Original Article

Pre-pregnancy body mass index and gestational weight gain in Thai pregnant women as risks for low birth weight and macrosomia

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Background and Objectives: Maternal pre-pregnancy body mass index (BMI) and gestational weight gain (GWG) have been reported to be associated with pregnancy outcomes. Due to the nutrition transition in Thailand, the double burden of malnutrition is increasing and this may have negative consequences on birth outcomes. This study aimed to investigate the relationship between pre-pregnancy BMI and GWG with the risks of low birth weight and macrosomia. **Methods and Study Design:** We performed a secondary analysis of data obtained from an iodine supplementation trial in mildly iodine-deficient Thai pregnant women. Pre-pregnancy BMI was classified using the WHO classification. GWG was categorized using the IOM recommendation. Binary and multinomial logistic regressions were performed. **Results:** Among 378 pregnant women, the prevalence of pre-pregnancy underweight (BMI<18.5 kg/m^2) and overweight (BMI≥25 kg/m^2) were 17.2% and 14.3%, respectively. Normal weight women had the highest median GWG [15.0 (12.0, 19.0) kg] when compared to overweight women [13.2 (9.0, 16.3) kg]. Forty-one percent of women had excessive GWG, while 23% of women gained weight inadequately. Women with a high pre-pregnancy BMI had a 7-fold higher risk of having a macrosomic infant. Women who had excessive GWG were 8 times more likely to deliver a newborn with macrosomia. **Conclusions:** Both high pre-pregnancy maternal weight and excessive weight gain during pregnancy increase risk of infant macrosomia. Therefore, maintaining normal body weight before and throughout pregnancy should be recommended in order to reduce the risk of excessive infant birth weight and its associated complications.

Key Words: pre-pregnancy body mass index, gestational weight gain, low birth weight, macrosomia, pregnant women

INTRODUCTION

Despite a rising trend in overnutrition in young children and in non-communicable diseases among adults,[1,2] the prevalence of low birth weight (LBW) in Thailand has remained at a constant level of 8-10% over the last 10 years.[3] Unfortunately, national representative data on macrosomia have not been available. A hospital-based retrospective study reported that macrosomia prevalence was 7.6% in overweight pregnant women and 0.9% in normal weight pregnant women.[4]

Undernutrition, both before and during pregnancy, results in poor fetal growth, LBW, and preterm birth.[5,6] In contrast, overnutrition is associated with a higher risk of macrosomia, cesarean delivery, and other pregnancy complications such as gestational diabetes and preeclampsia.[5-7] Maternal nutrition may not only affect the immediate pregnancy outcomes. Since fetal and early postnatal life is a period of rapid growth and development, nutritional perturbations during this period may predispose to health and diseases later in life.[8-10]

The relationship between pre-pregnancy nutritional status and gestational weight gain (GWG) with birth weight has been investigated in many studies in Thailand.[11-15] The evidence showed that low pre-pregnancy BMI and less GWG was one of the determinants of LBW in Thai population.[12,15] On the other hand, high GWG was associated with high birth weight.[11,13-14] The evidence of the relationship between maternal nutritional status on timing of delivery was also documented. High pre-pregnancy BMI increased risk of preterm delivery.[16-17] Among high pre-pregnancy BMI women, low GWG was associated with an increased risk of preterm delivery.[18]

Unfortunately, previous studies in Thailand did not simultaneously explore the relationship of various levels of pre-pregnancy weight and GWG with birth weight.[11-15] In order to obtain collective evidence on these associations, studies are needed to assess the risks for both LBW and macrosomia related to maternal body weight in populations presently undergoing the nutrition transition, such as Thailand. This knowledge can guide us to more appro-

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priate recommendations in Thailand and other countries in the region that are also facing the double burden of malnutrition. Therefore, this study aimed to investigate the association between pre-pregnancy BMI and GWG with the risks of LBW and macrosomia.

SUBJECTS AND METHODS

Subjects

This study is a secondary analysis of data obtained from a randomized double blind controlled trial on the effects of iodine supplementation in mild-to-moderately iodine-deficient pregnant women on thyroid function, pregnancy outcomes, and newborn development in Thailand. The intervention study was conducted among Thai pregnant women who had attended an antenatal clinic at Ramathibodi Hospital of Mahidol University in Bangkok, Thailand, between October 2008 and June 2013. Inclusion and exclusion criteria were explained in a previous publication.[19] Pregnant women were followed-up until delivery. The analyses were limited to 380 women who had birth outcome data.

The ethical review boards of Wageningen University, the Netherlands, and Ramathibodi Hospital, Thailand, approved the study protocol. The study was registered into the clinical trials database at https://clinicaltrials.gov and its identifier number is NCT00791466.

Methods

At enrolment, maternal characteristics of the women including age, parity, education, and occupation were recorded using a questionnaire. Data on birth weight and date of delivery were obtained from the hospital records. Self-reported pre-pregnancy weight and measured height at the enrolment were used for pre-pregnancy BMI (kg/m^2) calculation. Weight at the first antenatal visit (4%) or at the enrolment (1%) was used in women for whom pre-pregnancy weight was not available. Pre-pregnancy BMI was classified using the international cut-off points proposed by the World Health Organization (WHO): underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), or obese (≥30.0 kg/m^2).[20] Due to small number of obese women (n=15, 4%), women with BMI≥25.0 kg/m^2 were considered as overweight.

GWG was estimated as the difference in kilograms between the delivery weight and pre-pregnancy weight. GWG was categorized as inadequate, adequate, and excessive, according to the IOM recommendations.[21] Adequate GWG was defined as 12.5-18, 11.5-16, 7-11.5, and 5-9 kg for underweight, normal weight, overweight, and obese women, respectively. LBW was defined as weight at birth of <2,500 grams, while macrosomia was defined as weight at birth ≥4,000 grams. Preterm was defined as babies born alive before 37 weeks of pregnancy.

Maternal blood samples were collected at baseline, 2nd and 3rd trimester, and at delivery. Free thyroxine (fT4) concentration was analyzed using enzyme-labeled chemiluminescent competitive immunoassay (IMMULITE 2000, SIEMENS, Germany) and hemoglobin (Hb) concentration was analyzed using a flow cytometry method (automated blood count analyzer, Sysmex, USA) at Ramathibodi Hospital. We included fT4 and Hb concentrations in the analysis to ensure that pregnant women were comparable in all nutritional groups since some of them received iodine and iron supplementation.

Data analyses

Participant's characteristics are presented as means±SD, medians (first, third quartiles), or percentages, where appropriate. Participant's characteristics were compared by pre-pregnancy BMI and GWG categories using Chi-square test for discrete variables and analysis of variance (ANOVA) with Tukey's post hoc or Kruskal-Wallis test with Mann-Whitney *U* test for continuous data. Binary and multinomial logistic regressions were used to assess the relationship between pre-pregnancy BMI and GWG with birth weight and preterm delivery. The models were adjusted for parity, pre-pregnancy BMI or GWG, fT4 at 3rd trimester, sex of baby, gestational diabetes mellitus, preeclampsia, treatment group, and preterm delivery (for birth weight outcome only). All statistical analyses were performed using IBM SPSS statistics for Windows, Version 19.0 (IBM Corp., Armonk, NY).

RESULTS

Of 380 pregnant women, 2 women were excluded from data analyses because of the uncertainty in GWG (GWG less than 0.5 kg). Hence, the data of 378 pregnant women were analyzed. Maternal characteristics presented by pre-pregnancy BMI are shown in Table 1. The prevalence of underweight and overweight were 17.2% and 14.3%, respectively. Underweight women tended to be younger than normal and overweight women (p<0.01). Median GWG in normal weight women [15.0 (12.0, 19.0) kg] was higher than in overweight women [13.2 (9.0, 16.3) kg] (p<0.01). According to the IOM recommendation for GWG, 22.8 %, 36.2 %, and 41.0 % of women had inadequate, adequate, and excessive weight gain, respectively (Table 2). Median Hb concentrations were not different by either pre-pregnancy BMI or GWG categories (p>0.05) (Table 1, 2).

The average birth weight of infants born to underweight women was lower than that of infants born to overweight women (2,988±478 g vs 3,224±579 g, p<0.05). However, the average birth weight of infants born to normal weight women did not differ from that of infants born to underweight and overweight women (Table 3). Similarly, the average birth weight of infants born to inadequate GWG women was lower than that of those born to excessive GWG women (3,021±407 g vs 3,189±495 g, p<0.05) but it was similar to that of infants born to adequate GWG women (p>0.05).

The relationships between pre-pregnancy BMI and birth weight and preterm delivery are shown in Table 4. In an unadjusted multinomial logistic regression model, women who were underweight before pregnancy were 2.7 times (crude OR: 2.65, 95% CI: 1.08-6.53) as likely to have LBW infants compared to normal weight women. However, this significant relationship disappeared in the adjusted model. In addition, women who were overweight before pregnancy were 6.1 times (crude OR: 6.12, 95% CI: 1.83-20.4) as likely to have macrosomic infants compared to normal weight women. The relationship was stronger after adjusting for possible confounders (adjust-

Table 1. Characteristics of participants classified by pre-pregnancy body mass index (BMI)

Characteristics	Pre-pregnancy BMI[†]			
	Underweight	Normal weight	Overweight	*p*-value[‡,§]
No. of participants (%)	65 (17.2)	259 (68.5)	54 (14.3)	-
Maternal age, y[¶]	27.0±4.8[a]	30.0±4.8[b]	30.0±5.2[b]	<0.0001
Pre-pregnancy BMI[††], kg/m^2	17.7 (17.1, 18.1)[a]	21.0 (19.7, 22.3)[b]	27.9 (26.4, 30.5)[c]	<0.0001
Gestational weight gain, kg	13.7 (11.4, 18.5)[a,b]	15.0 (12.0, 19.0)[a]	13.2 (9.0, 16.3)[b]	0.036
Gestational weight gain, %				
Inadequate	35.4	22.4	9.3	0.000
Adequate	40.0	37.8	24.1	
Excessive	24.6	39.8	66.7	
Parity, %				
Primiparous	55.4	39.0	35.2	0.035
Multiparous	44.6	61.0	64.8	
Education, %				
<12 yr	4.6	8.1	13.0	0.411
12 yr	30.8	36.3	35.2	
>12 yr	64.6	55.6	51.9	
Occupation, %				
Officer workers	52.3	50.2	46.3	0.193
Owned business	12.3	17.4	9.3	
General employee	10.8	15.1	25.9	
Others	24.6	17.4	18.5	
Hemoglobin at baseline, g/L	117 (112, 124)	120 (113, 127)	120 (116, 127)	0.136
Hemoglobin at 3rd trimester, g/L	114 (110, 122)	116 (110, 122)	119 (111, 123)	0.289
Free thyroxine at 3rd trimester, ng/dL	0.79 (0.73, 0.88)	0.75 (0.63, 0.84)	0.72 (0.64, 0.82)	0.016

[†]BMI (kg/m^2): underweight (<18.5), normal weight (18.5-24.9), and overweight (≥25.0).
[‡]Chi-square test for discrete data.
[§]ANOVA or Kruskal-Wallis test for continuous data; [a,b,c]: values in a row with different letters differ.
[¶]Mean±SD (all such values).
[††]Median (first, third quartiles) (all such values).

Table 2. Characteristics of participants classified by gestational weight gain (GWG)

Characteristics	IOM gestational weight gain[†]			
	Inadequate	Adequate	Excessive	*p*-value[‡,§]
No. of participants (%)	86 (22.8)	137 (36.2)	155 (41.0)	-
Maternal age, y[¶]	29.0±5.9	30.0±4.9	29.0±4.5	0.139
Pre-pregnancy BMI, kg/m^{2}[††]	20.6 (18.3, 22.3)[a]	20.4 (18.8, 22.5)[a]	21.3 (19.8, 24.3)[b]	0.001
Gestational weight gain, kg	10.0 (7.6, 11.0)[a]	13.7 (12.6, 15.0)[b]	19.0 (17.0, 22.0)[c]	0.000
Parity, %				
Primiparous	38.4	37.2	46.5	0.230
Multiparous	61.6	62.8	53.5	
Education, %				
<12 yr	10.5	9.5	5.8	0.535
12 yr	38.4	32.1	36.1	
>12 yr	51.2	58.4	58.1	
Occupation, %				
Officer workers	43.0	50.4	53.5	0.566
Owned business	17.4	16.1	13.5	
General employee	17.4	18.2	15.9	
Others	22.1	15.3	20.0	
Hemoglobin at baseline, g/L	120 (113, 125)	120 (113, 126)	120 (114, 126)	0.974
Hemoglobin at 3rd trimester, g/L	114 (108, 122)	118 (111, 123)	115 (110, 123)	0.252
Free thyroxine at 3rd trimester, ng/dL	0.82 (0.75, 0.91)	0.77 (0.62, 0.85)	0.70 (0.62, 0.79)	0.000

[†]Adequate gestational weight gain: 12.5-18, 11.5-16, 7-11.5, and 5-9 kg for underweight, normal weight, overweight, and obese women.
[‡]Chi-square test for discrete data.
[§]ANOVA or Kruskal-Wallis test for continuous data; [a,b,c]: values in a row with different letters differ.
[¶]Mean±SD (all such values).
[††]Median (first, third quartiles) (all such values).

ed OR: 7.18, 95% CI: 2.00-25.8). There was no significant relationship between pre-pregnancy BMI and preterm delivery (p>0.05).

The relationships between GWG and birth weight and preterm delivery are summarized in Table 5. There was no relationship between inadequate GWG and having low or high birth weight (p>0.05). Nevertheless, the adjusted model showed that women who had excessive GWG were 8 times (adjusted OR: 8.04, 95% CI: 1.42-45.7) as likely to have macrosomic infants compared to women with normal GWG. GWG was not related to preterm delivery (p>0.05).

Table 3. Pregnancy outcomes classified by pre-pregnancy BMI and gestational weight gain

Pregnancy outcomes	Pre-pregnancy BMI				Gestational weight gain			
	Underweight	Normal weight	Overweight	*p*-value[†,‡]	Inadequate	Adequate	Excessive	*p*-value[†,‡]
No. of participants	65	259	54	-	86	137	155	-
Birth weight, g[§]	2,988±478[a]	3,116±405[a,b]	3,224±579[b]	0.016	3,021±407[a]	3,074±409[a,b]	3,189±495[b]	0.011
Birth weight, %								
<2,500 g	13.8	5.8	7.4	0.009	10.5	7.3	5.8	0.189
2,500-2,999 g	29.2	30.5	33.3		31.4	31.4	29.7	
3,000-3,999 g	55.4	61.4	48.1		57.0	59.9	58.1	
≥4,000g	1.5	2.3	11.1		1.2	1.5	6.5	
Gestational age at delivery, wk[¶]	39 (38, 40)	39 (38, 40)	38.5 (38, 39)	0.719	39 (38, 40)	39 (38, 39)	39 (38, 40)	0.908
Preterm delivery, %	10.8	6.6	7.9	0.345	11.6	5.8	7.7	0.296

[†]Chi-square test for discrete data.
[‡]ANOVA or Kruskal-Wallis test for continuous data; [a,b]: values in a row with different letters differ.
[§]Mean±SD (all such values).
[¶]Median (first, third quartiles) (all such values).

Table 4. Crude and adjusted odds ratios (OR) for pregnancy outcomes classified by pre-pregnancy BMI

	Crude OR			Adjusted OR[†]		
	Pre-pregnancy BMI (kg/m^2)			Pre-pregnancy BMI (kg/m^2)		
	<18.5	18.5-24.9	≥25.0	<18.5	18.5-24.9	≥25.0
Birth weight (g)						
<2,500	2.65 (1.08-6.53)[*]	Referent	1.63 (0.50-5.30)	2.64 (0.89-7.83)	Referent	0.87 (0.20-3.75)
2,500-2,999	1.06 (0.57-1.97)	Referent	1.39 (0.72-2.69)	0.89 (0.47-1.69)	Referent	1.26 (0.63-2.52)
3,000-3,999	Referent	Referent	Referent	Referent	Referent	Referent
≥4,000	0.74 (0.09-6.31)	Referent	6.12 (1.83-20.41)[**]	0.72 (0.08-6.83)	Referent	7.18 (2.00-25.80)[**]
Preterm delivery	1.72 (0.68-4.34)	Referent	1.78 (0.67-4.75)	0.78 (0.23-2.64)	Referent	0.49 (0.18-1.30)

[*]$p<0.05$, [**]$p<0.01$, multinomial logistic regression for birth weight and binary logistic regression for preterm.
[†]Adjusted for parity, gestational weight gain, free thyroxine at 3rd trimester, baby sex, gestational diabetes mellitus, preeclampsia (and preterm for birth weight model only).

Table 5. Crude and adjusted odds ratios (OR) for pregnancy outcomes classified by gestational weight gain

	Crude OR			Adjusted OR†		
	Gestational weight gain			Gestational weight gain		
	Inadequate	Adequate	Excessive	Inadequate	Adequate	Excessive
Birth weight (g)						
<2,500	1.51 (0.57-3.96)	Referent	0.82 (0.32-2.12)	1.19 (0.38-3.71)	Referent	0.60 (0.20-1.85)
2,500-2,999	1.05 (0.58-1.91)	Referent	0.98 (0.58-1.63)	0.95 (0.51-1.77)	Referent	0.88 (0.52-1.49)
3,000-3,999	Referent	Referent	Referent	Referent	Referent	Referent
≥4,000	0.84 (0.07-9.47)	Referent	4.56 (0.97-21.4)	0.80 (0.07-9.67)	Referent	8.04 (1.42-45.7)*
Preterm delivery	2.12 (0.80-5.61)	Referent	1.35 (0.54-3.42)	2.32 (0.85-6.35)	Referent	1.38 (0.53-3.57)

*$p<0.05$, multinomial logistic regression for birth weight and binary logistic regression for preterm.
†Adjusted for parity, pre-pregnancy BMI, free thyroxine at 3rd trimester, baby sex, gestational diabetes mellitus, preeclampsia (and preterm for birth weight model only).

DISCUSSION

Several publications reported the association between maternal pre-pregnancy BMI and GWG with pregnancy outcomes, especially birth weight. Findings from this secondary data analysis strengthened those results. Mothers who were underweight before pregnancy or gained weight inadequately tended to have a higher risk of having LBW infants when compared to overweight mothers or those who gained excessive weight. From the unadjusted multinomial logistic regression, underweight women had a 2.7-fold higher risk of having LBW infants, while overweight women had a 6-fold higher risk of having macrosomic infants compared to normal weight women. The relationship was stronger after adjusting for possible confounders, and overweight women had a 7-fold higher risk of having macrosomic infants. In addition, women who had excessive GWG were 8 times as likely to have macrosomic infants compared to women with normal GWG. These findings confirmed that maternal body weight both before and during pregnancy influence birth weight.

In accordance with our study, many investigators reported similar associations between pre-pregnancy BMI and birth weight. Fleten et al [22] reported a direct association between BMI and birth weight among 43,705 Norwegian mothers. The authors concluded that a one-unit increase in BMI resulted in a 20.3 gram increase in birth weight. Moreover, in a study among 292,568 singleton term Chinese pregnancies, pre-pregnancy underweight was associated with an increased risk of delivering a LBW infant (OR: 1.9, 95% CI: 1.3-1.6), while overweight and obese women had a 2.5- and 3.5-fold likelihood of giving birth to a macrosomic infant, respectively.[6] The association between BMI and birth weight can be related to several explanations: (1) protein-energy availability; (2) micronutrient intakes; and (3) plasma volume. Fetuses of low pre-pregnancy weight women may receive inadequate nutrients from the mothers and hence the growth of the fetus is restricted.[23] Previous evidence showed that micronutrient deficiencies which are common in developing countries contributed to intrauterine growth restriction (IUGR).[24] Increased micronutrient intakes leads to an increase in infant birth size and a reduction of IUGR in low pre-pregnancy BMI women. Moreover, underweight women have smaller plasma volume compared to normal or overweight women. A low plasma volume leads to a low cardiac output. Consequently, a low cardiac output may result in a low utero-placental blood flow and thus a decrease in nutrient transfer from the mothers to the fetuses in underweight women.[25] However, in the present study, a significant relationship between pre-pregnancy BMI and LBW disappeared in the adjusted regression model. This might be because other pregnancy complications, such as preeclampsia, play a stronger role in explaining LBW in this population.

Consistent with other reports, when GWG was taken into consideration, women who gained weight excessively during pregnancy showed a higher risk of having macrosomic babies when compared to women with normal GWG. In addition, a systematic review of the effect of maternal weigh gain during pregnancy on birth weight confirmed our findings that excessive GWG increased risk of high birth weight in normal and obese pregnant women.[26] However, due to limited sample size, we were not able to categorize our population by both pre-pregnancy weight and GWG simultaneously.

Although the international BMI cut-off points have been recommended and widely used as a tool for assessing individual nutritional status,[27] appropriate cut-off points for Asian populations are still controversial. Some evidence showed that Asians generally have a higher percentage of body fat than Europeans and the risks of type 2 diabetes and cardiovascular disease are substantial among Asians at BMI lower than the WHO cut-off point of 25 kg/m^2. Therefore, this information calls for redefining a different BMI classification for a different ethnic population. Unfortunately, there are not sufficient data to date to support this hypothesis and indicate an explicit BMI cut-off for Asian populations. Therefore, the WHO expert consultation recommended to continue using an international BMI cut-off.[20]

Despite the fact that many studies investigated the determinants of birth weight, only a few studies assessed the effect of macro and micronutrient status simultaneously. Micronutrient deficiencies such as iron and iodine deficiencies have been known to be related to LBW.[28-30] We do not have data on iron status. Nonetheless, Hb concentrations, which can be used as a proxy indicator for iron deficiency anemia when the level is low,[31] did not differ among pre-pregnancy BMI and GWG groups. We included fT4 level as a co-variate in both binary and multinomial logistic regression models since there were significant differences of fT4 concentrations among pre-pregnancy BMI and GWG groups. However, fT4 concentration did not affect birth weight in our regression models (data not shown). We also attempted to investigate the effect of

pre-pregnancy weight and GWG simultaneously, which has been rarely done in the previous studies.[11-15] We are aware that self-reported pre-pregnancy weight was used in our analysis and this may result in misclassification of pre-pregnancy BMI; however, this is the routine practice in Thailand. In addition, pre-pregnancy weight data were strongly correlated with baseline weight data (r=0.97, p<0.001) in this study.

Although the relationship between pre-pregnancy BMI and GWG with LBW was not found in this study, the findings showed that LBW still exists in this population at a level of 7% (data not shown). This may be due to other determinants, not only pre-pregnancy BMI and GWG, affect the risk of LBW.[12] Moreover, our results strengthened the evidence that over-nutrition both before and during pregnancy is related to higher risk of macrosomia. Although the data were collected from one hospital in Bangkok, the pregnant women who participated in the study were from various socio-ecomomic status, hence this information calls for more attention on maternal weight among reproductive age women during the nutrition transition in Thailand.

In conclusion, findings from the present study confirmed the strong association between pre-pregnancy BMI and GWG and adverse birth outcomes. Therefore, women should be advised to maintain appropriate body weight before and during pregnancy in order to prevent any detrimental effects on pregnancy outcomes.

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AUTHOR DISCLOSURES

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Original Article

Pre-pregnancy body mass index and gestational weight gain in Thai pregnant women as risks for low birth weight and macrosomia

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泰国孕妇孕前体质指数和孕期增重是低出生体重和巨大儿发生的危险因素

背景与研究目的：产妇怀孕前的体质指数（BMI）和孕期增重（GWG）与妊娠结局有关已被报道。泰国由于营养过渡，营养不良的双重负担不断增加，这可能会对妊娠结局产生负面影响。本研究旨在探讨孕前 BMI 和 GWG 与低出生体重和巨大儿发生风险的关系。**方法与研究设计**：我们对轻度碘缺乏的泰国孕妇进行碘补充试验的资料进行了二次分析。根据 WHO 的标准，对孕前 BMI 进行分类，根据 IOM 推荐的标准对 GWG 进行分类。进行二分类和多项无序分类 logistic 回归分析。**结果**：378 名孕妇中，怀孕前低体重（BMI<18.5 kg/m^2）和超重（BMI≥25 kg/m^2）的发生率分别为 17.2%和 14.3%。与超重女性 [13.2（9.0，16.3）kg] 相比，正常体重女性的 GWG 的中位数最高 [15.0（12.0，19.0）kg]。41%的女性 GWG 过多，而 23%的女性 GWG 不足。孕前 BMI 高的孕妇生产巨大儿的风险增加 7 倍。GWG 过多的孕妇生产巨大儿的风险增加 8 倍。**结论**：孕前体重高和孕期体重过度增加均增加巨大儿的发生风险。因此，应推荐在孕前和整个孕期均保持正常体重，以降低婴儿出生体重过重及其相关并发症的风险。

关键词：孕前体质指数、孕期增重、低出生体重、巨大儿、孕妇