29, 6.09)	6.01 (2.16, 16.77)**	6.90 (2.82, 16.86)**	46.29 (7.44, 288.26)**
FBW/MBMI	(continuous)	1.05 (1.04, 1.06)**	1.07 (1.06, 1.08)**	0.95 (0.94, 0.96)**	0.93 (0.91, 0.94)**	0.92 (0.91, 0.94)**	0.87 (0.84, 0.89)**
FHC (cm)	≥36 vs. <36	0.53 (0.28, 1.03)	0.27 (0.13, 0.56)*	1.52 (1.03, 2.24)*	2.54 (1.49, 4.31)*	2.61 (1.49, 4.55)**	6.91 (2.50, 19.13)*
Apgar score (<7)	Yes vs. No	0.32 (0.04, 2.40)	–	1.19 (0.45, 3.16)	–	1.60 (0.37, 6.92)	–

#: Adjusted odds ratio using multiple logistic regression after adjustment for age and each variable based on model selection; *: $p < 0.05$; **: $p < 0.001$.
Abbreviations: BMI: body mass index; LBW: low birth weight; FBW/MBMI: fetal birth weight/maternal body mass index; FHC: fetal head circumference.

Table 3 Risk factors for urinary incontinence during pregnancy.

Variable	Classification	Univariate		Multivariable	
		OR (95% CI)	*p* value[a]	aOR (95% CI)	*p* value[a]
Gestational age (y/o)	≥35 vs. <35	1.13 (0.95, 1.35)	0.1785	1.01 (0.83, 1.23)	0.9124
Education (y)	≤12 vs. >12	1.37 (0.84, 2.21)	0.2048	1.32 (0.79, 2.20)	0.2864
Parity	Primi- vs. Multiparity	0.79 (0.67, 0.94)	0.0066	0.77 (0.64, 0.94)	0.0092
Preterm (week)	<37 vs. ≥37	0.49 (0.38, 0.64)	<0.0001		
Mode of delivery	Instrument vs. Vaginal	0.94 (0.55, 1.61)	<0.0001	1.04 (0.60, 1.81)	<0.0001
	CS vs. Vaginal	0.25 (0.20, 0.31)		0.37 (0.24, 0.56)	
Preeclampsia or Gestational DM	Yes vs. No	0.61 (0.45, 0.82)	0.0010	–	
Labor augmentation	Yes vs. No	1.67 (1.41, 1.98)	<0.0001	–	
Labor duration (min)	≥400 vs. < 400	1.18 (0.92, 1.51)	0.1915	–	
Emergent CS	Yes vs. No	0.46 (0.31, 0.70)	0.0002	–	
Infant gender	Male vs. Female	1.11 (0.94, 1.31)	0.2236	–	
LBW (gm)	<2500 vs. ≥2500	0.51 (0.38, 0.68)	<0.0001	–	
Macrosomia (gm)	≥4000 vs. < 4000	1.88 (0.95, 3.75)	0.0719	–	
FHC (cm)	≥36 vs. < 36	0.93 (0.69, 1.25)	0.6261	–	
FBW/MBMI	(continuous)	1.01 (1.01, 1.02)	<0.0001	1.01 (1.00, 1.01)	0.0089
TBWI	(continuous)	1.02 (0.99, 1.04)	0.1580	1.03 (1.01, 1.06)	0.0125
Maternal initial BMI	BMI ≥25 vs. < 25	0.97 (0.78, 1.20)	0.7491	1.35 (1.04, 1.75)	0.0245

[a] p-value from univariate or multiple logistic regression.
Abbreviations: OR: odds ratio; DM: diabetes mellitus; CS: cesarean section; LBW: low birth weight; FHC: fetal head circumference; FBW/MBMI: fetal birth weight/maternal body mass index; TBWI: total body weight increase; BMI: body mass index.

Based on our data, the model for checking the proportional odds assumption had a $p < 0.0001$, which violated this assumption; therefore, a generalized logistic regression was applied for the following analysis. The associations between prepregnancy BMI and adverse pregnancy outcomes are shown in Table 2. Compared with women of normal weight, both overweight and obese women had a greater association with advanced maternal age (≥35 years old), low education level (≤12 years), multiparity (≥1), preterm delivery (<37 gestational weeks), CS, gestational weight gain above the IOM guidelines, preeclampsia, gestational DM, macrosomia (≥4000 gm) and large fetal head circumference (≥36 cm). After adjusting for age and other confounding factors, women with overweight and obesity were more likely to have adverse maternal outcomes (gestational weight gain above the IOM guidelines, preeclampsia and gestational DM) and fetal outcomes (large fetal head circumference and macrosomia) compared with women with normal weight [Table 2].

Table 4 Mean scores of the domains of the SF-12 and their relationship with maternal initial BMI.

SF-12	BMI < 25	BMI ≥ 25	*p* value[a]
Physical function	36.47	40.15	0.0180
Physical role	33.02	31.19	0.4190
Bodily Pain	71.47	69.51	0.1068
General health	53.85	55.43	0.1669
Vitality	58.80	58.13	0.6224
Social function	61.98	64.52	0.0979
Role emotional	65.16	61.87	0.1609
Metal health	72.95	71.92	0.3138
PCS of SF12	36.95	37.49	0.2194
MCS of SF12	51.36	50.67	0.2224

[a] t-test; SF-12: short form-12 health questionnaire.
Abbreviation: BMI: body mass index.

Prepregnancy underweight women were at a higher risk for low birth weight, preterm delivery, fetal birth weight/maternal body mass index (FBW/MBMI) and gestational weight gain below the IOM guidelines than normal weight women.

In Table 3, multivariable analyses demonstrate risk factors for UI during pregnancy, including multiparity, vaginal delivery, more gestational weight gain, a higher FBW/MBMI, and BMI. Overweight and obese women (BMI ≥ 25) were more likely to have UI during pregnancy than of normal weight and underweight women (BMI < 25), and the significant adjusted OR was 1.35 (95% CI: 1.04, 1.75). In terms of the individual components of the SF-12 associated with prepregnancy BMI, the physical function score was significantly higher for those who had a BMI ≥ 25 compared with those with a BMI < 25. However, other components of the SF-12 were not significantly different between those with a BMI ≥ 25 and those with a BMI < 25. There was no significant change in the PCS and MCS of the SF-12 in each group [Table 4].

Table 5 shows the sexual activity associated with prepregnancy BMI. More than 90% of pregnant women had reduced or no sexual activities regardless of their BMI. For individual component scores of the sexual questionnaires, the frequency of sexual activity in overweight and obese women (BMI ≥ 25) was more frequent than that of women with a BMI < 25 (3.1% vs. 1.7%).

Discussion

Prior reports have demonstrated that inappropriate prepregnancy weight is associated with increased risks for adverse pregnancy outcomes [3,5,7,23–29]. In the present study, prepregnancy underweight women were at risk for low birth weight, preterm delivery, and gestational weight gain below

Table 5 Sexual activity scores and relationships with maternal initial BMI in each group.

Variable	Classification	BMI < 25	%	BMI ≥ 25	%	Total	%	*p* value
Frequency of sexual activity	No	1497	82.8%	334	85.0%	1831	83.2%	0.0236[a]
	Decrease	280	15.5%	47	12.0%	327	14.9%	
	Same	31	1.7%	11	2.8%	42	1.9%	
	Increase	0	0.0%	1	0.3%	1	0.0%	
Willingness to have sexual activity	No	988	54.7%	227	57.8%	1215	55.2%	0.6524[a]
	Decrease	647	35.8%	129	32.8%	776	35.3%	
	Same	141	7.8%	29	7.4%	170	7.7%	
	Increase	31	1.7%	8	2.0%	39	1.8%	
Satisfaction from sexual activity	No	1512	83.7%	333	84.7%	1845	83.8%	0.5280[a]
	Decrease	136	7.5%	33	8.4%	169	7.7%	
	Same	156	8.6%	27	6.9%	183	8.3%	
	Increase	3	0.2%	0	0.0%	3	0.1%	
Dyspareunia	No	1611	89.1%	358	91.1%	1969	89.5%	0.3327[a]
	Decrease	39	2.2%	10	2.5%	49	2.2%	
	Same	87	4.8%	11	2.8%	98	4.5%	
	Increase	71	3.9%	14	3.6%	85	3.9%	
Total sexual activity score		1.24	(SD1.93)	1.13	(SD1.89)			0.2924[b]

[a] Chi-square test.
[b] t-test.
Abbreviation: BMI: body mass index.

the IOM guidelines than women of normal weight [6,12,14,28]. We also found that women with lower maternal BMI at delivery were more common in prepregnancy underweight group, resulting in the higher FBW/MBMI in BMI ≤ 18.5 group. A meta-synthesis suggests that gestational weight gain below the guidelines is associated with a higher risk for a fetus small for gestational age and preterm birth [12]. Furthermore, our results show that overweight and obese women are more likely to have gestational DM, preeclampsia, large fetal head circumference, macrosomia and gestational weight gain above the IOM guidelines than normal weight women [3,5,7,23–27]. There is a positive correlation between prepregnancy BMI and fetal size at birth, which is consistent with previous reports [6,12,14,23]. In this study, women with prepregnancy overweight and obesity had a 6- to 46-fold increased risk of macrosomia and a 2.5- to 6.9-fold increased risk of large fetal head circumference compared with women with normal weight. Lipschuetz et al. [30] demonstrated that large fetal head circumference had a stronger association with unplanned cesarean or instrumental delivery than high birth weight.

A previous study showed that gestational DM had adverse effects on maternal and fetal outcomes and was related to maternal BMI and possibly to gestational weight gain [31]. In this study, prepregnancy overweight and obese women had a 3.4- to 6.8-fold increased risk for gestational DM, which confirms previous studies indicating that prepregnancy overweight and obesity are independent risk factors for gestational DM [23,27,29]. A high prepregnancy BMI is a recognized risk factor for the development of gestational DM [23,27], but the risk of gestational DM in pregnant women with excessive weight gain is inconclusive [11,23]. A plausible explanation is that women diagnosed with gestational DM apply more lifestyle interventions, control their weight gain and monitor their blood sugar levels during pregnancy [29]. In addition to gestational DM, our study shows that a high prepregnancy BMI was associated with the development of preeclampsia. Obesity is a well-known risk factor for preeclampsia. Obese women have increased blood volume and cardiac output and elevated blood pressure during pregnancy [10]. Frederick et al. [32] demonstrated that every 1 kg/m^2 increase in prepregnancy BMI resulted in an 8% increased risk of preeclampsia. In the present study, women with prepregnancy obesity had a 3.7-fold increased risk of preeclampsia compared to women with normal prepregnancy BMIs.

Our results show that gestational weight gain and a higher prepregnancy BMI are reported determinants of UI during pregnancy. Epidemiological studies have documented that overweight and obesity are major risk factors for UI in women [33]. The explanation for UI in pregnancy is that added weight during pregnancy and obesity may bear down on pelvic tissues, causing chronic strain, stretching, and weakening of the muscles and nerve innervation to the bladder and urethra [33,34]. However, the association of prepregnancy overweight and obesity with UI in pregnancy is inconsistent in previous studies [16,35,36]. Lin et al. [35] demonstrated that body weight and BMI at the first visit were the contributing factors of UI during pregnancy. Women with a prepregnancy BMI greater than 30 were reported to have an increased risk of developing de novo stress UI in pregnancy [35,36]. Brown et al. [17] studied the role of BMI previously but found no association with UI in pregnancy. In the present study, we found that overweight and obese women (BMI ≥ 25) were more likely to have UI during pregnancy than normal weight and underweight women (BMI < 25) after controlling for confounding factors. In addition, we also observed that women with higher FBW/MBMI had a greater incidence of UI than women with lower FBW/MBMI, that may be associated with the weight of the fetus, or the size of the pregnant woman, but the real cause requires further research in the future.

Obesity is known to increase the risk of many diseases and reduce the overall QoL. The scores for PCS, MCS and the 8

domains of the Short Form 36 health questionnaire (SF-36) decreased from prepregnancy to pregnancy [37]. However, little information is available about the impact of prepregnancy BMI on health-related QoL changes [15]. In the current study, there were not significant changes in the PCS and MCS scores. Sahrakorpi et al. [15] used a 15D questionnaire to assess changes in 750 women's health-related QoL during pregnancy and postpartum in different BMI groups. The health-related QoL of all women decreased during the course of pregnancy, but the decrease was significantly greater in the obese BMI group [15].

Sexual dysfunction during pregnancy may have a significant impact on a woman's QoL. Pregnancy is usually associated with a regression in intercourse frequency, sexual desire, satisfaction and orgasm experience [38]. Our results show that more than 90% of pregnant women had reduced or no sexual activities, which is compatible with a prior report [39]. Fok et al. [39] found that 93% of Chinese pregnant women reported an overall reduction in their sexual activities during pregnancy. The main reasons for reducing sexual activity included decreased libido, a doctor's suggestion and increased fear for the fetus' health [38]. Studies conducted in the non-Chinese countries demonstrated that 86–100% of couple have sexual activities during pregnancy [38,39]. Different expressions of sexual activity during pregnancy between Eastern and Western populations may be related to biopsychosocial and cultural factors. Staruch et al. [38] reported that although the frequency of vaginal intercourse was reduced, 87% of pregnant women remained sexually active during pregnancy. More than 75% of the respondents had no complications during pregnancy at the time of recruitment, but the role of health care provider in counselling sexual activities is inadequate because only 30% of respondents consulted health care providers about sex life during pregnancy. As the matter of fact, medical staff can provide the information to pregnant women that sexual activities will not normally cause complications in the pregnancy.

In the present study, there were no significant differences in sexual scores among the 4 BMI groups. For individual component scores of the sexual questionnaires, the frequency of sexual activity in women with overweight and obesity (BMI $\geq$ 25) was less than that of women with a BMI < 25. A previous study demonstrated an inverse correlation between prepregnancy BMI and mean total score of female sexual function index (FSFI), desire and orgasm in the third trimester of pregnancy [40]. Ribeiro et al. [40] observed that in the second trimester, the mean total FSFI scores for overweight and obese women (BMI $\geq$ 25) were similar to those of normal weight women, but the sexual function of overweight and obese women was worse in the third trimester.

Several limitations of this study require attention. First, when assessing the association between gestational weight gain and adverse pregnancy outcomes, this study had a limited sample size of some important but rare pregnancy complications, such as birth injury, low Apgar score at 5 min, and neonatal death, in women with prepregnancy overweight and obesity. Second, the prepregnancy weight was self-reported, which is subject to recall error and can lead to an underestimation or overestimation of gestational weight gain, UI and sexual activity. Third, there was no distinction between the types of UI during pregnancy. Despite these limitations, the strengths of this study include adjusting for as many confounding factors as possible and using patient interviews and medical record data rather than birth certificate data. The correlation between gestational weight gains recommended by the 2009 IOM guidelines with pregnancy outcomes can be investigated objectively.

In conclusion, this study demonstrated that prepregnancy BMI and gestational weight gain affected not only the perinatal outcomes of the mother and fetus but also UI and sexual activity during pregnancy. Our results suggest that maintaining a normal prepregnancy BMI and avoiding excessive weight gain during pregnancy can lead to better pregnancy outcomes. A systemic review has shown that weight loss can reduce the prevalence of UI [33]. Health care providers need to inform women to start pregnancy with a BMI in the normal weight category; during pregnancy, weight gain should be limited to the IOM guidelines.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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