Determining optimal gestational weight gain in the Korean population: a retrospective cohort study

Sae Kyung Choi, Guisera Lee, Yeon Hee Kim, In Yang Park, Hyun Sun Ko and Jong Chul Shin*

Abstract

Background: The World Health Organization (WHO) international body mass index (BMI) cut-off points defining pre-pregnancy BMI categories in the Institute of Medicine (IOM) guidelines are not directly applicable to Asians. We aimed to define the optimal gestational weight gain (GWG) for the Korean population based on Asia-specific BMI categories.

Methods: Data from 2702 live singleton deliveries in three tertiary centers between 2010 and 2011 were analyzed retrospectively. A multivariable logistic regression analysis was conducted to determine the lowest aggregated risk of composite perinatal outcomes based on Asia-specific BMI categories. The perinatal outcomes included gestational hypertensive disorder, emergency cesarean section, and fetal size for gestational age. In each BMI category, the GWG value corresponding to the lowest aggregated risk was defined as the optimal GWG.

Results: Among the study population, 440 (16.3%) were underweight (BMI < 18.5), 1459 (54.0%) were normal weight (18.5 ≤ BMI < 23), 392 (14.5%) were overweight (23 ≤ BMI < 25) and 411 (15.2%) were obese (BMI ≥ 25). The optimal GWG by Asia-specific BMI category was 20.8 kg (range, 16.7 to 24.7) for underweight, 16.6 kg (11.5 to 21.5) for normal weight, 13.1 kg (8.0 to 17.7) for overweight, and 14.4 kg (7.5 to 21.9) for obese.

Conclusion: Considerably higher and wider optimal GWG ranges than recommended by IOM are found in our study in order to avoid adverse perinatal outcomes. Revised IOM recommendations for GWG could be considered for Korean women according to Asian BMI categories. Further prospective studies are needed in order to determine the optimal GWG for the Korean population.

Keywords: Pregnancy, Weight gain, Pregnancy outcomes, Body mass index

Background

The rates of overweight and obesity among women of childbearing age have risen dramatically, and this represents a medically important issue [1, 2]. The prevalence of obesity among women in Korea is 27.5%, and this rate increases to 47.8% when the overweight and obese categories are combined. From 1998 to 2001, the prevalence of obesity increased from 25.9% to 29.1% in Korean women. According to recent data from the Korea Centers for Disease Control and Prevention, the Korea National Health and Nutrition Examination Survey, and Ministry of Health and Welfare, this increase has leveled out, with no significant change in the prevalence of obesity among Korean women between 2005 and 2013. However, the rate of obesity increases rapidly with age in childbearing women. When we consider the increased prevalence of older age pregnant women in Korea, the proportion of obese childbearing-aged women is of greater concern, despite the fact that recent data do not show a significant increase in obesity among Korean women.

Obese women tend to gain weight during pregnancy excessively, resulting in postpartum weight retention. These women will not only have a high risk pregnancy due to the pre-pregnancy obese state, but will also have a high risk for metabolic disorders in the future [3]. Moreover, excessive gestational weight gain causes maternal...
and neonatal complications, such as gestational dia-
betes, hypertensive disorder, labor induction, cesarean
delivery, anesthetic complications, postpartum hemorrhage,
neonatal intensive care unit admission, macrosomia, and
congenital anomalies [4–8]. Therefore, proper gestational
weight gain is important for improving perinatal outcomes.

The Institute of Medicine (IOM) suggested new
guidelines for adequate gestational weight gain in 2009,
considering the incidences, long-term sequelae, and
baseline risks of several potential outcomes associated
with gestational weight gain. The new guidelines specified
different weight gains for women who were underweight,
normal weight, overweight, and obese. These classifica-
tions are based on body mass index (BMI), defined as
weight in kilograms divided by height in meters squared
(kg/m²). The IOM guidelines recommend a weight gain
of 12.5–18 kg for the underweight group (BMI < 18.5),
11.5–16 kg for the normal group (18.5 ≤ BMI < 25),
7.0–11.5 kg for the overweight group (25 ≤ BMI < 30),
and 5.0–9.1 kg for the obese group (BMI ≥ 30) [9].

The IOM guideline is most widely used, though it is
applicable to various racial and ethnic groups. However,
this guideline is mainly based on the Caucasian standard,
and confirmatory studies are needed because there may
be racial differences in body conditions, such as maternal
height, pelvic shape, and fat deposition according to
weight gain. Furthermore, the World Health Organization
(WHO) expert consultation revised the cut-off value of
BMI to determine overweight and obesity in the Asian
population. WHO expert consultation discussed this issue
on the grounds that Asians have a different correlation be-
tween BMI, body fat deposition, and health risk than Eu-
ropes [10]. Asians are more likely to have a lower BMI,
even though they tend to have more abdominal obesity
than other races. Furthermore, in Asia, the risk of type 2
diabetes and cardiovascular disease is higher in person
with BMI < 25 [11]. Therefore, a revised recommendation
for gestational weight gain is needed for Asian people.

The purpose of the present study is to suggest the
proper gestational weight gain (GWG) considering Asian
population-specific characteristics. We aimed to define
GWG ranges for each pre-pregnancy BMI category de-
efined by the WHO Asian classification among Korean
women.

**Methods**

From 2010 to 2011, 4557 pregnant women delivered their
babies in three tertiary centers at the Catholic Medical
Center, Seoul St. Mary’s Hospital, Uijeongbu St. Mary’s
Hospital, and St. Vincent Hospital. We retrospectively
reviewed the medical records of 3285 term (37 completed
weeks of gestation or later) singleton pregnant women.
The pre-pregnancy BMI and GWG were calculated using
pre-pregnancy body weight reported by each individual
and physical measurement at admission for delivery. We
excluded persons that are not Koreans or did not report
their body weight before pregnancy. Finally, 2702 preg-
nant women were enrolled as the study population.

We reviewed pre-pregnancy BMI, weight gain during preg-
nancy, and maternal and neonatal outcomes in the medical
records. The maternal outcomes included gestational hyper-
tensive disorder, gestational diabetes, mode of delivery, emer-
gency cesarean section due to failed labor, 4th degree perineal
laceration, and postpartum hemorrhage and infection. The
neonatal outcomes included fetal size for gestational age.

The pre-pregnancy BMI was classified according to
Asia-specific standards from the WHO as follows:

1) Underweight: BMI < 18.5
2) Normal: 18.5 ≤ BMI < 23
3) Overweight: 23 ≤ BMI < 25
4) Obese: BMI ≥ 25

The size of the neonate was based on their birth weight
at delivery. Birth weight that was less than the 10th per-
centile was classified as small for gestational age (SGA)
and birth weight greater than the 90th percentile was clas-
sified as large for gestational age (LGA). This was derived
from the most widely used criterion based on a worldwide
study conducted Alexander GR et al. [12].

Statistical analyses were performed using SAS version
9.3 (SAS Institute Inc., Cary, NC, USA). Discrete data are
expressed as number (%) by analysis of the chi-square test.
Continuous data are expressed as mean ± standard devi-
ation or median values using ANOVA or Kruskal-Wallis
test respectively. We confirmed the perinatal outcomes
that showed meaningful changes according to GWG. The
most meaningful perinatal outcomes included gestational
hypertensive disorder, emergency cesarean section, and
fetal size for gestational age. A univariate multivariable lo-
gistic regression analysis was conducted to determine odd
ratios (with 95% confidence intervals [CI]) of each out-
come relating to increase in GWG. They were adjusted
for age, parity, occupation, mode of delivery, and medical
history as factors affecting GWG. Total risk was estimated
by spline estimation using predicted risk for each complica-
tion. We defined the GWG ranges stratified according to
Asia-specific BMI categories that did not exceed a 5%
increase from the lowest predicted risk.

This study was approved by ethics committee of the
Clinical Research Coordinating Center of the Catholic
Medical Center (XC11RIMI0029K).

**Results**

Baseline characteristics and obstetric outcomes of study
participants are summarized in Table 1. Among the study
population, 440 (16.28%) were underweight (BMI < 18.5),
1459 (54.00%) were normal (18.5 ≤ BMI <23), 392
were overweight (23 ≤ BMI < 25), and 412 (15.25%) were obese (25 ≤ BMI). Half of the study population was primiparous, and the other half was multiparous. One thousand nine hundred fifty-five participants (59.18%) underwent vaginal delivery, and 1103 (40.82%) underwent cesarean section. Among the individuals who underwent cesarean section, 266 underwent operation due to emergency such as arrest disorder or non-reassuring fetal heart rate, defined as failed labor. The rates of gestational diabetes and gestational hypertensive disorder were 6.22% and 5.03%, respectively.

Perinatal outcomes

Perinatal outcomes indicating significant risks with a GWG of 1 kg were gestational hypertensive disorder, emergency cesarean section, and fetal size for gestational age. Logistic models for perinatal outcomes showed that an increase in GWG was associated with a decrease in the predicted risk of SGA and increase in that of LGA. Furthermore, increase in GWG was associated with increased predicted risks of gestational hypertension and failed labor (Fig. 1).

The odd ratio for each outcome was calculated on the basis of maternal age, height, parity, occupation, education, medical history, and mode of delivery. All confounders were highly significant predictors of GWG. The risk for SGA decreased (OR 0.93; 95% CI = 0.91–0.96) and the risk for LGA increased (OR 1.07; 95% CI = 1.04–1.11) as the GWG increased by 1 kg. The incidence of gestational hypertension increased according to GWG (OR 1.03; 95% CI = 1.00–1.07). The risk of failed labor also increased (OR 1.02; 95% CI = 0.99–1.05), but the adjusted odd ratio was not statistically significant (Table 2).

Gestational weight gain

The lowest total predicted risks were calculated in each interval according to the Asian BMI classification. The recommended weight gain range was set as the range that does not exceed a 5% increase from the lowest predicted risk. The optimal GWG values were observed to be between 16.7 and 24.7 kg for underweight women and between 11.5 and 21.5 kg for normal women. Overweight and obese women achieved the optimal GWG values between 8.0 and 17.7 kg and 7.5 and 21.9 kg, respectively (Table 3). The optimal GWG in our study was higher and the range was wider than that of the IOM guideline. The optimal GWG for underweight and obese women was outside the IOM recommended range.

Discussion

In this study, we examined the proper weight gain range during pregnancy according to Asian BMI classification. When inappropriate weight gain was observed, the incidence of poor perinatal prognostic factors such as LGA, hypertension, emergency cesarean section, and SGA increased. Optimal GWG based on the risk of meaningful perinatal outcomes was higher for women who were in a lower BMI category and lower for women who were in a higher BMI category. The optimal GWG in this Korean population differed from that of the IOM guidelines, which was based on data from Caucasian women. The optimal GWG in our study was higher and the range was wider than that of the IOM guideline. The optimal GWG for underweight and obese women was outside the IOM recommended range.

Several previous studies have found the importance of proper GWG. Not only excessive GWG, but also

**Table 1** Baseline characteristics of the study population

| Characteristics                  | Total = 2702 |
|----------------------------------|--------------|
| Age (years)                      | 32.59 ± 4.75 |
| Occupation                       |              |
| Yes                              | 981 (36.31%) |
| No                               | 1721 (63.69%)|
| Education                        |              |
| Elementary school or less        | 19 (0.70%)   |
| Middle school graduate           | 69 (2.55%)   |
| High school graduate             | 893 (33.05%) |
| University graduate or higher    | 1821 (63.69%)|
| Medical history                  |              |
| Yes                              | 350 (12.95%) |
| No                               | 2352 (87.05%)|
| Pre-pregnancy BMI category       |              |
| Underweight (< 18.5 kg/m²)       | 440 (16.28%) |
| Normal (18.5 to <23 kg/m²)       | 1459 (54.00%)|
| Overweight (23 to <25 kg/m²)     | 391 (14.47%) |
| Obese (≥ 25 kg/m²)               | 412 (15.25%) |
| Parity                           |              |
| Primiparous                      | 1351 (50%)   |
| Multiparous                      | 1351 (50%)   |
| Duration of pregnancy (weeks)    | 38.73 ± 1.29 |
| Mode of delivery                 |              |
| Vaginal delivery                 | 1599 (59.18%)|
| Cesarean section                 | 1103 (40.82%)|
| elective                         | 837 (30.96%) |
| emergency                        | 266 (9.84%)  |
| Size for gestational age         |              |
| SGA                              | 358 (13.25%) |
| AGA                              | 2217 (82.05%)|
| LGA                              | 127 (4.7%)   |
| Gestational diabetes             | 168 (6.22%)  |
| Gestational hypertensive disorder| 136 (5.03%)  |

BMI body mass index, SGA small for gestational age, AGA appropriate for gestational age, LGA large for gestational age.
insufficient weight gain can cause poor perinatal outcomes. While excessive weight gain during pregnancy is associated with LGA, maternal hypertension, and cesarean section, low maternal weight or insufficient GWG is associated with intrauterine fetal growth restriction, low birth weight, and preterm delivery [13–19]. Bodnar et al. explored the association between GWG and SGA, LGA, spontaneous preterm births (PTB), and medically indicated PTBs among 5550 pregnant women. They reported that the adjusted risk of SGA increased as GWG declined and the risk of LGA increased with increasing GWG. They also reported that low GWG were associated with an increased risk of spontaneous PTB and high GWG was related to an increased risk of indicated PTB [13]. Kiel et al. reported a population-based cohort study of 20,251 pregnant obese women delivering full-term singleton infants to examine the effect of GWG on pregnancy outcomes (preeclampsia, cesarean delivery, SGA, and LGA). They reported that increasing risk of preeclampsia, cesarean delivery, and LGA birth and decreasing risk of SGA birth with increasing GWG [15]. The results of our study were similar to these findings.

We suggested an optimal GWG guideline based on Asian BMI categories that differed from the IOM

### Fig. 1 Predicted risk of each composite outcome.

- **a** The predicted risk of SGA with GWG.
- **b** The predicted risk of LGA with GWG.
- **c** The predicted risk of gestational hypertension with GWG.
- **d** The predicted risk of failed labor with GWG.

GWG was positively correlated with the predicted risk of LGA, gestational hypertension, and failed labor, but showed a negative correlation with the predicted risk of SGA. SGA, small for gestational age; LGA, large for gestational age; GWG, gestational weight gain.

### Table 2 Odds of each outcome relating to one unit increase in GWG

| Outcome                  | Unadjusted | P value | Adjusted      | P value |
|--------------------------|------------|---------|---------------|---------|
|                          | OR (95% CI)|         | OR (95% CI)   |         |
| SGA                      | 0.93 (0.91–0.96) | <0.0001 | 0.93 (0.91–0.96) | <0.0001 |
| LGA                      | 1.08 (1.05–1.12) | <0.0001 | 1.07 (1.04–1.11) | <0.0001 |
| Gestational hypertension | 1.04 (1.00–1.07) | 0.0327  | 1.03 (1.00–1.07) | 0.0601  |
| Failed labor             | 1.05 (1.02–1.07) | <0.0001 | 1.02 (0.99–1.05) | 0.1273  |

Adjusted for age, height, parity, occupation, education, medical history, and mode of delivery

GWG gestational weight gain, OR odds ratio, CI confidence interval, SGA small for gestational age, LGA large for gestational age.
guideline. Some previous studies provided insight into whether racial or ethnic differences altered the association between GWG and various perinatal outcomes. The results from these analyses were that racial or ethnic group did not affect the relationship between GWG and outcomes [16, 17]. Nevertheless, in some studies, various recommendations for different populations were proposed besides the IOM GWG guideline. The Brazilian Ministry of Health recommended its own GWG guideline based on the IOM guidelines and Atalah’s curve, which was a recommendation for Chilean women to monitor the progress of their nutritional state during pregnancy according to pre-pregnancy BMI [18, 19]. There were also several studies that suggested optimal GWG for Asian populations such as China, Vietnam, and Singapore [20–22]. This implies that the GWG should be different depending on demographic characteristics.

The optimal GWG range in our study was higher and wider than the IOM recommendation, as reported by Andreas et al. They established a GWG guideline using a new statistical technique by setting the GWG as a continuous variable and considering factors that affect weight gain, such as smoking or parity, as effect modifiers [23]. We hypothesize that the reason for the wider and higher GWG is not only differences in statistical methods but also the lower proportion of LGA in the study population limited to Korean women showing minimal ethnic differences.

The optimal GWG range for obese women was similar to that for overweight women but wider than those for other groups because predicted risks for all factors were relatively higher regardless of weight gain. This result supports our previous finding that pre-pregnancy obesity itself is a major risk factor for adverse perinatal outcomes.

### Table 3 Optimal weight gain range with the lowest risk

| Pre-pregnancy weight category | Asian Pacific BMI | Optimal weight gain range (kg) |
|------------------------------|------------------|--------------------------------|
| Underweight                  | Less than 18.5 kg/m² | 20.8 (16.7–24.7) |
| Normal                       | 18.5–22.9 kg/m² | 16.6 (11.5–21.5) |
| Overweight                   | 23.0–24.9 kg/m² | 13.1 (8.0–17.7) |
| Obese                        | 25 kg/m² and greater | 14.4 (7.5–21.9) |

BMI, body mass index

**Fig. 2** Predicted risk by body mass index classification. (a) Underweight group. (b) Normal group. (c) Overweight group. (d) Obese group. Total predicted risks were calculated using the risk for each complication. We defined the lowest total predicted risks and recommended weight gain ranges that did not exceed a 5% increase from the lowest predicted risks according to Asia-specific BMI categories. BMI, body mass index; SGA, small for gestational age; LGA, large for gestational age; PIH, pregnancy induced hypertension
We previously reported that pre-pregnancy obesity more closely correlated with adverse perinatal outcomes than excessive GWG [24].

In summary, the most notable prognostic factors related to GWG were inappropriate birth weight, development of gestational hypertension disorder, and increasing rate of emergency cesarean section. Our study indicates that GWG guidelines should be revised based on the characteristics of the Korean population considering these factors. Our guideline suggests an optimal GWG that is higher and wider than the IOM guideline.

There are some limitations to our study. First, this is a retrospective study. No reliable and objective method was used to measure the pre-pregnancy BMI and GWG of the patients because they were calculated using pre-pregnancy body weight reported by each individual. Second, there was lack of birth weight curve adjusted on Korean population. The study population showed high rate of SGA and low rate of LGA stemming from ethnic differences. Third, several outcomes such as GDM, Apgar score, and admission to NICU were excluded from the most meaningful perinatal outcomes. Although we did not found statistically significant correlations in this study, it remains unchanged that they are important factors associated with GWG. Finally, the high cesarean section rate, which was a characteristic problem of Korean population, could affect the results of the statistical analysis. Despite such limitations, our study has strength in that it provided a reference standard for clinical practice by presenting revised GWG guidelines suitable for Korean population. However, further prospective studies required to determine both adverse pregnancy outcome depending on high GWG and optimal GWG for Korea population. There is a need to conduct prospective studies based on the Korean birth weight standard in the future.

**Conclusions**

There are many factors that affect perinatal morbidity and mortality, but a typical modifiable influencing factor is maternal weight gain during pregnancy [25, 26]. Pregnant women who gain weight according to the recommend guidelines have a good prognosis for birth weight, fetal growth, and postpartum weight retention [27]. Therefore, it is an important task of healthcare providers to improve maternal health by proposing and managing appropriate GWG. Furthermore, GWG guidelines adapted to the characteristics of the Asian population need to be considered, although the IOM guideline is the most used currently.

**Abbreviations**

BMI: Body mass index; GWG: Gestational weight gain; IOM: Institute of Medicine; LGA: Large for gestational age; PTB: Spontaneous preterm births; SGA: Small for gestational age; WHO: World Health Organization

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**Availability of data and materials**

All data supporting the conclusion of the article are available from the corresponding author on reasonable request.

**Authors’ contributions**

SK Choi participated in the design of the study and acquisition and interpretation of data. SK Choi is the first author and participated in drafting of manuscript. JC Shin is the corresponding author. Guisera Lee, YH Kim, FY Park, and HS Ko participated in data acquisition. All authors have read and approved the final manuscript.

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**Ethics approval and consent to participate**

This study was approved by an ethics committee of the Clinical Research Coordinating Center of the Catholic Medical Center (XC11RIMI0029). The data was retrospectively reviewed.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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