Short Communication

Associations of the pre-pregnancy body mass index and gestational weight gain with pregnancy outcomes in Taiwanese women

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BACKGROUND**:** Pre-pregnancy weight and gestational weight gain (GWG) are important factors in both maternal and infant outcomes. Little information is available in relation to different levels of pre-pregnancy body mass index (BMI) and body weight gain on obstetric outcomes in Taiwan. This study investigated the associations between pregnancy complications with pre-pregnant BMI and GWG, in Taiwanese women. METHODS: Data were extracted from a delivery room information bank on all women delivering singleton babies in a medical center. Eight hundred and sixty pregnant women were included. The collected variables included basic information, GWG, and pregnancy and neonatal outcomes. Pregnant women were categorized according to their pre-pregnant BMI and GWG to evaluate the impacts of pre-pregnant BMI and maternal weight gain on the risk of pregnancy complications. Univariate and multivariable logistic regression analyses were performed, and odds ratios were calculated. RESULTS: Pre-pregnancy BMI≥24 kg/m^2 increased the risks of gestational diabetes mellitus, preeclampsia, and preterm labor. Preeclampsia and Cesarean delivery were positively associated with high weight gains (>18 kg), whereas a low birth weight and preterm labor were strongly associated with low weight gains (<10 kg). A higher birth weight was found with a GWG of >14 kg in women who were underweight and normal weight before pregnancy. CONCLUSION: An appropriate maternal BMI (18.5-24 kg/m^2) at conception followed by a suitable gestational weight gain (10-14 kg) has substantial impact on the overall health of pregnant women and would lead to better obstetric management for Taiwanese women.

Key Words: body mass index (BMI), pre-pregnancy weight, gestational weight gain (GWG), pregnancy outcomes, low birth weight

INTRODUCTION

It was reported that compared to women with a normal pre-pregnancy body mass index (BMI), underweight women were more likely to deliver small-for-gestational-age (SGA) infants.[1] Pre-pregnancy obesity produces increased risks of preeclampsia, eclampsia, gestational diabetes, a cesarean delivery, and macrosomia.[2] Also, gestational weight gain (GWG) is an important factor in both maternal and infant outcomes.[3,4] The largest amount of maternal weight gain was found in whites living in developed countries.[5] Asian populations in general had lower weight gains.[6] Thorsdottir *et al*.[7] suggested in an American population study that unnecessary GWG had no beneficial effects on health and inferred that a low weight gain should also be avoided to optimize birth outcomes. Attempts were made to categorize pre-pregnancy BMI and maternal weight gain in relation to risks of pregnancy complications and adverse birth outcomes. In 1990, the Institute of Medicine (IOM) in the US last revised guidelines for weight gain during pregnancy, which recommended an optimal weight gain range for women based on their pre-pregnancy BMI.[8] The Japan Society of Obstetrics and Gynecology also issued guidelines for optimal weight gain during pregnancy based on the pre-pregnancy BMI.[9] However, little information is available in relation to different levels of pre-pregnancy BMI and body weight gain on obstetric outcomes in Taiwan. At present, there is only a recommendation for maternal weight gain from the Department of Health (DOH) in Taiwan for women with a normal weight before pregnancy.

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Therefore, we conducted this retrospective cohort study to investigate associations between pregnancy complications with the pre-pregnancy BMI and GWG, in Taiwanese women.

MATERIALS AND METHODS

Subjects

The obstetric database at Mackay Memorial Hospital in New Taipei City contains prospectively collected data on all pregnant women admitted to this hospital. There were 956 pregnant women identified in the database from April to June 2007. Women with a stillbirth, multiple pregnancies, and missing BMI data were excluded. In total, 860 women with singleton pregnancies were included in this study. Demographic characteristics of the pregnant women included: pre-pregnancy BMI, age, parity, GWG, and gestational age at delivery. Gestational weight gain was calculated as the difference between the measured weight at the last prenatal visit closest to delivery and the self-reported pre-pregnancy weight. Although maternal pre-pregnancy weight was self-reported, this method was considered accurate even among obese people,[10] and was used in various studies for calculating pre-pregnant BMI and GWG.[4,11] Antepartum complications included preeclampsia and gestational diabetes mellitus (GDM). Preeclampsia was diagnosed by a blood pressure of ≥140 mmHg or proteinuria of ≥300 mg per 24 hours after the 20th week of gestation.[11] Gestational diabetes mellitus was diagnosed on the basis of a 75-g oral glucose tolerance test if the following diagnostic criteria were in two of three categories: a fasting blood glucose of >100 mg/dL, plasma glucose levels at 60 min of >180 mg/dL and at 120 min of >150 mg/dL after loading.[4] Neonatal complications included a low birth weight (LBW, birth weight of <2500 g), high birth weight (>3500 g), preterm labor (gestational wk <37 wk), intrauterine growth restriction (IUGR), and fetal distress. Since macrosomia frequently occurs and the body frame size is relatively smaller in the Taiwanese than that of Caucasian women, we used >3500 g as a high neonatal birth weight. Intrauterine growth restriction was defined as a mean birth weight below the 10th percentile as a cut-off value.[12]

Exposure variables

On the basis of self-reported information on weight and height from the first pregnancy interview, the pre-pregnancy BMI (kg/m^2) was categorized into underweight (BMI <18.5), normal-weight (18.5≤ BMI <24), and overweight (BMI ≥24) groups. These categories were based on the definition of the DOH classification in Taiwan.[13] Gestational weight gain was categorized as low (<10 kg), medium (10-14 kg), high (14-18 kg), and very high (≥18 kg). These cut-offs were chosen because the general recommended maternal weight gain is 10-14 kg for pregnant women.[13] Since there is a 4-kg range, we considered 14-18 kg as high and >18 kg as very high weight gain categories.

Statistical analysis

We used SPSS 15.0 (SPSS, Chicago, IL, USA) software for all statistical analyses. Demographic data are presented as the mean±SD. Differences in proportions of categorical variables were compared using a chi-square test. A multivariable logistical regression was used to evaluate the association between GWG and perinatal complications. In the multiple logistic regression models, categories of GWG and pre-pregnant BMI were mutually adjusted to estimate independent associations with a number of pregnancy outcomes and birth complications. Medium GWG and normal weight BMI were used as reference groups. We estimated the adjusted odds ratios (ORs) for pregnancy outcomes including preeclampsia and gestational DM. In addition, the adjusted ORs for a number of birth complications and neonatal outcomes were estimated. We used significance levels of 0.05 for all statistical tests, and ORs are presented with the 95% confidence intervals (CIs).

RESULTS

Demographic data of all subjects showed that the mean

Table 1. Maternal characteristics categorized by different pre-pregnancy body mass index (BMI) levels

		Underweight		Normal weight		Overweight		*p*-value
		BMI <18.5		18.5≤ BMI <24		24 ≤BMI		
	n	*n*	%	*n*	%	*n*	%	
	860	143	16.6	583	67.8	134	15.6	
Age (yr)								< 0.001
19-25	51	21	41.2	23	45.1	7	13.7	
26-30	275	46	16.7	186	67.6	43	15.6	
31-35	388	54	13.9	272	70.1	62	16.0	
≥36	146	22	15.1	102	69.9	22	15.1	
Parity								0.010
Primiparous	513	97	18.9	353	68.8	63	12.3	
Multiparous	347	46	13.2	230	66.3	71	20.4	
Gestational age (wk)								0.058
<37	67	14	20.9	37	55.2	16	23.9	
≥37	793	129	16.3	546	68.9	118	14.9	
GWG								0.009
< 10	106	16	15.1	60	56.6	30	28.3	
10 ≤ GWG < 14	262	42	16.0	180	68.7	40	15.3	
14 ≤ GWG < 18	298	55	18.5	208	69.8	35	11.7	
18 ≤ GWG	194	30	15.5	135	69.6	29	14.9	

GWG, gestational weight gain. p <0.05 indicates a significant difference by chi-squared test or Fisher's exact test.

Table 2. Unadjusted odds ratio (OR) of neonatal outcome risks and pregnancy complications by pre-pregnancy body mass index (BMI)

	Birth weight <2500 g		Birth weight ≥ 3500 g		Preterm labor		Cesarean delivery		Fetal distress		IUGR		Preeclampsia		GDM	
BMI (kg/m^2)	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
<185	1.70 (0.72-4.03)	0.230	1.00 (0.59-1.67)	0.986	1.75 (0.91-3.36)	0.091	0.63 (0.40-1.00)	0.049	1.63 (0.82-3.26)	0.166	3.33 (0.88-12.5)	0.076	0.45 (0.06-3.57)	0.449	1.64 (0.31-8.54)	0.557
18.5-24	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
>24	1.09 (0.42-2.81)	0.865	2.30 (1.44-3.67)	0.001	2.04 (1.07-3.86)	0.029	1.83 (1.24-2.71)	0.002	1.13 (0.51-2.52)	0.764	0.87 (0.10-7.50)	0.899	3.52 (1.29-9.62)	0.014	4.48 (1.28-15.7)	0.019

CI: confidence interval; IUGR, intrauterine growth restriction; GDM, gestational diabetes mellitus. $p < 0.05$ indicated significant difference by Cochran's and Mantel-Haenszel statistics

Table 3. Univariate odds ratio (OR) of pregnancy outcomes by gestational weight gain (GWG) according to different categories of the body-mass index (BMI)

GWG	Birth weight < 2500 g		Birth weight ≥ 3500 g		Preterm labor		Cesarean delivery		Fetal distress	
	OR(95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
BMI <18.5										
<10 kg	6.33 (1.29-31.1)	0.023	3.80 (0.22-66.2)	0.360	2.73 (0.70-10.7)	0.150	0.19 (0.02-1.59)	0.125	-	-
10-14 kg	1.00		1.00		1.00		1.00		1.00	
14-18 kg	1.62 (0.36-7.27)	0.526	10.7 (1.32-87.1)	0.027	0.11 (0.01-0.96)	0.046	0.48 (0.17-1.33)	0.157	0.47 (0.12-1.79)	0.269
≥18 kg	0.67 (0.07-6.85)	0.733	20.0 (2.38-168)	0.006	0.43 (0.08-2.29)	0.321	0.86 (0.29-2.55)	0.783	0.43 (0.08-2.29)	0.321
18.5≤ BMI <24										
< 10 kg	2.03 (0.78-5.25)	0.145	0.48 (0.14-1.69)	0.254	1.45 (0.56-3.75)	0.440	1.23 (0.63-2.41)	0.540	2.25 (0.69-7.36)	0.181
10~14 kg	1.00		1.00		1.00		1.00		1.00	
14~18 kg	0.71 (0.29-1.73)	0.447	2.04 (1.13-3.66)	0.018	0.56 (0.24-1.27)	0.163	1.16 (0.73-1.85)	0.536	1.25 (0.47-3.35)	0.660
≥ 18 kg	0.85 (0.31-2.34)	0.748	3.65 (2.00-6.69)	< 0.001	0.17 (0.04-0.74)	0.018	1.81 (1.10-2.98)	0.019	1.77 (0.64-4.87)	0.272
BMI ≥24										
< 10 kg	3.30 (0.60-18.3)	0.171	0.28 (0.80-0.96)	0.043	5.78 (1.11-30.3)	0.038	0.83 (0.31-2.25)	0.719	2.79 (0.24-32.25)	0.412
10~14 kg	1.00		1.00		1.00		1.00		1.00	
14~18 kg	1.32 (0.20-8.64)	0.772	0.39 (0.13-1.11)	0.077	2.45 (0.42-14.3)	0.319	0.99 (0.39-2.52)	0.975	5.03 (0.54-47.34)	0.158
≥ 18 kg	1.38 (0.18-10.8)	0.762	1.10 (0.41-2.98)	0.851	1.41 (0.19-10.6)	0.740	2.05 (0.78-5.42)	0.148	1.39 (0.08-23.23)	0.817

Range in parentheses indicates 95% confidence interval (CI). (-): no data collected for analysis. $p < 0.05$ indicates a significant difference by Cochran's and Mantel-Haenszel statistics.

BMI was 21.2±3.3 kg/m^2, age was 31.7±4.0 yr, gestational age was 38.4±1.9 wk, parity was 1.5±0.6, and infant birth weight was 3124±486 g. The mean GWG in this population was 14.9±4.6 kg. Among all subjects, 67.8% were in a normal weight range, which left 16.6% and 15.6% classified as underweight and overweight before pregnancy, respectively. Among these subjects, 30.5% gained 10-14 kg and 34.7% gained 14-18 kg. Only 12.3% of the groups had low (<10 kg) and 22.5% had high GWGs (≥18 kg). Distributions of age range, parity, gestational age, and GWG among the 3 pre-pregnancy BMI categories are shown in Table 1.

Effects of the pre-pregnancy BMI on pregnancy outcomes

Compared to a normal BMI, a higher pre-pregnancy BMI increased the risk of a high neonatal birth weight, preterm labor, a Cesarean delivery, preeclampsia, and GDM. Women with a pre-pregnant BMI of <18.5 showed few associations with the pregnancy complications examined (Table 2).

Effects of GWG in different categories of BMI on pregnancy outcomes

The risk of a low birth weight was observed with lower weight gains in the BMI <18.5 group, whereas a higher birth weight was found with a gestational weight gain of >14 kg in women who were underweight and normal weight before pregnancy, respectively. There was an association between low weight gains and preterm labor in the high-BMI group (Table 3).

DISCUSSION

This is the first analysis of pre-pregnancy BMI and GWG in relation to pregnancy complications and adverse neonatal outcomes among Taiwanese women. Although the case number was small and participants were restricted to the northern part of the island, this study can be considered a pilot study in Taiwan. In this study, we classified pre-pregnancy BMIs of Taiwanese women according to the definition of the DOH in Taiwan. Our classification differs from that for Caucasian women in which pre-pregnant BMIs of <19.8 and >26 were defined as underweight and overweight, respectively, based on the quartile range of BMI of women at reproductive age.[8] Body mass index is significantly correlated with adiposity and can adequately predict body fat percentage as long as age and gender are taken into account.[14] However, the relationship between body fat percentage and BMI is ethnic-specific. Asian countries have a low prevalence of obesity, despite their high rates of obesity-related diseases. At the same BMI, Asians have a higher body fat percentage compared to Caucasians.[15] Even among Asians, BMI cut-off points for obesity and being underweight differ among various countries.[16] As maternal anthropometry differs across ethnic groups, maternal recommendations based on data complied from Caucasians is not applicable to Asians. Also, recommendations derived from other Asian countries might not be suitable for Taiwanese women.

We found that women with a pre-pregnancy BMI of <18.5 showed few associations with the pregnancy complications studied, while women with a pre-pregnancy BMI of >24 were associated with preeclampsia, GDM, a cesarean delivery, and preterm labor. These results indicated that having a pre-pregnancy BMI above the normal range poses a risk for pregnancy complications. A study by Wataba *et al*.[11] also found that Japanese women with a pre-pregnancy BMI ranging from 18 to 23.9 had the fewest pregnancy related complications.

The recommendations from IOM showed that optimal weight gain in pregnancy from the Caucasian women were 12-18 kg for low pre-pregnancy BMI (<19.8), 11.5-16 kg for a moderate pre-pregnancy BMI (19.8-26), and 7-11.5 kg for a high pre-pregnancy BMI (>26).[8] That report was similar to a study performed by Wong *et al*,[17] who analyzed 500 pregnant women with good pregnancy outcomes in Hong Kong. Their recommended weight gains for ethnic Chinese women were 13-16.7, 11-16.4, and 7-14.4 kg for low (<19), moderate (19-23.5), and high (>23.5) pre-pregnancy BMIs, respectively. With the current study design, we could not establish weight gain recommendations among the different pre-pregnancy BMI groups. We found that regardless of the pre-pregnancy BMI, a GWG of >18 kg increased the risk of preeclampsia and a Cesarean delivery. A GWG of <10 kg increased the risks of a low birth weight and preterm labor. These results suggest that for all subjects, 10-18 kg gains seemed to have no adverse effects during pregnancy. However, when the pre-pregnancy BMI was classified in relation to weight gain during pregnancy, we found that for women with low and normal BMI, a weight gain of >14 kg resulted in a higher neonatal birth weight. The absence of an association with excessive weight gain in the group with a BMI of >24 could be the result of insufficient power because of limitations due to sample size in this study. Because the majority of subjects recruited in this study were within a normal weight range, fewer subjects were available in the underweight and overweight categories. Distributions in these 2 groups may thus be less precise.

In conclusion, data from this investigation suggest that an appropriate maternal BMI (18.5-24) at conception followed by suitable gestational weight gain (10-14 kg) has substantial impacts on the overall health of pregnant women and can lead to better obstetric management.

AUTHOR DISCLOSURES

The authors declare that they have no competing interests.

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懷孕前身體質量指數及懷孕期體重增加量與台灣孕婦懷孕結果相關性之研究

背景：懷孕前體重及懷孕期體重增加量對產後母親及嬰兒併發症的發生有非常重要的影響。但是在台灣，懷孕前身體質量指數與懷孕期體重增加量對懷孕結果的相關資料很少，故本研究探討台灣懷孕婦女其懷孕前不同身體質量指數與懷孕期體重增加量對懷孕結果的相關性。方法：這是一個回顧式的世代研究，符合本研究個案數為 860 名。資料來源為某醫學中心建置之產房資料庫，輔以病歷查詢，內容包括孕婦基本資料、懷孕前身高與體重、懷孕期體重變化、懷孕期併發症等。孕婦根據其懷孕前身體質量指數，及懷孕期體重增加量分組，來評估不同身體質量指數及體重增加量對懷孕期風險指標的相關性。本研究使用多元邏輯迴歸分析法，並計算勝算比。結果：當產婦懷孕前身體質量指數≥24 kg/m^2，其發生懷孕型糖尿病、子癇前症及早產的風險增加。懷孕期體重增加量≥18 公斤與發生子癇前症及剖腹產的風險呈正相關。而懷孕期體重增加量<10 公斤則與嬰兒早產及出生體重過低的風險有強相關性。懷孕前體重過輕或正常而懷孕期間體重增加量>14 公斤與嬰兒體重過重相關。結論：孕婦在懷孕前有適當的身體質量指數(18.5-24 kg/m^2)，且懷孕期間體重增加量維持在 10-14 公斤，對於懷孕婦女整體的健康狀況有正面影響並有較佳的懷孕結果。

關鍵字：身體質量指數、懷孕前體重、懷孕期體重變化、懷孕結果、低出生體重