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## OBSTETRICS

# Association between Gestational Weight Gain and Small for Gestational Age in Underweight Pregnant Women

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## ABSTRACT

**Objectives:** To compare the rate of small-for-gestational age (SGA), low birth weight (LBW), and other pregnancy outcomes between underweight pregnant women who had adequate and inadequate gestational weight gain (GWG).

**Materials and Methods:** A total of 300 singleton, uncomplicated, underweight pregnant women were included in a retrospective cohort study. Study group consisted of 100 women who had inadequate GWG and another 200 women who had adequate GWG were in comparison group. Data were retrieved from medical records, including baseline and obstetric characteristics, trimester-specific and total weight gain, delivery data, and pregnancy outcomes. Rate of SGA and other pregnancy outcomes were compared between the 2 groups.

**Results:** Both groups were comparable in terms of age, BMI, and parity. Compared with women with adequate GWG, those with inadequate GWG had significantly lower weight gain in every trimester. Women with inadequate GWG were significantly more common to have preterm delivery (11% vs. 2%, p = 0.001), LBW (29% vs. 6%, p < 0.001), and SGA (18% vs. 6.5%, p = 0.002). Logistic regression analysis showed that 2nd trimester weight gain ≤ 7 kg was the only independent associated factor for SGA (adjusted odds ratio (OR) 9.92, 95% confidence interval (CI) 2.06-47.68, p = 0.004). On the other hand, inadequate GWG was the only independent associated factor for LBW (adjusted OR 5.82, 95%CI 2.11-16.0, p = 0.001).

**Conclusion:** Underweight pregnant women who had inadequate GWG significantly increased risk of preterm delivery, LBW, and SGA. Second trimester weight gain ≤ 7 kg was independently associated with SGA and inadequate GWG was independently associated with LBW.

**Keywords:** underweight, gestational weight gain, small for gestational age, low birth weight.

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# ความสัมพันธ์ระหว่างน้ำหนักตัวที่เพิ่มขึ้นขณะตั้งครรภ์กับการคลอดทารกน้ำหนักแรกเกิดน้อยกว่าอายุครรภ์ ในมารดาที่น้ำหนักต่ำกว่าเกณฑ์

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## บทคัดย่อ

***วัตถุประสงค์***: *เพื่อเปรียบเทียบอัตราการเกิดทารกที่มีนำหนักน้อยกว่าอายุครรภ์ (SGA) ทารกที่มีน้ำหนักน้อยกว่า 2,500 กรัม (LBW) และผลของการตั้งครรภ์ ระหว่างหญิงตั้งครรภ์ที่มีน้ำหนักตัวก่อนตั้งครรภ์ต่ำกว่าเกณฑ์ ที่มีน้ำหนักเพิ่มขึ้นระหว่างตั้งครรภ์ต่ำกว่าเกณฑ์และตามเกณฑ์*

***วัสดุและวิธีการ***: *ทำการศึกษาแบบ retrospective cohort study ในหญิงตั้งครรภ์เดี่ยวที่มีน้ำหนักตัวก่อนตั้งครรภ์ต่ำกว่าเกณฑ์ และไม่มีภาวะแทรกซ้อนระหว่างตั้งครรภ์ จำนวน 300 คน โดยแบ่งเป็นกลุ่มศึกษาคือหญิงตั้งครรภ์ที่มีการเพิ่มขึ้นของน้ำหนักตัวระหว่างตั้งครรภ์ต่ำกว่าเกณฑ์ (< 12.5 กิโลกรัม) จำนวน 100 คน และกลุ่มเปรียบเทียบคือหญิงตั้งครรภ์ที่มีการเพิ่มขึ้นของน้ำหนักตัวระหว่างตั้งครรภ์ตามเกณฑ์ (12.5-18 กิโลกรัม) จำนวน 200 คน ทำการสืบค้นข้อมูลจากเวชระเบียน ได้แก่ ข้อมูลพื้นฐานทั่วไป ข้อมูลทางสูติศาสตร์ การฝากครรภ์ น้ำหนักตัวระหว่างการตั้งครรภ์ การคลอด และผลลัพธ์ของการตั้งครรภ์ทั้งในส่วนของมารดาและทารก ทำการเปรียบเทียบอัตราการเกิด SGA LBW และผลของการตั้งครรภ์ ระหว่าง 2 กลุ่ม*

***ผลการศึกษา***: *ทั้ง 2 กลุ่มไม่แตกต่างกันในเรื่องของ อายุ ดัชนีมวลกาย และจำนวนครั้งของการคลอด กลุ่มศึกษามีการเพิ่มขึ้นของน้ำหนักตัวระหว่างตั้งครรภ์และในแต่ละไตรมาสน้อยกว่าอย่างมีนัยสำคัญทางสถิติ กลุ่มศึกษามีอัตราการคลอดก่อนกำหนด ทารกที่น้ำหนักตัวน้อยกว่าอายุครรภ์ LBW และ SGA สูงกว่ากลุ่มเปรียบเทียบอย่างมีนัยสำคัญทางสถิติ (11% และ 2%, p = 0.001; 29% และ 6%, p < 0.001; 18% และ 6.5%, p = 0.002; ตามลำดับ) การวิเคราะห์แบบ Logistic regression analysis พบว่าปัจจัยเสี่ยงต่อการเกิด SGA ได้แก่ การเพิ่มขึ้นของน้ำหนักตัวมารดาในช่วงไตรมาสที่สองไม่เกิน 7 กิโลกรัม (adjusted odds ratio (OR) 9.92, 95% confidence interval (CI) 2.06-47.68, p = 0.004) และปัจจัยเสี่ยงต่อการเกิด LBW ได้แก่ การเพิ่มขึ้นของน้ำหนักตัวระหว่างการตั้งครรภ์ที่ต่ำกว่าเกณฑ์ (adjusted OR 5.82, 95%CI 2.11-16.0, p = 0.001)*

***สรุป***: *ในหญิงที่มีน้ำหนักตัวก่อนตั้งครรภ์ต่ำกว่าเกณฑ์ที่มีน้ำหนักเพิ่มขึ้นระหว่างการตั้งครรภ์ต่ำกว่าเกณฑ์ เพิ่มความเสี่ยงต่อการเกิด ทารกคลอดก่อนกำหนด LBW และ SGA การเพิ่มขึ้นของน้ำหนักตัวในช่วงไตรมาสที่สองไม่เกิน 7 กิโลกรัม เป็นปัจจัยเสี่ยงที่สำคัญต่อการเกิด SGA ส่วนการมีน้ำหนักเพิ่มขึ้นระหว่างการตั้งครรภ์ต่ำกว่าเกณฑ์ เป็นปัจจัยเสี่ยงที่สำคัญต่อการเกิด LBW*

***คำสำคัญ***: *น้ำหนักตัวก่อนตั้งครรภ์ต่ำกว่าเกณฑ์ การเพิ่มขึ้นของน้ำหนักตัวระหว่างตั้งครรภ์ ทารกที่น้ำหนักน้อยกว่าอายุครรภ์ ทารกแรกเกิดน้ำหนักน้อย*

## Introduction

Maternal overweight and obesity have been associated with various pregnancy complications such as gestational diabetes, preeclampsia, large for gestational age (LGA) infants, macrosomia, cesarean delivery, postpartum hemorrhage, etc[1, 2]. On the other hand, underweight pregnant women were also at higher risk for some other complications, including low birth weight (LBW), small for gestational age (SGA), and preterm birth, as reported from many previous studies[1-7].

Gestational weight gain (GWG) is another important determinant for some other adverse outcomes, including SGA, LBW, and preterm birth[5, 8-11]. A systematic review showed that GWG below the recommendations was associated with higher risk of SGA and preterm birth[8]. A recent study reported higher risk of SGA among underweight pregnant women with inadequate GWG[9]. However, a previous study reported that pre-pregnancy body mass index (BMI) independently associated with SGA regardless of GWG[3]. Other reported associated factors for SGA and LBW included maternal smoking, maternal age, maternal anemia, and low socio-economic level[10, 12-14]. Although a few studies in Thailand also reported that pre-pregnancy underweight increased the risk of LBW and preterm birth, rate of SGA was not reported and GWG was not taken into account[15, 16]. A previous study at Siriraj Hospital showed that both pre-pregnancy underweight and inadequate GWG independently associated with SGA[17].

Both SGA and LBW newborns are at higher risk of perinatal short- and long-term morbidity and mortality, such as perinatal asphyxia, poor thermoregulation, hypoglycemia, polycythemia, impaired immune function, stillbirth and neonatal death, and impaired long-term neurodevelopment[18-20].

Currently, there is also limited information regarding this specific issue of GWG among underweight pregnant women and pregnancy outcomes at Siriraj Hospital. Therefore, the objective of this study was to compare the rate of SGA and LBW between underweight pregnant women who had adequate and inadequate GWG. In addition, factors associated with SGA and LBW were evaluated. Understanding the relationship between GWG and adverse outcomes among underweight women could help improving care and minimizing the risk associated with SGA and LBW in the future.

## Materials and Methods

After approval from Siriraj Institutional Review Board, a retrospective cohort study was conducted in 300 singleton, underweight pregnant women (BMI < 18.5 kg/m$^2$) at the Department of Obstetrics and Gynecology, Faculty of Medicine Siriraj Hospital. Sample size was estimated based on a pilot study that showed rate of SGA among underweight pregnant women who gained adequate and inadequate weight were 8% and 20%, respectively. At 95% significance level and 80% power, using 1:2 ratio, at least 96 and 192 women with inadequate and adequate GWG were required. Inclusion criteria were singleton pregnant women who started antenatal care before 14 weeks of gestation and delivered at > 28 weeks of gestation. Exclusion criteria were women with chronic illness (diabetes, heart disease, hypertension, or thyroid disease, etc.), those who received medications such as corticosteriods or chemotherapy, and those with fetal anomalies. Study group consisted of 100 pregnant women with inadequate GWG and another 200 pregnant women with adequate GWG were randomly selected as a comparison group.

Pre-pregnancy BMI was calculated by measured height and weight before 12 weeks of gestation or self-reported pre-pregnancy weight. BMI category and adequacy of GWG were classified according to the Institute of Medicine (IOM) recommendation. Adequate GWG was defined as weight gain of 12.5 - 18 kg and inadequate weight gain was defined as weight gain of < 12.5 kg[21]. Gestational weight gain was calculated by subtracting pre-pregnancy weight from weight at delivery. Trimester-specific weight gain was also evaluated by determining weight differences between pre-pregnancy weight, weight at 14-16 weeks of gestation, weight at 26-28 weeks of gestation, and

weight at delivery.

Data was retrieved from medical records, including demographic data, antenatal care data, labor and delivery data, and pregnancy and neonatal outcomes. The main outcomes of interest were SGA, which was defined as infant birth weight of < 10$^{th}$ percentile for gestational age and LBW, which was defined as infant birth weight of < 2,500 g. Birth weight for gestational age percentiles was evaluated by World Health Organization (WHO) weight percentile calculator based on infant birth weight from the same population[22].

Descriptive statistics, including mean, standard deviation, number, and percentage were used to describe various characteristics as appropriate. Student t-test and chi-square test or Fisher's exact test were used to compare various characteristics between study and comparison groups. Logistic regression analysis was used to determine independent associated factors for SGA and LBW, adjusted for potential confounders. Adjusted odds ratios (OR) and 95% confidence intervals (CI) were estimated. A p value of < 0.05 was considered statistically significant.

## Results

Of 300 underweight pregnant women included in this study, study group were 100 pregnant women with inadequate GWG whereas comparison group were 200 pregnant women with adequate GWG. Table 1 shows the comparison of baseline characteristics between the 2 groups. No significant differences were found in terms of maternal age, BMI, gestational age (GA) at first antenatal care (ANC), and parity. Rate of maternal anemia was slightly higher among cases than controls (20% vs. 14%) but without statistical significance (p = 0.181).

**Table 1.** Comparison of baseline characteristics between the 2 groups.

| Characteristics | Adequate GWG n = 200 mean ± SD | Inadequate GWG n = 100 mean ± SD | p value |
|---|---|---|---|
| Age (years) | 27.6 ± 5.8 | 26.7 ± 6.3 | 0.211 |
| BMI (kg/m$^2$) | 17.2 ± 1.0 | 17.0 ± 1.2 | 0.121 |
| GA at first ANC (weeks) | 9.6 ± 4.2 | 10.1 ± 4.7 | 0.357 |
| | **n (%)** | **n (%)** | |
| Nulliparous | 163 (67%) | 63 (63%) | 0.492 |
| Anemia | 28 (14%) | 20 (20%) | 0.181 |

GWG: gestational weight gain, SD: standard deviation, BMI: body mass index, GA: gestational age, ANC: antenatal care

Comparisons of trimester-specific weight gain between 2 groups are presented in Table 2. Mean GWG and each trimester weight gain (WG) in controls were significantly higher than those of cases (p < 0.001). Cases were also significantly more likely to have first trimester WG ≤ 2 kg (68% vs. 43%, p < 0.001), second trimester WG ≤ 7 kg (88% vs. 51.5%, p < 0.001), and third trimester WG ≤ 5 kg (64% vs. 35%, p < 0.001).

Comparisons of pregnancy outcomes are demonstrated in Table 3, women with inadequate GWG were significantly more likely to have LBW and SGA than those with adequate GWG (29% vs. 6%, p < 0.001, and 18% vs. 6.5%, p = 0.002, respectively). There were no significant differences between the 2 groups with regard to rates of primary cesarean section (CS), preeclampsia, and postpartum hemorrhage (PPH). Mean GA at delivery was significantly lower in cases than controls, but without clinical significance (38.0 ± 1.3 vs. 38.4 ± 0.9 weeks, p = 0.002). However,

cases were significantly more likely to have preterm delivery than controls (11% vs 2%, p = 0.001). In terms of neonatal outcomes, infant birth weight of study group was significantly lower than those of comparison group (2,752 ± 382.0 vs. 3,017 ± 333.8, p < 0.001). In addition, Infants of women in the study group were also more likely to have jaundice that requires phototherapy and hypoglycemia than those of comparison group (17% vs. 9%, p = 0.039, and 2% vs. 0%, p = 0.044, respectively). Both groups were comparable with regard to the rates of birth asphyxia and neonatal intensive care unit (NICU) admission.

**Table 2.** Trimester-specific weight gain between the 2 groups.

| Weight gain | Adequate GWG n = 200 | Inadequate GWG n = 100 | p value |
|---|---|---|---|
| | **mean ± SD** | **mean ± SD** | |
| GWG (kg) | 15.0 ± 1.6 | 10.2 ± 1.9 | < 0.001 |
| **Trimester-specific weight gain** | | | |
| First trimester WG (kg) | 2.5 ± 1.5 | 1.3 ± 2.0 | < 0.001 |
| Second trimester WG (kg) | 6.9 ± 1.7 | 5.1 ± 1.6 | < 0.001 |
| Third trimester WG (kg) | 5.6 ± 1.8 | 3.8 ± 2.1 | < 0.001 |
| **Trimester-specific weight gain with different cutoff** | **n (%)** | **n (%)** | |
| First trimester WG  2 kg | 86 (43%) | 68 (68%) | < 0.001 |
| Second trimester WG ≤ 7 kg | 103 (51.5%) | 88 (88%) | < 0.001 |
| Third trimester WG ≤ 5 kg | 70 (35%) | 64 (64%) | < 0.001 |

GWG: gestational weight gain, SD: standard deviation, WG: weight gain

**Table 3.** Comparison of maternal and neonatal outcomes between the 2 groups.

| Outcomes | Adequate GWG n = 200 | Inadequate GWG n = 100 | p value |
|---|---|---|---|
| Maternal outcomes | | | |
| Mean GA at delivery ± SD (weeks) | 38.4 ± 0.9 | 38.0 ± 1.3 | 0.002 |
| Preterm delivery | 4 (2%) | 11 (11%) | 0.001 |
| Primary C/S | 63 (31.5%) | 21 (21%) | 0.076 |
| Preeclampsia | 6 (3%) | 2 (2%) | 0.612 |
| PPH | 4 (2%) | 3 (3%) | 0.589 |
| Neonatal outcomes | | | |
| Mean birth weight ± SD (grams) | 3,017 ± 333.8 | 2,752 ± 382.0 | < 0.001 |
| LBW | 12 (6%) | 29 (29%) | < 0.001 |
| SGA | 13 (6.5%) | 18 (18%) | 0.002 |
| Apgar < 7 at 1 min | 5 (2.5%) | 4 (4%) | 0.473 |
| Phototherapy | 18 (9%) | 17 (17%) | 0.039 |
| Hypoglycemia | 0 (0%) | 2 (2%) | 0.044 |
| NICU admission | 0 (0%) | 1 (1%) | 0.152 |

GWG: gestational weight gain, GA: gestational age, SD: standard deviation, C/S: cesarean section, PPH: postpartum hemorrhage, LBW: low birth weight, SGA: small-for-gestational age, NICU: neonatal intensive care unit

Logistic regression analysis was performed to determine independent associated factors for SGA and LBW and the results are shown in Table 4 and Table 5. After adjusting for confounding variables, the only independent associated factor of SGA was 2nd trimester weight gain < 7 kg (adjusted OR 9.92, 95%CI 2.06-47.68, p = 0.004), while the independent associated factor for LBW was inadequate GWG (adjusted OR 5.82, 95%CI 2.11-16.0, p = 0.001).

**Table 4.** Logistic regression analysis to determine independent associated factors for SGA.

| Variables | Adjusted OR (95%CI) | p value |
|---|---|---|
| Maternal age 20 - 34 years | 1.0 | |
| Maternal age < 20 years | 0.80 (0.21-3.09) | 0.744 |
| Maternal age ≥ 35 years | 0.91 (0.27-2.98) | 0.869 |
| Multiparous | 0.78 (0.32-1.93) | 0.592 |
| 1st trimester weight gain ≤ 2 kg | 2.29 (0.89-5.89) | 0.087 |
| 2nd trimester weight gain ≤ 7 kg | 9.92 (2.06-47.68) | 0.004 |
| 3rd trimester weight gain ≤ 5 kg | 2.04 (0.75-5.55) | 0.163 |
| Inadequate GWG | 1.12 (0.41-3.10) | 0.823 |
| Anemia | 0.35 (0.08-1.60) | 0.175 |

SGA: small-for-gestational age, OR: odds ratio, CI: confidence interval, GWG: gestational weight gain

**Table 5.** Logistic regression analysis to determine independent associated factors for LBW.

| Variables | Adjusted OR (95%CI) | p value |
|---|---|---|
| Maternal age 20 - 34 years | 1.0 | |
| Maternal age < 20 years | 0.86 (0.27-2.72) | 0.795 |
| Maternal age ≥ 35 years | 0.43 (0.12-1.56) | 0.200 |
| Multiparous | 0.44 (0.18-1.07) | 0.069 |
| 1st trimester weight gain ≤ 2 kg | 1.49 (0.63-3.52) | 0.365 |
| 2nd trimester weight gain ≤ 7 kg | 1.02 (0.37-2.79) | 0.970 |
| 3rd trimester weight gain ≤ 5 kg | 1.14 (0.47-2.75) | 0.771 |
| Inadequate GWG | 5.82 (2.11-16.0) | 0.001 |
| Anemia | 0.69 (0.25-1.88) | 0.469 |

LBW: low birth weight, OR: odds ratio, CI: confidence interval, GWG: gestational weight gain

# Discussion

Underweight pregnant woman has been reported to increase risk of adverse pregnancy outcomes, including SGA[1-5], LBW[1, 2, 4, 15, 16], and preterm birth[1-4, 15, 16]. However, GWG should also be considered as another important determinant of such adverse outcomes, especially among these high-risk women.

The results of this study demonstrated that among underweight pregnant women, GWG below IOM recommendation increased the risks of SGA, LBW and preterm delivery compared to those with normal GWG. This was similar to what has been reported by many

previous studies. A previous systematic review of over 1 million pregnant women reported that GWG less than IOM recommendation significantly increased the risk of SGA and preterm delivery[8]. Other previous studies also reported that inadequate GWG increased the risk of SGA and LBW, regardless of pre-pregnancy BMI[3, 5]. However, the results of a recent systematic review supported the findings of this study that although no significant association between maternal pre-pregnancy BMI and SGA were observed, risk of SGA significantly increased among underweight women with inadequate GWG[9].

After adjusting for potential confounders, multivariate analyses demonstrated that second trimester weight gain of ≤ 7 kg independently increased risk of SGA by almost 10 folds. This was similar to previous studies which also reported that in the second trimester, insufficient weight gain was associated with SGA[23, 24] and LBW[10]. On the other hand, only inadequate GWG independently increased risk of LBW by almost 6 folds. This was comparable to the results of a previous systematic review which reported that inadequate GWG was associated with increased risks of LBW, in both developing and developed countries[25]. However, low weekly weight gain was associated with preterm birth, but not LBW[25].

Both SGA and LBW have been shown to increase various neonatal morbidities and mortality, such as stillbirth, hypoxic composite neonatal morbidity, and impaired childhood neurodevelopment, etc[18, 20, 26]. Therefore, understanding associated risk factors could help improve awareness for better surveillance and early identification which lead to appropriate management to improve neonatal outcomes. Not only being underweight increased the risks of adverse neonatal outcomes, the results of this study also signified the importance of GWG during pregnancy, especially during second trimester. According to the IOM recommendation, recommended weekly weight gain during the second and third trimester among underweight pregnant women should be 0.51 kg (0.44-0.58 kg)[21].

The exact mechanisms underlying the relationship between inadequate GWG and adverse pregnancy outcomes are still not known. However, this could probably be related to inadequate maternal nutritional status or nutritional transfer to the fetus. The effects might be more pronounced among underweight women. This should be further investigated and explored in future studies.

On the other end, gaining weight above recommendation has been reported to be associated with adverse outcomes in every pre-pregnancy BMI category, including LGA, macrosomia, and cesarean delivery[8, 11, 17]. In addition, lower rates of SGA and preterm birth have been reported among women who gained weight above recommendation from a systematic review[8]. However, currently there is still no recommendation for underweight women to gain more weight than recommended range to reduce adverse outcomes. Further evaluations are needed to determine appropriate weight gain ranges for each population.

Some limitations should be mentioned. Pre-pregnancy weight was obtained by self-report which might be inaccurate that there might be some misclassifications of BMI category. There might be some errors in obtaining trimester-specific weight gain due to differences in antenatal care schedule. However, such variations should not significantly alter the results. Generalization of the results might also be limited since the study was conducted in a single tertiary care hospital. Birth weight percentile was estimated based on the population of the hospital, which might not be representative of general population. For multiparous women, information on previous adverse pregnancy outcomes as well as changes in BMI after previous deliveries were not available and, therefore, were not taken into account in the analysis. The strength of the study may include the information on trimester-specific weight gain and it was taken into account in the analysis. Potential confounders were taken care of by multivariate analysis that independent associated factors were identified.

Being underweight and inadequate weight gain might only be a proxy to inadequate nutritional status. Actual nutritional status could not be evaluated in this study and more in-depth studies on this issue are needed to assess the relationship with adverse outcomes. Nonetheless, the results of this study could

be applied into clinical practice to improve care of underweight pregnant women. These at-risk women should be counseled and advised regarding appropriate and adequate nutrition during pregnancy. Weight gain monitoring is needed, especially during second trimester. Underweight pregnant women with inadequate weight gain should be further monitored closely for fetal growth and appropriate management should be provided in a timely manner.

## Conclusion

In conclusion, being underweight independently increased the risk of LBW, while inadequate GWG independently increased risk of SGA among underweight pregnant women. Appropriate nutritional counseling should be provided and weight gain monitoring are needed. Keeping weight gain of these at-risk women could possibly help minimizing the risk of adverse outcomes.

## Potential conflicts of interest

The authors declare no conflicts of interest.

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