# Pregnancy outcome according to gestational weight gain on the basis of 2009 Institute of medicine(IOM) recommendations

Eun Joo Lee

Department of Medicine

The Graduate School, Yonsei University

# Pregnancy outcome according to gestational weight gain on the basis of 2009 Institute of medicine(IOM) recommendations

Eun Joo Lee

Department of Medicine

The Graduate School, Yonsei University

# Pregnancy outcome according to gestational weight gain on the basis of 2009 Institute of medicine(IOM) recommendations

Directed by Professor Yong Won Park

The master's Thesis

submitted to the Department of Medicine ,

The Graduate School, Yonsei University

in partial fulfillment of the requirement for the degree

of master of medical science

Eun Joo Lee

June 2010

This certifies that the Master's Thesis
of Eun Joo Lee is approved.

---

Thesis Supervisor : Yong Won Park

---

Thesis Committee Member#1 : Ja-Young Kwon

---

Thesis Committee Member#2 : Chung Mo Nam

The Graduate School
Yonsei University

June 2010

# Acknowledgements

본 논문이 완성되기까지 각별한 노고와 관심을 아끼지 않으시고 지도해 주신 박용원 교수님께 진심으로 감사를 드리며, 지도 편달을 아끼지 않으신 권자영 교수님, 남정모 교수님께 깊은 감사를 드립니다.
또한 무한한 사랑과 격려로 이끌어주신 여러 교수님들과 너무나도 소중한 저의 가족들께 이 논문을 바칩니다.

저자 씀

# Table of contents

ABSTRACT····· 1

I. INTRODUCTION····· 4

II. MATERIALS AND METHOD ····· 6

III. RESULTS ····· 8

IV. DISCUSSION····· 15

V. CONCLUSION ····· 17

REFERENCES····· 19

ABSTRACT(IN KOREAN)····· 23

# List of figures

Figure 1. Coefficient of birth weight according to gestational weight gain ·····8

Figure 2. Number of pregnant women to visit on each gestational week ·····9

# List of tables

Table 1. Maternal characteristics ·····10

Table 2. Maternal outcomes ·····11

Table 3. Neonatal outcomes·····12

Table 4. Multivariate logistic regression of maternal outcomes ·····13

Table 5. Multiple regression analysis and multivariate logistic regression of neonatal outcomes ·····14

## Abstract

# Pregnancy outcome according to gestational weight gain on the basis of the 2009 IOM recommendations

Eun Joo Lee

*Department of Medicine*
*The Graduate School, Yonsei University*

(Directed by Professor Yong Won Park)

Objectives: The aim of this study was to quantify the relationship between weekly maternal weight gain during pregnancy and birth weight. We also evaluated the effects of gestational weight gain on both maternal and neonatal outcomes using pre-pregnancy BMI and the 2009 IOM recommendations.

Methods: A retrospective cohort study was conducted. Study population consisting of 3,426 singleton pregnancies delivered at Yonsei University Health System in Seoul, Korea from January 1, 2006 through December 31, 2009. Subject women were grouped into four BMI categories: underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), and obese (≥30). Gestational weight gain was categorized as "Less" if it

was below the IOM recommended range for pre-pregnancy BMI, “Within” if it was within this range, and “More” if it was above the set range.

Results: Maternal weight gain between 30 to 40 gestational weeks having the greatest effect on birth weight. "More" weight gain group had increased odds of pregnancy induced hypertension (PIH) and gestational diabetes mellitus (GDM). Especially, overweight and obese women with excessive weight gains had significantly increased odds of PIH (overweight: OR, 1.66; 95% CI: 1.15-2.43, obesity: OR, 2.14; 95% CI: 1.10-3.87) and GDM(overweight: OR, 1.94; 95% CI: 1.63-3.52, obesity: OR, 4.0; 95% CI: 2.46-9.54).
Underweight women with “Less” or “Within” maternal weight gain groups had significantly increased odds of delivering an infant with SGA (Less: OR, 1.82; 95% CI: 1.28-2.58, Within: OR, 1.57; 95% CI: 1.08-2.27 ) and "More" weight gain group had significantly increased odds of delivering an infant with LGA (normal weight: OR, 1.74; 95% CI: 1.31-2.31, overweight: OR, 3.53; 95% CI: 2.31-5.38, obesity: OR, 2.75; 95% CI: 1.59-4.72).

Conclusions: During the period between 30 to 40 gestational weeks, maternal gestational weight gain has the largest influence on birth weight. Overweight and obese women with excessive gestational weight gain had a significantly increased risk of adverse pregnancy outcome.

Therefore, physicians should not only monitor pre-pregnancy BMI but also maternal weight gain.

---

Keywords: gestational weight gain, birth weight, pregnancy outcome

**Pregnancy outcome according to gestational weight gain on the basis of the 2009 IOM recommendations**

Eun Joo Lee

*Department of Medicine*
*The Graduate School, Yonsei University*

(Directed by Professor Yong Won Park)

## I. INTRODUCTION

Birth weight is an important indicator of infant survival and childhood morbidity [1] and now also appears to be associated with future risk of type 2 diabetes, hypertension, cardiovascular disease, and other disorders [2, 3]. However, little is known about the effects of weight change during pregnancy and the influence of gestational weight gain on maternal and perinatal outcomes when stratified by maternal pre-pregnancy BMI. Previous studies have generally found that fetal birth weight is only affected by maternal weight gains during the second [4, 7] or the second and third trimesters [5, 6, 8, 9]. There was little relationship has been found between weight gains during the first trimester and birth weight [4-6].

In 1990, the Institute of Medicine (IOM) established recommendations for weight gain during pregnancy based on body mass index (BMI) [10]. More recently, in May 2009, the IOM reexamined the evidence concerning the relationships between maternal weight gains occurring before, during, and after pregnancy and maternal–child health outcomes which includes maternal postpartum weight retention and childhood obesity [11]. Unlike the 1990 guidelines, the new 2009 IOM recommendations provide upper weight gain limits for obese women using established adult BMI cutoffs [12, 13]. Per these recommendations, underweight women (BMI<18.5) should gain 12.5-18.0 kg during pregnancy, normal weight women (BMI 18.5-24.9) 11.5-16.0 kg, overweight women (BMI 25.0-29.9) 7.0-11.5 kg, and obese women (BMI ≥30.0) 5.0-9.0 kg. Weight loss or weight maintenance during pregnancy is not recommended by the IOM.

Gaining weight outside of the recommendation ranges can result in poorer birth outcomes due to increased maternal and fetal complications [14]. Excessive weight gain is now known to be associated with an increased risk of cesarean section and macrosomia, while inadequate maternal weight gain can result in small for gestational age (SGA) infants and preterm births [15].

According to previous studies, pre-pregnancy obesity is an independent risk factor for many adverse outcomes, including gestational diabetes, preeclampsia, cesarean delivery, macrosomia, stillbirth, and increased medical care [16-22]. Among pregnant women in the Unites States, the prevalence of overweight and obesity (defined as a pre-pregnancy BMI > 26) has almost doubled in the last 20 years, from 24% in 1983 to 45% in 2007, with almost one half of pregnant women in the United States now beginning pregnancy as either overweight or obese [23].

Studying the relationship between pregnancy outcome and gestational weight gain is important, as gestational weight gain can be controlled through proper

counseling and monitored with planning during pregnancy. Previous studies have explored the linear relationships between the rates of maternal weight gain during different trimesters and birth weight. The reported most sensitive trimester of maternal weight gain with respect to impact on fetal growth has ranged throughout pregnancy. However, there was no study to investigate the association between weekly maternal weight gain and birth weight.

The objective of this study was to quantify the relationship between weekly maternal gestational weight gain and birth weight. We also evaluated the effects of pregnancy weight gain on maternal and neonatal outcomes using pre-pregnancy BMI on the basis of 2009 IOM recommendations.

## II. MATERIALS AND METHOD

A retrospective cohort study was conducted. Study population consisting of 3,426 singleton pregnancies delivered at Yonsei University Health System in Seoul, Korea from January 1, 2006 through December 31, 2009. Information regarding maternal height, maternal pre-pregnancy weight and gestational weight gain was available for all subjects.

To create a homogenous study population, we excluded women younger than 18 years and older than 40 years, neonates delivered at less than 34 gestational weeks or more than 42 gestational weeks, congenitally malformed neonates, and women with chronic medico-surgical illness such as chronic diabetes and chronic hypertension, as these individuals were more likely to experience adverse pregnancy outcomes unrelated to gestational weight gain [24, 25]. In addition, we excluded women whose pre-pregnancy BMI, gestational weight change and newborn's birth weight were not known or recorded. Gestational age was estimated using the infant's date of birth and the mother's last normal menstrual period (LNMP). If the LNMP was missing or inaccurate, a clinical estimate of gestational age was used. All gestational weight changes (weight

loss, maintenance, and gain) were calculated by subtracting the pre-pregnancy weight from the maternal weight at the time of visit. BMIs (kg/m2) were calculated from the self-reported maternal weight and height data. Women were grouped into four categories of BMI: underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), and obese (≥30). Small-for-gestational age (SGA) infants were defined as <10th percentile, and large-for-gestational age (LGA) infants were defined as >90th percentile. Gestational weight gain was categorized as "Less" if it was below the IOM recommended range for pre-pregnancy BMI, "Within" if it was within the range, and "More" if it was above the range.

Maternal characteristics including maternal age, parity, BMI, marital status, length of gestation, and total gestational weight gain were stratified by BMI group. To evaluate weekly gestational weight gains, maternal weight was measured at each antenatal visit. Maternal outcomes evaluated were primary cesarean section, gestational diabetes, pregnancy induced hypertension, and preterm delivery (defined as delivery before 37 weeks). Neonatal outcomes evaluated were birth weight, SGA, LGA, APGAR scores at 5 minutes, and NICU admission. Because previous cesarean delivery has been shown to be predictive of subsequent cesarean deliveries, only primary cesarean deliveries were considered to be relevant maternal outcomes. All outcomes were tracked using the ten International Classification of Diseases (ICD) coding levels.

The resulting data were analyzed using ANOVA, the Chi-square test, multiple linear regression analysis and multiple logistic regression analysis. Statistical significance was defined at a P-value of <0.05. All statistical analyses were performed using SAS (version 9.1; *SAS* Institute *Inc*., Cary, NC, USA).

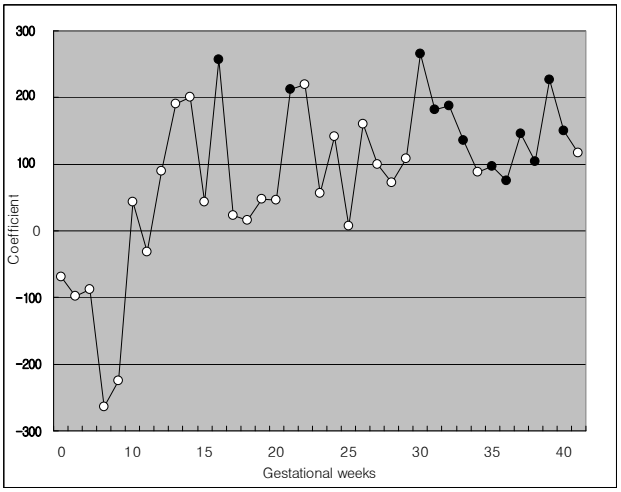
## III. RESULTS

### 1. Weekly gestational weight gain and birth weight

To further evaluate the relationship between maternal weekly weight gain during pregnancy and newborn birth weight, we analyzed the data using the coefficients. Specifically, the coefficient was defined as the change in newborn weight (in grams) per kilogram of maternal weight gain, and the results are summarized in **Figure 1.**

**Figure 1.**

**Coefficients of birth weight according to weekly gestational weight gain**

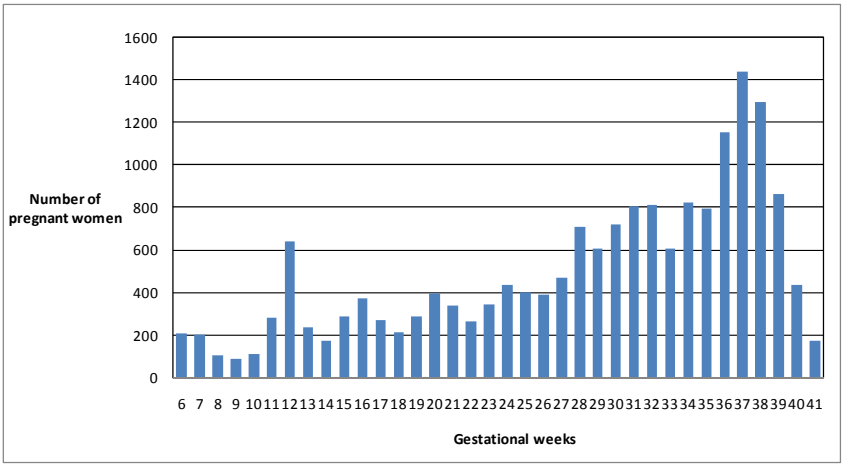



The statistically significant coefficients are represented by solid dots, and non-significant coefficients are represented by empty dots.

These data indicate that maternal weight gains after mid-trimester are significantly related to birth weight. In particular, maternal weight gains between 30 to 40 gestational weeks have the greatest effect on neonatal birth weight.

To evaluate weekly gestational weight gains, maternal weight was measured at each antenatal visit. Number of pregnant women to visit on each gestational week was described in **Figure 2.**

**Figure 2.**
Number of pregnant women to visit on each gestational week




As gestational weeks went on, the intervals of routine antenatal visit were shorter, therefore we could check the more pregnant women's body weight.

## 2. **Pregnancy outcome according to gestational weight gain**

Maternal characteristics according to pregnancy BMI category and IOM recommendation grouping are summarized in **Table 1**.

**Table 1. Maternal characteristics**

| | N | Age(Y) | BMI ($kg/m^2$) | Nulli parity (%) | Smoker (%) | Married (%) | Length of gestation (wks) | GWG (kg) |
|---|---|---|---|---|---|---|---|---|
| **BMI<18.5 (N=502)** | | | | | | | | |
| Less GWG | 237 | 30.8±3.6 | 17.5±0.8 | 62.9 | 0 | 99.2 | 37.5±3.1 | 10.0±2.2 |
| Within GWG | 222 | 31.0±3.6 | 17.5±1.4 | 66.2 | 0 | 100 | 38.6±1.9 | 14.9±1.6 |
| More GWG | 43 | 30.7±3.5 | 17.4±0.9 | 67.4 | 0 | 100 | 38.6±1.8 | 22.6±7.1 |
| **BMI:18.5-24.9 (N=2538)** | | | | | | | | |
| Less GWG | 885 | 32.0±3.9 | 21.2±1.7 | 51.7 | 0 | 99.7 | 37.3±3.2 | 8.9±2.0 |
| Within GWG | 1103 | 31.7±3.8 | 21.0±1.6 | 56.6 | 0 | 100 | 38.3±2.0 | 13.9±1.4 |
| More GWG | 547 | 31.3±3.8 | 21.1±1.7 | 64.5 | 0 | 100 | 38.5±1.8 | 19.8±3.4 |
| **BMI:25.0-29.9 (N=268)** | | | | | | | | |
| Less GWG | 35 | 33.1±3.7 | 27.1±1.5 | 42.9 | 0 | 100 | 36.2±3.9 | 3.4±3.3 |
| Within GWG | 108 | 32.7±4.2 | 26.8±1.4 | 39.8 | 0 | 98.1 | 37.8±2.4 | 9.4±1.3 |
| More GWG | 124 | 31.7±4.4 | 26.8±1.2 | 51.6 | 0 | 100 | 37.6±2.8 | 15.7±3.3 |
| **BMI≥30.0 (N=122)** | | | | | | | | |
| Less GWG | 12 | 31.3±3.6 | 34.9±5.2 | 50.0 | 0 | 100 | 35.6±5.6 | 2.5±1.0 |
| Within GWG | 34 | 32.8±6.0 | 31.7±1.6 | 64.7 | 0 | 100 | 37.5±2.4 | 6.8±1.4 |
| More GWG | 76 | 30.4±4.6 | 35.0±3.2 | 56.8 | 1.32 | 98.7 | 37.2±2.1 | 14.7±5.0 |

BMI: Body mass index

GWG: Gestational weight gain

With the exceptions of BMI and gestational weight gain, no other significant differences were found among the 12 groups.

Data regarding maternal and neonatal outcomes stratified by pre-pregnancy BMI category and IOM recommendation grouping are described in **Table 2 and Table 3.**

**Table 2. Maternal outcomes**

| | Primary C/S (%) | Preterm delivery <37wks (%) | PIH (%) | GDM (%) |
|---|---|---|---|---|
| **BMI<18.5 (N=502)** | | | | |
| Less GWG | 43.1 | 12.3 | 3.4 | 1.7 |
| Within GWG | 34.2 | 21.9 | 2.7 | 1.4 |
| More GWG | 34.8 | 11.6 | 7.0 | 4.7 |
| **BMI:18.5-24.9 (N=2538)** | | | | |
| Less GWG | 30.2 | 14.0 | 4.6 | 1.1 |
| Within GWG | 44.2 | 15.0 | 5.0 | 2.1 |
| More GWG | 45.5 | 11.3 | 8.8 | 3.8 |
| **BMI:25.0-29.9 (N=268)** | | | | |
| Less GWG | 64.7 | 34.3 | 5.7 | 2.9 |
| Within GWG | 55.6 | 19.4 | 7.4 | 7.4 |
| More GWG | 58.1 | 20.2 | 8.1 | 4.0 |
| **BMI≥30.0 (N=122)** | | | | |
| Less GWG | 83.3 | 50.0 | 8.3 | 8.3 |
| Within GWG | 64.7 | 29.4 | 11.8 | 8.8 |
| More GWG | 78.9 | 31.6 | 10.2 | 7.9 |

C/S: Cesarean section

PIH: Pregnancy induced hypertension

GDM: Gestational diabetes mellitus

GWG: Gestational weight gain

**Table 3. Neonatal outcomes**

| | Birth weight(g) | 5 min Apgar <7 (%) | SGA(%) | LGA(%) | NICU (%) |
|---|---|---|---|---|---|
| **BMI<18.5 (N=502)** | | | | | |
| Less GWG | 2778.0±554.5 | 5.1 | 22.8 | 5.1 | 16.9 |
| Within GWG | 2829.0±676.5 | 2.7 | 20.3 | 7.7 | 11.3 |
| More GWG | 3121.9±487.2 | 4.7 | 12.2 | 9.3 | 11.6 |
| **BMI:18.5-24.9 (N=2538)** | | | | | |
| Less GWG | 2939.6±544.1 | 2.3 | 16.3 | 14.0 | 16.0 |
| Within GWG | 2980.6±708.2 | 2.1 | 14.0 | 11.5 | 11.1 |
| More GWG | 3251.2±556.3 | 2.9 | 8.8 | 18.5 | 10.6 |
| **BMI:25.0-29.9 (N=268)** | | | | | |
| Less GWG | 2727.5±895.4 | 2.8 | 17.1 | 17.1 | 20.0 |
| Within GWG | 3148.7±625.7 | 2.5 | 7.5 | 18.5 | 16.7 |
| More GWG | 3172.6±836.7 | 4.0 | 11.5 | 30.6 | 16.1 |
| **BMI≥30.0 (N=122)** | | | | | |
| Less GWG | 3215.7±1261.1 | 8.3 | 8.3 | 41.7 | 33.3 |
| Within GWG | 3175.1±551.8 | 5.9 | 2.9 | 26.5 | 17.6 |
| More GWG | 3299.3±835.4 | 7.9 | 5.3 | 23.7 | 17.1 |

SGA: Small for gestational age

LGA: Large for gestational age

NICU: Neonatal intensive care unit

Data from a multivariate logistic regression analysis of maternal outcomes resulting adjusted odds ratio with 95% confidence intervals are summarized in **Table 4**.

Compared with the normal BMI group, women in the underweight group had significantly decreased odds of primary cesarean section, while women in the overweight and obesity groups had significantly increased odds. Preterm delivery rate is higher in all obese group. Furthermore, with the exception of the underweight group, all women in the "More" weight gain group had increased odds of pregnancy induced hypertension (PIH) and gestational diabetes mellitus (GDM). Especially, overweight and obese women with excessive weight gains had significantly increased odds of PIH (Overweight: OR, 1.66; 95% CI: 1.15-

2.43, Obesity: OR, 2.14; 95% CI: 1.10-3.87) and GDM(Overweight: OR, 1.94; 95% CI: 1.63-3.52, obesity: OR, 4.0; 95% CI: 2.46-9.54).

**Table 4. Multivariate logistic regression of maternal outcomes**

| | **Primary C/S (%)** | **Preterm delivery <37wks (%)** | **PIH (%)** | **GDM (%)** |
|---|---|---|---|---|
| | Adjusted odds Ratio (95% Confidence Interval) | | | |
| **BMI<18.5 (N=502)** | | | | |
| Less GWG | 0.96 (0.80-1.15) | 0.79 (0.52-1.21) | 0.66* (0.35-0.97) | 0.81 (0.55-1.12) |
| Within GWG | 0.66** (0.49-0.89) | 1.61* (1.13-2.30) | 0.52* (0.25-0.87) | 0.66* (0.34-0.97) |
| More GWG | 0.68* (0.50-0.93) | 0.75 (0.29-1.93) | 1.42 (0.75-1.94) | 2.30 (0.93-3.52) |
| **BMI:18.5-24.9 (N=2538)** | | | | |
| Less GWG | 0.55 (0.28-1.06) | 0.93 (0.72-1.19) | 0.91 (0.48-1.50) | 0.52 (0.30-0.88) |
| Within GWG | Reference | Reference | Reference | Reference |
| More GWG | 1.05 (0.85-1.31) | 0.71* (0.52-0.97) | 1.82** (1.31-2.36) | 1.84** (1.40-2.24) |
| **BMI:25.0-29.9 (N=268)** | | | | |
| Less GWG | 2.14* (1.04-4.41) | 2.97** (1.45-6.08) | 1.14 (0.96-1.44) | 1.39 (0.85-1.77) |
| Within GWG | 1.53* (1.02-2.29) | 1.37 (0.83-2.27) | 1.51 (0.94-0.57) | 3.72** (1.85-4.99) |
| More GWG | 1.64* (1.12-2.41) | 1.44 (0.90-2.29) | 1.66* (1.15-2.43) | 1.94** (1.63-3.52) |
| **BMI≥30.0 (N=122)** | | | | |
| Less GWG | 5.92 (0.68-9.33) | 5.68** (1.81-17.84) | 1.71** (1.45-2.16) | 4.22 (0.85-7.33) |
| Within GWG | 2.31* (1.13-4.71) | 2.37* (1.11-5.04) | 3.52** (2.02-5..57) | 4.14* (1.18-14.47) |
| More GWG | 4.07*** (1.83-9.05) | 2.62** (1.57-4.37) | 2.14* (1.10-3.87) | 4.0*** (2.46-9.54) |

* p<0.05, ** p<0.01, *** p<0.001

**Table 5. Multiple regression analysis and multivariate logistic regression of neonatal outcomes**

| | Birth weight | 5 min Apgar <7 (%) | SGA(%) | LGA(%) | NICU (%) |
|---|---|---|---|---|---|
| | Coefficient (standard error) | Adjusted odds Ratio (95% Confidence Interval) | | | |
| **BMI<18.5 (N=502)** | | | | | |
| Less GWG | -202.6** (28.0) | 2.50* (1.23-5.11) | 1.82* (1.28-2.58) | 0.41** (0.22-0.75) | 1.63* (1.11-2.41) |
| Within GWG | -151.6* (45.5) | 1.44 (0.58-3.58) | 1.57* (1.08-2.27) | 0.60 (0.35-1.03) | 1.02 (0.65-1.61) |
| More GWG | 141.3* (46.6) | 2.29 (0.52-10.04) | 0.87 (0.55-1.36) | 0.79 (0.28-2.24) | 1.06 (0.41-2.74) |
| **BMI:18.5-24.9 (N=2538)** | | | | | |
| Less GWG | -41.0 (26.7) | 1.09 (0.59-1.99) | 1.24 (0.54-2.84) | 1.25 (0.96-1.63) | 1.65* (1.18-1.99) |
| Within GWG | Reference | Reference | Reference | Reference | Reference |
| More GWG | 270.6** (108.3) | 1.41 (0.74-2.70) | 0.59** (0.42-0.83) | 1.74* (1.31-2.31) | 0.95 (0.69-1.33) |
| **BMI:25.0-29.9 (N=268)** | | | | | |
| Less GWG | -253.1* (108.3) | 1.38 (0.18-0.53) | 1.15 (0.45-2.90) | 1.59 (0.65-3.90) | 2.01 (0.86-4.70) |
| Within GWG | 168.1 (63.4) | 1.34 (0.40-4.54) | 0.50 (0.24-1.05) | 1.75* (1.04-2.94) | 1.61 (0.94-2.76) |
| More GWG | 192.0* (59.7) | 2.37 (0.88-6.37) | 0.70 (0.38-1.28) | 3.53*** (2.31-5.38) | 1.55 (0.92-2.59) |
| **BMI≥30.0 (N=122)** | | | | | |
| Less GWG | 235.1 (253.7) | 4.27 (0.53-34.46) | 0.56 (0.07-4.37) | 5.49** (1.72-17.55) | 4.02* (1.19-13.55) |
| Within GWG | 194.5 (156.9) | 2.93 (0.66-12.98) | 0.19 (0.03-1.38) | 2.77** (1.26-6.06) | 1.72 (0.70-4.24) |
| More GWG | 318.7** (103.5) | 4.02** (1.59-10.21) | 0.34* (0.12-0.95) | 2.75** (1.59-4.72) | 1.66 (0.89-3.10) |

* p<0.05, ** p<0.01, *** p<0.001

**Table 5.** shows that women with an initial BMI<18.5 with “Less” or “Within” maternal weight gain groups had significantly increased odds of delivering an infant with SGA (Less: OR, 1.82; 95% CI: 1.28-2.58, Within: OR, 1.57; 95% CI: 1.08-2.27 ). Additionally, with the exception of the underweight group, all women in the "More" weight gain group had significantly increased odds of delivering an infant with LGA (normal weight: OR, 1.74; 95% CI: 1.31-2.31, overweight: OR, 3.53; 95% CI: 2.31-5.38, obesity: OR, 2.75; 95% CI: 1.59-4.72). Two extreme groups (BMI<18.5 with “Less” weight gain group and BMI≥30 with “More” weight gain group)had increased odds of every bad neonatal outcomes

All covariates were chosen *a priori* based on existing literature, and all models were adjusted for maternal age, marital status, smoking, parity, gestational age, PIH and GDM.

## IV. DISCUSSION

We found that changes in maternal weight during the third trimester of pregnancy have a more profound influence on newborn size than do weight changes in either of the earlier trimesters. And it is consistent with the period of physiologic fetal weight gain. In our study, the coefficients of birth weight according to weekly gestational weight gain show positive value except first trimester. These results are in agreement with previous studies of gestational weight gain by trimester. However the number of visited pregnant women has rapidly increased after 28 gestational weeks, so maternal weight gains between 30 to 40 gestational weeks have the greatest statistical power on neonatal birth weight.

Past studies much attention has been given to increasing birth weight, which is positively correlated to maternal weight gain during pregnancy. Previous

studies indicate that low maternal weight gain is a common risk factor for infants with SGA and spontaneous preterm deliveries [26,27].

However, while relatively large maternal weight gains decrease the incidence of infants with low birth weights, excessive weight gains may result in adverse sequelae for both the mother and fetus. In recent studies, women who gain large amounts of weight during pregnancy may suffer complications during pregnancy and delivery and may increase the neonate's risk of obesity later in life [28-30].

We also found that overweight and obese women with excessive pregnancy weight gains did face a significantly greater risk of adverse pregnancy outcomes.

A point to be considered is the prevalence of overweight and obesity in Asia is lower than America and Europe. Therefore we could detect compositional differences between study groups as compared to Western studies. In 2000, the World Health Organization (WHO) established different BMI ranges for the Asia-Pacific region pertaining to risk factor and morbidity predictions. In Asians, the BMIs at which an individual is considered overweight (≥ 23.0 kg/m2) and obese (≥25.0 kg/$m^2$) are less than those of the traditional WHO criteria. [31,32]. However, the 2009 IOM recommendations suggest that weight gain ranges for short women and for racial or ethnic groups are the same as those for the whole population. And currently, there are no other guidelines regarding recommended weight gain during pregnancy that are specifically tailored to Asian women. In addition, the prevalence of obesity in Korea has recently been rapidly increasing as a result of poor diets and physical inactivity. Based on the national health and nutrition surveys, the prevalences of obesity in Korea were 26.3% in 1998, 30.6% in 2001, and 31.8% in 2005. Therefore, overweight and obese women in Korea also will need preconception counseling, which may include plans for weight control and understand new guidelines.

Because many pregnancies are still unplanned, women who are either underweight or obese at the time of conception may not have the time to normalize their BMI. Consequently, it is very important for physicians to suggest methods to reduce the risk of adverse maternal and neonatal outcomes, and such women should be closely monitored and followed.

To our knowledge, our study is the first study to quantify maternal weekly weight gain and birth weight throughout pregnancy not by trimester. . Furthermore, we are also the first report to compare maternal and neonatal outcomes among 12 groups subcategorized by pre-pregnancy BMI and gestational weight gain per the 2009 IOM recommendations. In addition, we have completed one of the largest and latest, single center cohort studies with a homogenous population of single-ethnicity. Besides, this schematic allowed for the ability to control for multiple potential confounders such as maternal age, marital status, smoking, parity, gestational age and PIH and GDM..

However, our study have some limitations. In this retrospective study, pre-pregnancy BMI was determined exclusively by self-reported pre-pregnancy weight. Because overweight women may underestimate their body weight [33], these individuals may have been advised to gain more weight than would be actually recommended. We acknowledge that several other essential confounders, including dietary behaviors and physical activities of the women, could have influenced our results, and thus our findings may not be entirely generalizable to other ethnicities.

## V. CONCLUSIONS

In conclusion, during the period between 30 to 40 gestational weeks, maternal gestational weight gain has the largest influence on neonate birth weight. Overweight and obese women with excessive gestational weight gains had a significantly increased risk of adverse pregnancy outcomes.

Therefore, we recommend that physicians monitor not only pre-pregnancy BMI but also maternal weight gain throughout pregnancy. Further large prospective study is needed to confirm such relationships between maternal weight gain and pregnancy outcome.

**References**

1. McCormick MC. The contribution of low birth weight to infant mortality and childhood morbidity. N Engl J Med 1985;312:82-90.

2. Mi J, Law C, Zhang KL, Osmond C, Stein C, Barker D. Effects of infant birthweight and maternal body mass index in pregnancy on components of the insulin resistance syndrome in China. Ann Intern Med 2000;132:253-60.

3. Godfrey KM. Maternal regulation of fetal development and health in adult life. Eur J Obstet Gynecol Reprod Biol 1998;78:141-50.

4. Hickey CA, Cliver SP, McNeal SF, Hoffman HJ, Goldenberg RL. Prenatal weight gain patterns and birth weight among nonobese black and white women. Obstet Gynecol 1996;88:490-6.

5. Strauss RS, Dietz WH. Low maternal weight gain in the second or third trimester increases the risk for intrauterine growth retardation. J Nutr 1999;129:988-93.

6. Villar J, Belizan JM. The timing factor in the pathophysiology of the intrauterine growth retardation syndrome. Obstet Gynecol Surv 1982;37:499-506.

7. Li R, Haas JD, Habicht J-P. Timing of the influence of maternal nutritional status during pregnancy on fetal growth. Am J Hum Biol 1998;10:529-39.

8. Scholl TO, Hediger ML, Ances IG, Belsky DH, Salmon RW. Weight gain during pregnancy in adolescence: predictive ability of early weight gain. Obstet Gynecol 1990;75:948-53.

9. Abrams B, Selvin S. Maternal weight gain pattern and birth weight. Obstet Gynecol 1995;86:163-9.

10. Olsen O, Aaroe Clausen J: Routine ultrasound dating has not been shown to be more accurate than the calendar method. Br J Obstet Gynaecol 1997, 104(11):1221-2.

11. Institute of Medicine. Weight gain during pregnancy. Reexamining the guidelines. Prepublication copy: uncorrected proofs. Washington, DC: National Academy Press; 2009.

12. Institute of Medicine. Nutrition During Pregnancy: Part I: Weight gain, Part II: Nutrient Supplements. Washington, DC: National Academy Press; 1990.

13. National Heart, Lung, and Blood Institute. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. The evidence report. http://www.nhlbi.nih.gov/guidelines/obesity/ob_gdlns.pdf. Accessed 14 Dec 2009.

14. Gardosi J, Geirsson RT: Routine ultrasound is the method of choice for dating pregnancy. Br J Obstet Gynaecol 1998,105(9):933-6.

15. Geirsson RT, Busby-Earle RM: Certain dates may not provide a reliable estimate of gestational age. Br J Obstet Gynaecol 1991,98(1):108-9.

16. Hackmon, R., James, R., O''Reilly Green, C., Ferber, A., Barnhard, Y., et al. The impact of maternal age, body mass index and maternal weight gain on the glucose challenge test in pregnancy. The Journal of Maternal-Fetal & Neonatal Medicine 2007; 20, 253-7.

17. Morin, K. H., & Reilly, L. Caring for obese pregnant women. Journal of Obstetric, Gynecologic, and Neonatal Nursing 2007;36, 482-9.

18. Ramachenderan, J., Bradford, J., & McLean, M. Maternal obesity and pregnancy complications: A review. Australian and New Zealand Journal of Obstetrics and Gynaecology 2008;48, 228-35.

19. Thompson, D. R., Clark, C. L., Wood, B., & Zeni, M. B. Maternal obesity and risk of infant death based on Florida birth records for 2004. Public Health Reports 2008; 123, 487–93.

20. Salihu, H. M., Dunlop, A. L., Hedayatzadeh, M., Alio, A. P., Kirby, R. S., & Alexander, G. R. Extreme obesity and risk of stillbirth among black and white gravidas. Obstetrics and Gynecology 2007;110, 552-7.

21. Salihu, H. M., Alio, A. P., Wilson, R. E., Sharma, P. P., Kirby, R. S., & Alexander, G. R. Obesity and extreme obesity: New insights into the black-white disparity in neonatal mortality. Obstetrics and Gynecology 2008;111, 1410-6.

22. Chu, S. Y., Bachman, D. J., Callaghan, W. M., Whitlock, E. P., Dietz, P. M., Berg, C. J., et al. Association between obesity during pregnancy and increased use of health care. New England Journal of Medicine 2008;358, 1444-53.

23. Institute of Medicine.Influence of Pregnancy Weight on Maternal and Child Health Workshop Report. Washington, DC: The National Academies Press; 2007.

24. Tabcharoen, C., Pinjaroen, S., Suwanrath, C., & Krisanapan, O. Pregnancy outcome after age 40 and risk of low birth weight. Journal of Obstetrics and Gynaecology 2009;29(5), 378-83.

25. Lewis, L. N., Hickey, M., Doherty, D. A., & Skinner, S. R. How do pregnancy outcomes differ in teenage mothers? A Western Australian study. Medical Journal of Australia 2009; 190(10), 537-41.

26. Abrams B, Newman V, Key T, Parker J: Maternal weight gain and preterm delivery. Obstet Gynecol 1989;74:577-83.

27. Abrams B, Newman V: Small-for-gestational-age birth: maternal predictors and comparison with risk factors of spontaneous preterm delivery in the same cohort. Am J Obstet Gynecol 1991;164:785-90.

28. Linne Y, Neovius M. Identification of women at risk of adverse weight development following pregnancy. Int J Obes (Lond) 2006;30:1234-9.

29. Stotland NE, Hopkins LM, Caughey AB. Gestational weight gain, macrosomia, and risk of cesarean birth in nondiabetic nulliparas. Obstet Gynecol 2004;104:671-7.
30. Thorsdottir I, Torfadottir JE, Birgisdottir BE, Geirsson RT. Weight gain in women of normal weight before pregnancy: complications in pregnancy or delivery and birth outcome. Obstet Gynecol 2002;99:799-806.
31. WHO. Obesity: Preventing and Managing the Global Epidemic: Report of a WHO Consultation. Geneva: WHO; 2000
32. Ministry of Health & Welfare. The Third Korea National Health and Nutrition Examination Survey(KNHANES III), 2005 : Health Examination. Ministry of Health & Welfare; 2006
33. Stevens-Simon C, Roghmann KJ, McAnarney ER. Relationship of self-reported prepregnant weight and weight gain during pregnancy to maternal body habitus and age. J Am Diet Assoc 1992;92:85-7

**Abstract ( In Korean)**

# 2009 IOM 권고사항을 기초로 한 임신 중 산모 체중 증가에 따른 임신 예후

<지도교수 박용원>

연세대학교 대학원 의학과

이 은 주

**목적**: 임신 중 산모의 주당 체중 증가 량과 출생 체중과의 관계를 조사 하고 2009 년 IOM 권고안을 기초로 한 체질량 지수 기준에 따른 산모 체중 증가량과 임신 예후를 분석하고자 하였다.

**연구 대상 및 방법**: 2006 년 1 월부터 2009 년 12 월까지 본원에서 분만한 3426 명의 단태아 임신을 대상으로 후향적으로 분석 하였다. 산모들은 체질량 지수에 따라 4 개의 집단으로 분류

하였고, 저체중(<18.5), 정상체중(18.5-24.9), 과체중(25-29.9), 비만(≥30)군으로 정의 하였다.

임신 중 체중 증가량은 임신 전 체질량 지수에 따른 IOM 권고사항을 기준으로 권장 범위보다 적은 “미달” 군과 권장 범위에 해당 하는 “적정” 군, 권장 범위보다 많은 체중증가를 보인 “초과” 군으로 분류 하였다.

**결과**: 임신 30-40 주의 체중 증가가 출생 체중에 미치는 영향이 가장 높았다. 과체중군과 비만군 중 “초과”체중군에 해당하는 경우 임신성 고혈압(과체중군: OR, 1.66; 95% CI: 1.15-2.43, 비만군: OR, 2.14; 95% CI: 1.10-3.87)과 임신성 당뇨 (과체중: OR, 1.94; 95% CI: 1.63-3.52, 비만: OR, 4.0; 95% CI: 2.46-9.54)의 위험이 유의하게 증가하였다.

체질량 지수 18.5 미만의 저체중군 중 “미달” 또는 “적정”체중 증가군 에서는 주수에 비해 과소체중아(SGA)의 위험도가 증가 하였다(“미달”군: OR, 1.82; 95% CI: 1.28-2.58, “적정”군: OR, 1.57; 95% CI: 1.08-2.27). 반대로 “초과” 체중군에 속하는 경우에는 과체중아(LGA)의 위험이 증가 하였다(정상 체중군: OR, 1.74; 95% CI: 1.31-2.31, 과체중군: OR, 3.53; 95% CI: 2.31-5.38, 비만군: OR, 2.75; 95% CI: 1.59-4.72).

**결론**: 산모의 체중 증가와 출생 체중이 가장 밀접한 연관이 있는 주수는 임신 30-40 주로 나타났다. 본 연구에서는 과체중과 비만 여성에서 과도한 임신중 체중증가가 있을 경우 불량한 임신 예후의 위험이 증가하였다. 따라서 임신전 체질량 지수뿐만 아니라 임신중 산모의 체중 증가에도 주의가 필요하다.

---

**핵심 되는 말: 임신 중 체중 증가, 출생 체중, 임신 예후**