Does Gestational Weight Gain in Normal Pre-Pregnancy BMI Pregnant Women Reflect Fetal Weight Gain?

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Objective: *To identify the correlation between gestational weight gain in pregnant women with normal pre-pregnancy body mass index (BMI) and fetal weight gain.*
Material and Method: *Uncomplicated normal pre-pregnancy BMI Thai singleton pregnant women with less than 16 weeks' gestation participated in this study between June 2008 and September 2009. Serial measurements of maternal and fetal weight using ultrasound examination were recorded every four weeks from 16 to 36 weeks' gestation.*
Results: *Two hundred seventy four uncomplicated pregnant women were included in this study of which 166 met inclusion criteria during a period of the study. There was a significant correlation between gestational weight gain and both estimated fetal weight gain and actual infant birth weight ($p < 0.05$). Using the multiple regression analysis, gestational weight gain between 16 to 28 weeks' gestation, multiparity, and male infants were independent factors and were significantly correlated with both fetal weight gain and actual infant birth weight ($p < 0.05$).*
Conclusion: *For pregnant women with normal pre-pregnancy BMI, gestational weight gain can predict intrauterine fetal weight as well as infant birth weight.*

Keywords: *Infant birth weight, Fetal weight, Gestational weight gain, Pre-pregnancy BMI*

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To date, many studies have shown results of inappropriate gestational weight gain and various adverse maternal and fetal outcomes[1-4]. In daily practice, obstetricians usually use gestational weight gain as a predictor of intrauterine fetal growth with each prenatal visit. It is interesting that if all pregnant women gain their weight similarly, whether difference in pre-pregnancy body mass index (BMI) affects fetal growth the same way.

Previous studies reveal that pre-pregnancy BMI affects fetal growth. Pre-pregnancy overweight and obesity causes prolonged pregnancy, fetal macrosomia or large for gestational age, preterm premature rupture of membranes and preeclampsia[5-8]. Pre-pregnancy underweight increases the risk of preterm delivery, which is associated with low birth weight[9-11]. Normal pre-pregnancy BMI is usually used as a reference for these studies; however, there is still no clear conclusion about the relationship between gestational weight gain and fetal weight gain.

The purpose of the present study was to identify the correlation between gestational weight gain and fetal weight gain in normal pre-pregnancy BMI Thai pregnant women. Findings from the present study will lead to clinical applications about fetal growth assessments in daily obstetric care, especially in low-resourced areas.

Material and Method

After ethical approval from the Siriraj Institute Review Board, 274 uncomplicated normal pre-pregnancy BMI (18.5 to 24.9 kg/m^2) Thai singleton pregnant women were enrolled in the present study during the period between June 2008 and September 2009. The overall criteria emphasized that all participants were non-smokers, gestational age of less than 16 weeks, and had sure gestational ages that was confirmed by their last menstrual period and ultrasound examination. One hundred and eight pregnant women were excluded during a period of the present study because of their loss to follow up, maternal and fetal complication, such as preterm delivery, pregnancy induced hypertension and fetal anomaly. Data of the

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remaining 166 pregnant women were fully collected and analyzed.

Baseline characteristics of the subjects included age, parity, height, and pre-pregnancy weight. Maternal height was measured in centimeters by a standard measurement technique. Pre-pregnancy weight was recorded according to the patients' self-report as usually done in routine practices. Routine antenatal care, as usual, was provided for all subjects.

The first examination started at 16 weeks' gestation and then followed every 4 weeks until 36 weeks' gestation. On each visit, maternal weight (with their clothes on, but excluding shoes) was measured and recorded to the nearest 0.1 kg by using a standard digital scale (TANITA HD-316, Japan). Estimation of fetal weight by ultrasound was performed within the unit of Maternal Fetal Medicine by two senior obstetricians. Each obstetrician did not know the examination results of the other obstetrician. Inter-observer and intra-observer variations was tested and concluded in only minimal variations (correlation coefficient > 0.95, p-value < 0.001). The GE voluson E8 ultrasound machine with linear transabdominal probe was used for fetal biometries in standard plane, including biparietal diameter, head circumference, abdominal circumference, and femur length. In addition, the estimation of fetal weight was calculated using the Hadlock equation.

Results of all delivery, including gestational age at birth, route of delivery, fetal gender, and birth weight, were recorded for further analysis. Data was documented on an Excel spreadsheet (Microsoft, USA) and analyzed using the software SPSS for Windows. Descriptive statistics including means, standard deviation, number, and percentage were used to analyze results. Pearson's correlation analysis and multiple linear regression analysis were also used to evaluate the degree of relationship among gestational weight gain, maternal BMI gain, estimated fetal weight, and actual infant birth weight. A linear graph was additionally generated to display the correlation among gestational weight gain, maternal BMI gain, and estimated fetal weight. Statistical tests were two-tailed with p-value < 0.05 to indicate statistical significance.

Results

After performing a serial ultrasonography in the present study population, all data were analyzed. The baseline and obstetric characteristics of the study population were reported as shown in Table 1 and 2. The trends of mean gestational weight gain, mean maternal BMI gain and mean estimated fetal weight gain by ultrasonography are shown in Fig. 1 and were displayed as having similar trends in all parameters, but with difference in gaining rate. Increase of fetal weight during each period of pregnancy escalated continuously, whereas gestational weight gain usually increased more during the second trimester of pregnancy and less after that.

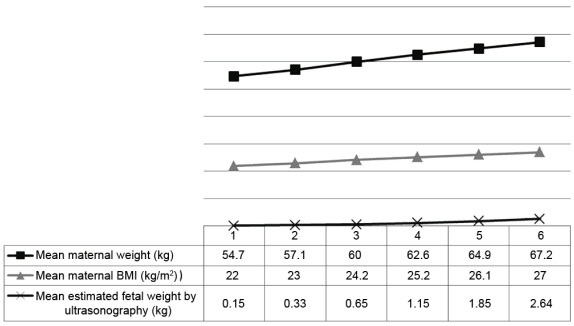
High correlation between gestational weight gain and maternal BMI gain was noted (r = 0.996, p-value < 0.01) in the present study. Fig. 2 and 3 revealed correlation between estimated fetal weight gain by ultrasonography, actual infant birth weight and gestational weight gain during 16 to 36 weeks' gestation. Significant correlation between parameters was reported and correlation coefficient(r) were

Table 1. Baseline characteristics of the study populations (n = 166)

	Mean ± SD (min-max)
Age (year)	27.7 ± 5.5 (15-41)
Pre-pregnancy BMI (kg/m^2)	20.9 ± 1.7 (18.5-24.9)
Total gestational weight gain (kg)	
16-36 weeks' gestation	12.5 ± 3.5 (4.5-23.3)
Total maternal BMI gain (kg/m^2)	
16-36 weeks' gestation	5.0 ± 1.4 (1.7-9.1)

Table 2. Obstetric characteristics of the population study (n = 166)

	Number (%)
Parity	
0	96 (57.8)
≥ 1	70 (42.2)
Route of delivery	
Vaginal delivery	113 (68.1)
Cesarean delivery	53 (31.9)
Fetal gender	
Male	101 (60.8)
Female	65 (39.2)
	Mean ± SD (min-max)
Gestational age at birth (weeks)	38.7 ± 1.1 (37-41)
Infant birth weight (g)	3,130.0 ± 339.2 (2,510-3,990)



	1	2	3	4	5	6
Mean maternal weight (kg)	54.7	57.1	60	62.6	64.9	67.2
Mean maternal BMI (kg/m^2))	22	23	24.2	25.2	26.1	27
Mean estimated fetal weight by ultrasonography (kg)	0.15	0.33	0.65	1.15	1.85	2.64

Fig. 1 Trends of mean gestational weight gain, mean maternal BMI gain and mean estimated fetal weight gain by ultrasonography at 16, 20, 24, 28, 32 and 36 weeks' gestation (shown as number 1 to 6 in the table, respectively)

0.163 (p-value < 0.05) and 0.213 (p-value < 0.01), respectively.

Periods of gestational age were divided into two intervals, in which Table 3 revealed significant correlation between gestational weight gain and both estimated fetal weight gain by ultrasonography and actual infant birth weight, which was found only during 16 to 28 weeks' gestation (r = 0.193 and 0.264, respectively, p-value < 0.05). This was supported by multiple regression analysis in Table 4 and 5, which showed that gestational weight gain during 16 to 28 weeks' gestation was an independent factor and was significantly correlated with both estimated fetal weight gain by ultrasonography and actual infant birth weight (p-value < 0.05). Moreover, multiparity and male infants were also found to be other independent factors for estimated fetal weight gain by ultrasonography and actual infant birth weight, respectively (p-value < 0.05).

Table 3. Correlation between gestational weight gain and fetal growth (n = 166)

Gestational weight gain interval (weeks' gestation)	Total fetal weight gain by ultrasound (gram) r (p-value)	Actual infant birth weight (gram) r (p-value)
16-28	0.193 (0.013)	0.264 (0.001)
28-36	0.068 (0.368)	0.074 (0.346)

* Statistical significant, p-value < 0.05

Discussion

In the past, many studies have shown a strong relationship between gestational weight gain and fetal weight[3,12,13]. Based on the belief that normal pre-pregnancy BMI leads to normal pregnancy outcomes, it is interesting that most of the previous researches revealed that abnormal pre-pregnancy BMI was associated with maternal and fetal morbidity. For the present study, the authors observed only normal pre-pregnancy BMI pregnant women to approve the clinical application on predicting fetal weight. This is the first time in Thailand that the relationship between maternal and fetal weight gain were explored in prospective fashion.

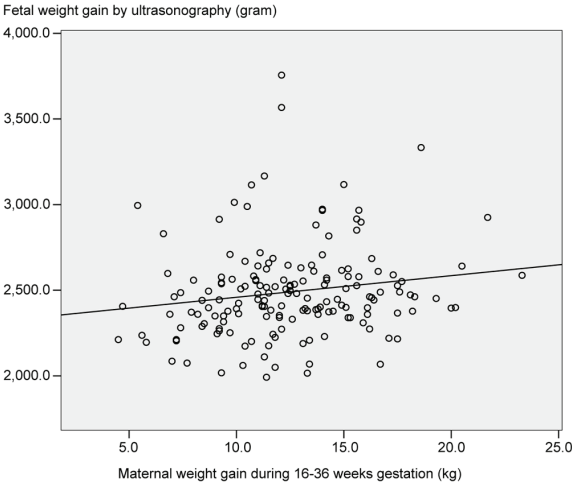


Fig. 2 Scatter plot between estimated fetal weight gain by ultrasonography and gestational weight gain during 16-36 weeks gestation, correlation coefficient = 0.163 (p-value < 0.05)

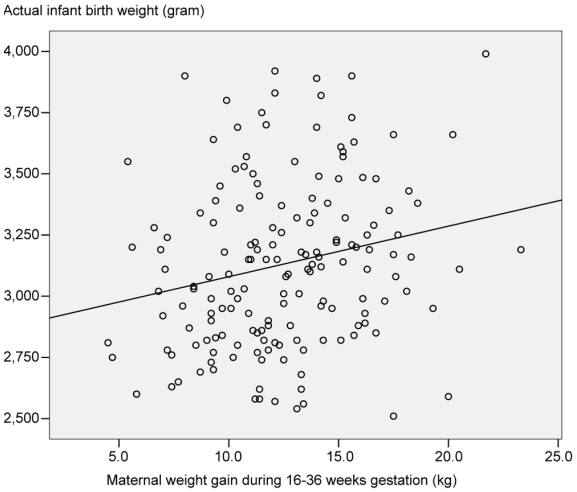


Fig. 3 Scatter plot between actual infant birth weight and gestational weight gain during 16-36 weeks gestation, correlation coefficient = 0.213 (p-value < 0.01)

Table 4. Multiple linear regression analysis between estimated fetal weight gain by ultrasonography and variables (n = 166)

Variables	Beta	Standard error	p-value
Multiparity	123.082	41.417	0.003*
Male infant	13.704	42.652	0.748
Gestational weight gain (kg) (16-28 weeks gestation)	21.270	9.854	0.032*
Gestational weight gain (kg) (28-36 weeks gestation)	-0.846	12.737	0.947

* Statistical significant, p-value < 0.05

Table 5. Multiple linear regression analysis between actual infant birth weight and variables (n = 166)

Variables	Beta	Standard error	p-value
Multiparity	90.389	51.082	0.079
Male infant	107.503	52.606	0.043*
Gestational weight gain (kg) (16-28 weeks of gestation)	36.876	12.153	0.003*
Gestational weight gain (kg) (28-36 weeks of gestation)	-10.110	15.709	0.521

* Statistical significant, p-value < 0.05

The present study showed a significant correlation among gestational weight gain, maternal BMI gain and estimated fetal weight; however, only during 16 to 28 weeks' gestation were independent factors (p-value < 0.05). Similar to the previous study, mid-gestational weight gain was sensitive to fetal growth[14,15]. Cellular hypertrophy and the accumulation of fat, glycogen, and connective tissue caused higher rate of fetal weight gain than gestational weight gain during the third trimester. As a result, in normal pre-pregnancy BMI, prediction of fetal weight gain using gestational weight gain could be applicable only during the second trimester.

Previous studies revealed an impact of maternal pre-pregnancy BMI on infant birth weight[16-18], but none discussed its influence during pregnancy. In the present study, the authors were concerned about this and found that maternal BMI gain was highly correlated with gestational weight gain, and that both had similar trends during pregnancy. As a result, this parameter could be applied as an alternative parameter instead of gestational weight gain for predicting infant birth weight.

From the result of the present study, multiparity was significantly associated with estimated fetal weight, but not associated with actual infant birth weight. Although overall maternal weight decreases during postpartum, accumulation of adipose tissue usually increases and causes postpartum weight retention in multiparous women[19,20]. This may interfere with an ultrasound examination and causes some error in fetal weight calculation. In addition, male gender was found to be an independent factor for actual infant birth weight. One study suggested that male infants have more fat-free mass[21]. As a result, male infants weigh more than females at birth. Using ultrasonography, fetal fat mass may be abandoned because most parameters included only fetal bony parts. This could explain why fetal gender was not correlated to fetal weight gain by ultrasonography but was associated only with actual infant birth weight.

The present study still has some limitations. Firstly, some factors that are associated with fetal weight gain or birth weight were not involved in the present study, for instance, paternal height, which affects infant birth weight and cannot be explained by maternal or other pre-pregnancy factors and socioeconomic statuses. Secondly, there may be errors when using ultrasonography in estimating fetal weight during pregnancy. However, the authors chose the Hadlock formula, which has minimal variation and high accuracy for estimation of fetal weight. Moreover, using ultrasonography is a common investigation in routine practice and is the best way to predict fetal weight during the antepartum period.

In conclusion, according to normal pre-pregnancy BMI, gestational weight gain can predict intrauterine fetal weight as well as infant birth weight, especially during 16 to 28 weeks' gestation, multiparity, and male infant.

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Potential conflicts of interest

None.

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น้ำหนักตัวที่เพิ่มขึ้นขณะตั้งครรภ์ของมารดาที่มีดัชนีมวลกายปกติก่อนการตั้งครรภ์สะท้อนการเพิ่มขึ้นของน้ำหนักทารกในครรภ์หรือไม่

ตรีภพ เลิศบรรณพงษ์, ภัทรวลัย ตลึงจิตร, วิทยา ถิฐาพันธ์

วัตถุประสงค์: *เพื่อแสดงความสัมพันธ์ระหว่างน้ำหนักตัวที่เพิ่มขึ้นขณะตั้งครรภ์ของสตรีที่มีดัชนีมวลกายปกติก่อนการตั้งครรภ์และน้ำหนักตัวที่เพิ่มขึ้นของทารกในครรภ์*

วัสดุและวิธีการ: *สตรีตั้งครรภ์ชาวไทยซึ่งไม่มีภาวะแทรกซ้อนและมีดัชนีมวลกายก่อนการตั้งครรภ์ปกติ อายุครรภ์น้อยกว่า 16 สัปดาห์ เข้าร่วมการศึกษาระหว่างเดือนมิถุนายน พ.ศ. 2551 และกันยายน พ.ศ. 2552 ได้รับการตรวจติดตามน้ำหนักตัวขณะตั้งครรภ์และน้ำหนักตัวของทารกในครรภ์ด้วยคลื่นเสียงความถี่สูงทุก 4 สัปดาห์ ตั้งแต่อายุครรภ์ 16-36 สัปดาห์*

ผลการศึกษา: *จากจำนวนสตรีตั้งครรภ์ที่ไม่มีภาวะแทรกซ้อนที่เข้าร่วมการศึกษาทั้งหมด 274 คน คงเหลือสตรีตั้งครรภ์จำนวน 166 คน ที่เข้าเกณฑ์การศึกษาในระหว่างการศึกษา พบว่าน้ำหนักตัวที่เพิ่มขึ้นขณะตั้งครรภ์มีความสัมพันธ์กับทั้งน้ำหนักตัวที่เพิ่มขึ้นของทารกในครรภ์และน้ำหนักทารกแรกเกิดอย่างมีนัยสำคัญทางสถิติ (p-value < 0.05) เมื่อใช้การวิเคราะห์การถดถอยพหุคูณพบว่าน้ำหนักตัวที่เพิ่มขึ้นขณะมีอายุครรภ์ระหว่าง 16 ถึง 28 สัปดาห์, การตั้งครรภ์หลัง และทารกเพศชายเป็นตัวแปรอิสระและมีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับทั้งน้ำหนักตัวที่เพิ่มขึ้นของทารกในครรภ์และน้ำหนักทารกแรกเกิด (p-value < 0.05)*

สรุป: *ในสตรีตั้งครรภ์ที่มีดัชนีมวลกายปกติก่อนการตั้งครรภ์ น้ำหนักตัวที่เพิ่มขึ้นขณะตั้งครรภ์สามารถทำนายได้ทั้งน้ำหนักตัวของทารกในครรภ์และน้ำหนักทารกแรกเกิด*