

Determining optimal gestational weight gain (GWG) in a northwest Chinese population

A CONSORT

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Abstract

To determine optimal gestational weight gain (GWG) for the Chinese population.

Live singleton deliveries at the largest maternal & childcare hospital in northwest China from 2010 to 2012 were analyzed retrospectively. Multivariable logistic regression analysis was conducted to determine the lowest aggregated risk of interested perinatal outcomes based on Chinese adult body mass index (BMI) categories.

Eight thousand eight hundred seventy enrolled parturients were divided into 4 groups according to their prepregnancy BMI: underweight (21.31%, BMI < 18.5 kg/m²), normal weight (67.81%, 18.5 kg/m² ≤ BMI < 24 kg/m²), overweight (8.99%, 24 kg/m² ≤ BMI < 28 kg/m² and obese (1.89%, BMI ≥ 28 kg/m²). The optimal GWG values for the above 4 groups were 16.7 kg (GWG range, 12.0–21.5), 14.5 kg (9.5–19.5), 11.5 kg (7.0–16.5), and 8.0 kg (5.0–13.0). The rates of inadequate, optimal and excessive GWG in present study were 6.14% (545), 62.34% (5529), and 31.52% (2796) respectively, which were significantly different from those of the 2009 Institute of Medicine recommendation ($\chi^2 = 1416.05$, Pinteraction < 0.0001).

Wider optimal GWG ranges than those recommended by Institute of Medicine were found in our study, and our proposed criteria seems to be practical to the Chinese population.

Abbreviations: BMI = body mass index, CI = confidence intervals, CS = cesarean section, GWG = gestational weight gain, IOM = Institute of Medicine, LGA = large for gestational age birth weight, OR = odds ratio, SGA = small for gestational age birth weight, WHO = World Health Organization.

Keywords: Chinese population, gestational weight gain, pregnancy outcomes, prepregnancy body mass index

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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1. Introduction

The appropriate prepregnancy body mass index (BMI) and gestational weight gain (GWG) are important protective factors to obtain good perinatal outcomes and promote maternal and infant health. Prepregnancy maternal underweight and inadequate GWG are linked to small for gestational age birth weight (SGA) and possibly preterm birth.^[1–3] Prepregnancy maternal overweight and obesity as well as excessive GWG are associated with high risk of gestational diabetes, gestational hypertension, large for gestational age birth weight (LGA), cesarean section (CS), postpartum hemorrhage, postpartum weight retention,^[4–8] and long-term metabolic disorders after delivery.^[9–12]

It is not possible for all women of childbearing age to be at an ideal BMI before conception. Different from prepregnancy BMI, GWG is controllable by dietary counseling and lifestyle modification.^[13,14] The US Institute of Medicine (IOM) established the gestational weight gain guidelines in 1990^[15] and revised it in 2009^[16] because of the high prevalence of obesity in childbearing age women^[17,18] and new knowledge about several potential sequelae regarding pregnancy. The new guidelines suggest different weight gain for women in different categories, these classifications based on BMI contains underweight, normal weight, overweight, and obese.^[16] The IOM recommendation has been widely used by various racial and ethnic groups all over the world for clinical guidance and scientific research, facilitating

the comparison of international data.^[11,18–20] However, the recommendation may be not suitable for Asian populations because they are mainly based on the Caucasian standard. Moreover, many previous studies indicate that there may be racial differences in genetic characteristics, such as maternal height, pelvic shape. Furthermore, the World Health Organization (WHO) international BMI cut-off points are different from Asia standard.^[21] We also have our own official BMI Standard in China,^[22,29] which leads to the prepregnancy BMI categories in the IOM guidelines that cannot be directly used to Chinese. Also, several studies have built different optimal GWG ranges for different Asian populations,^[23–25] emphasizing the requirement for determining country-specific GWG guidelines. However, there is no official GWG guidelines for Chinese population in China at present.

We aimed to define GWG range for each prepregnancy BMI category based on the Chinese-specific classification among Chinese women. Further, to analyze the proportion distribution of GWG according to our determined optimal GWG range and compared it with that of the IOM.

2. Methods

2.1. Study population

A birth cohort study was performed during 2010 to 2012 at Gansu Provincial Maternity & Child Care Hospital, the largest maternal and childcare hospital in Lanzhou, China. Eligible participants were recruited upon their delivery time at this hospital. And an in-person interview was carried out upon obtaining written consent within 1 to 3 days after delivery. This study was approved by the human investigation committees of the Gansu Provincial Maternity and Child Care Hospital and the Yale University. Then a standardized and structured questionnaire was conducted to collect information of the eligible participants, including demographic and lifestyle factors, medical, and residential history. Information on maternal complications and birth outcomes were extracted from medical records. More information about the cohort has previously been published.^[26–28] In this study, our inclusion criteria included term (37 completed weeks of gestation or later) singleton pregnancy with available data. Exclusion criteria included multiple pregnancies, PTB, presence of pelvic tumor, fetal anomalies, and pre-existing medical diseases. Moreover, the patients with previous cesarean section were also excluded. A total of 14,359 eligible women were invited to participate, 10,542 (73.4%) participants completed questionnaire among them, 8870 parturient who fit the inclusion criteria were enrolled in the end.

2.2. Maternal anthropometry

Maternal anthropometry containing height, prepregnant and predelivery weight, were abstracted from either the questionnaire or medical record of the study participants. The GWG was calculated using the weight before delivery. Prepregnancy BMI (kg/m^2) was calculated and categorized based on Chinese Adult BMI criteria^[22,29] but not the standards from the WHO.^[21,30] The differences among the 3 standards were presented in Table 1.

2.3. Perinatal outcomes

The maternal outcomes were recorded, including gestational hypertension, gestational diabetes, cesarean section, perineal laceration, and postpartum hemorrhage. The neonatal outcomes

Table 1

Differences of BMI category standards between Chinese and WHO.

Category	Chinese standards	WHO standards	WHO Asia-specific standards
Underweight	<18.5 kg/m^2	<18.5 kg/m^2	<18.5 kg/m^2
Normal weight	18.5 to <24 kg/m^2	18.5 to <25 kg/m^2	18.5 to <23 kg/m^2
Overweight	24 to <28 kg/m^2	25 to <30 kg/m^2	23 to <25 kg/m^2
Obese	$\geq 28 \text{ kg}/\text{m}^2$	$\geq 30 \text{ kg}/\text{m}^2$	$\geq 25 \text{ kg}/\text{m}^2$

BMI = body mass index, WHO = World Health Organization.

included LGA and SGA infants. The size of the newborn was based on their birth weight in medical records. LGA was defined as neonatal weight greater than the 90th percentile and SGA was defined as the birthweight less than the 10th percentile.^[31]

2.4. Statistical analysis

All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina). Pearson χ^2 -test was employed to analyze discrete data expressed as number (%). ANOVA was used to analyze continuous data expressed as mean \pm standard deviation (SD). Unconditional logistic regression models were used to confirm the association between perinatal outcomes and GWG. Then univariate and multivariable logistic regression analyses were performed to estimate odds ratios (OR) and 95% confidence intervals (95% CI) for the associations between perinatal outcomes with the increasing in GWG. They were adjusted for age, height, parity, occupation, education status as potential confounding variables affecting GWG. Additional adjustment variables for infant gender, active and passive smoking, alcohol consumption, household monthly income per capita, and physical activity did not result in GWG changes in the logistic model, so they were not enrolled in the final model. The predicted probability of each interested perinatal outcome was estimated as a function of GWG. After that, an aggregate risk as a final function of GWG was acquired by summing the predicted probability of each interested perinatal outcome and stratified by pre-pregnancy BMI category. We defined the GWG corresponding to the lowest aggregated risk as the optimal GWG of each pre-pregnancy BMI category stratified according to Chinese Adult BMI categories. The optimal GWG range was defined that did not exceed a 5% increase from the lowest aggregated risk in each BMI category.

3. Results

A total of 8870 parturients were included in our final analysis. 6554(73.89%) of those were primiparous, 2316(26.11%) were multiparous. Among the study population, 1890(21.31%) were underweight ($\text{BMI} < 18.5 \text{ kg}/\text{m}^2$), 6015(67.81%) were normal weight ($18.5 \text{ kg}/\text{m}^2 \leq \text{BMI} < 23.9 \text{ kg}/\text{m}^2$), 797(8.99%) were overweight ($24 \text{ kg}/\text{m}^2 \leq \text{BMI} < 27.9 \text{ kg}/\text{m}^2$) and 168(1.89%) were obese ($\text{BMI} \geq 28 \text{ kg}/\text{m}^2$). Five thousand five hundred eighty one (63%) parturients underwent vaginal delivery, 3289(37%) parturients underwent cesarean section. A total of 8045(90.70%) participants delivered an appropriate for gestational age (AGA) baby. 173(1.95%) women delivered an SGA baby and 652 (7.35%) women delivered an LGA baby. A total of 75(0.85%) parturients were diagnosed with gestational diabetes. The

Table 2
Distribution of selected characteristics of the study population. Urban China (2010–2012).

Characteristics	Total (n=8870)
Maternal age(years)	28.54±4.22
Height(cm)	162.16±4.72
Education(years)	
≤ 9	1766 (19.91%)
≥10 and ≤12	1528 (17.23%)
≥13	5472 (61.69%)
Missing	104 (1.17%)
Parity	
Primiparous	6554 (73.89%)
Multiparous	2316 (26.11%)
Pre-pregnancy BMI category	
Underweight (<18.5 kg/m ²)	1890 (21.31%)
Normal weight (≥18.5 and <23.9 kg/m ²)	6015 (67.81%)
Overweight (≥24 and <27.9 kg/m ²)	797 (8.99%)
Obese (≥28 kg/m ²)	168 (1.89%)
Duration of pregnancy (weeks)	39.01±1.03
Mode of delivery	
Vaginal delivery	5581 (63%)
Cesarean delivery	3289 (37%)
Gestational diabetes	75 (0.85%)
Gestational hypertension	301 (3.39%)
Size for gestational age	
SGA	173 (1.95%)
AGA	8045 (90.70%)
LGA	652 (7.35%)

AGA = appropriate for gestational age, BMI = body mass index, LGA = large for gestational age, SGA = small for gestational age.

prevalence of gestational hypertension in the population was 3.39%. General characteristics and perinatal outcomes of the study population were shown in Table 2.

3.1. The determination of optimal GWG according to the risk of adverse perinatal outcomes.

As shown in Table 3, the risks of gestational hypertension, cesarean section, postpartum hemorrhage, and fetal size were associated with the change of GWG initially. After putting the adjustment variables into the model, postpartum hemorrhage showed no statistically significant association with GWG (OR, 1.007; 95%CI, 0.998–1.017). The confounders contained maternal age and height, parity, education status, occupation, were all highly significant predictors of GWG. Increase in GWG

by 1kg was associated with increased risks of gestational hypertension (OR, 1.025; 95%CI, 1.015–1.036), cesarean section (OR, 1.021; 95%CI, 1.014–1.027). The risk for LGA increased (OR, 1.035; 95% CI, 1.026–1.043) but the risk for SGA decreased (OR, 0.970; 95% CI, 0.945–0.996) as the GWG increased by 1kg. In Figure 1, we confirmed the lowest aggregated risk corresponding GWG value as the optimal GWG of each BMI category. The recommended GWG ranges were defined as the range that does not exceed a 5% increase from the lowest predicted risk in each BMI category. Based on our study, the optimal GWG was 16.7, 14.5, 11.5, and 8.0kg for each BMI group. Moreover, the optimal GWG range for underweight women was between 12.0 and 21.5kg, and 9.5 to 19.5kg for normal weight women, 7.0 to 16.5kg and 5.0 to 13.0kg for overweight and obese women, respectively.

3.2. The comparison of optimal GWG between present study and the 2009 IOM Guideline

The estimated optimal GWG value and range for each BMI category along with the 2009 IOM Guideline values for reference were showed in Table 4. We re-evaluated the study population based on our recommendation’s rate of inadequate, optimal, and excessive GWG was 6.14% (545), 62.34% (5529), and 31.52% (2796), compared with 11.68% (1036), 34.13% (3027), and 54.19% (4807) according to the 2009 IOM recommendation, were statistically significant (1416.05, P_{interaction} < 0.0001), which were showed in Table 5.

4. Discussion

GWG is one of the most important clinical indicators for either fetal development or maternal and child health. The results in present study concur with current published literatures in strong association between inappropriate GWG and adverse perinatal outcomes. Excessive GWG has been linked to high prevalence of cesarean section and gestational hypertension, large gestational age fetals, postpartum weight retention, and child obesity.^[20,32,33] On the contrary, insufficient GWG is associated with small gestational age babies,^[34,35] preterm delivery, NICU admission, and stunting at 5 years.^[36] Moreover, the impact due to the changes in weight and body composition during pregnancy may persist into the postpartum period and whole life of the parturients.^[37] Therefore, childbearing age women have an obligation to control their GWG in order to reduce the risk of the maternal, infant morbidity, and metabolic diseases.

Table 3
Odds of each outcome relating to 1-unit increase in GWG.

Gestational outcomes	Without adjustment		With adjustment*	
	OR (95%CI)	P value	OR (95%CI)	P value
Gestational hypertension	1.027 (1.016–1.038)	<.0001	1.025 (1.015–1.036)	<.0001
GDM	0.993 (0.959–1.027)	.6805		
Cesarean section	1.019 (1.013–1.025)	<.0001	1.021 (1.014–1.027)	<.0001
Perineal laceration	0.996 (0.986–1.007)	.5163		
Postpartum hemorrhage	1.025 (1.014–1.036)	<.0001	1.007 (0.998–1.017)	.1253
LGA	1.034 (1.026–1.042)	<.0001	1.035 (1.026–1.043)	<.0001
SGA	0.948 (0.921–0.976)	<.0001	0.970 (0.945–0.996)	.0218

CI = confidence interval, GDM = gestational diabetes mellitus, GWG = gestational weight gain, LGA = large for gestational age, OR = odds ratio, SGA = small for gestational age.

* Adjusted for maternal age and height, parity, education status, occupation.

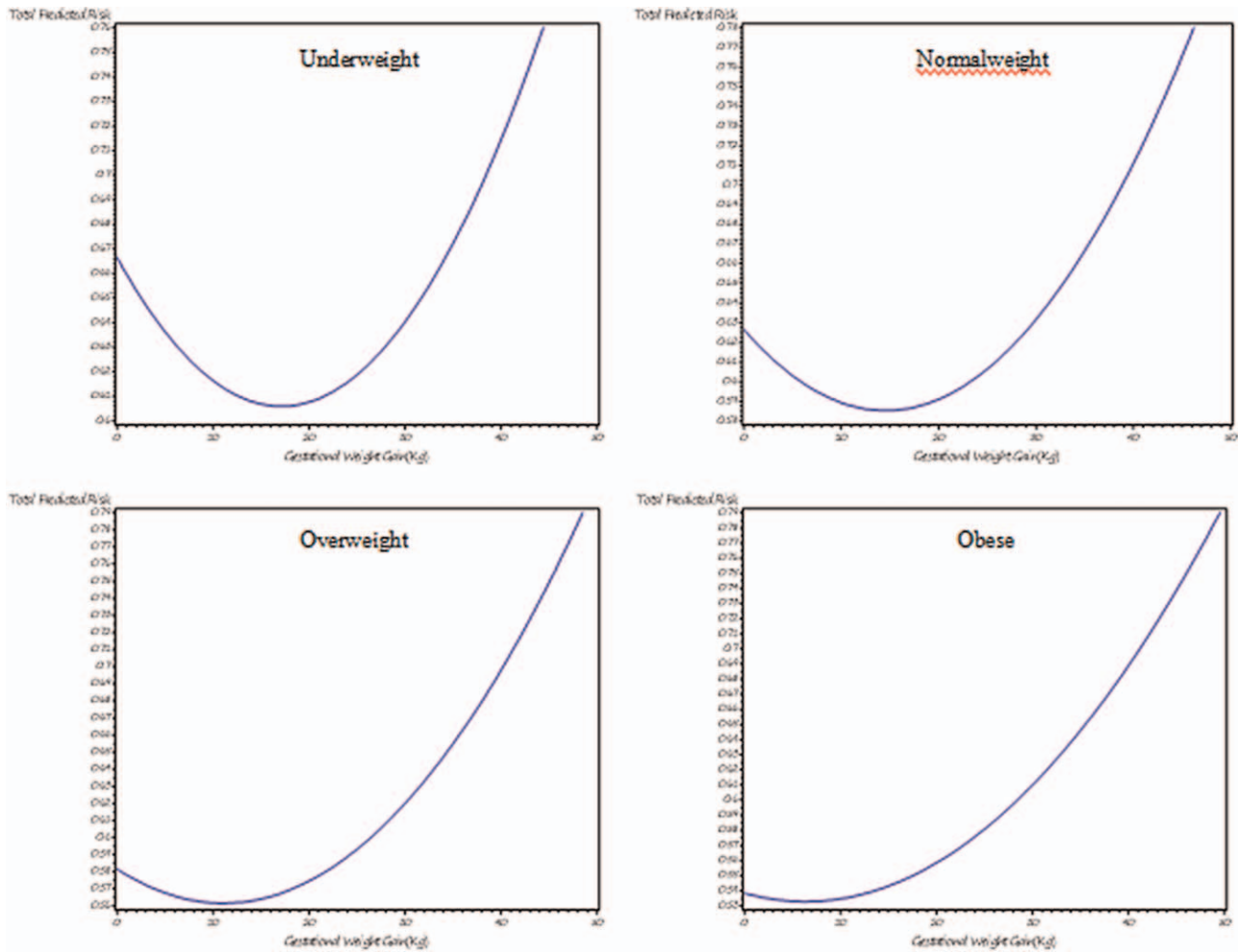


Figure 1. Total predicted risk according to gestational weight gain (GWG) by Chinese adult body mass index (BMI) categories.

The recommendation of proper GWG is crucial to the maternal and child health. There are mainly 2 methods to establish the optimal GWG, one based on disease risk^[24,38] and the other is percentile method.^[25,39] The percentile method is taking the P_{2.5} to P₇₅ of ideal population (obtaining a good pregnancy outcome) as the proper range. Prasert Sunsanevithayakul reported that the optimal GWG for their study group was proposed to achieve a high proportion of appropriate for-gestational age infants, which used the percentile method.^[25] In the other hand, the most frequently used indicators of the disease risk are low birth weight and large birth weight rate. IOM revised the recommendation for obese

women from ≥7kg to 5~9kg according to the prevalence of overweight and obesity rates, large gestational age, and postpartum weight retention rates based on the American population in 2009.^[40] Our study used the similar methodology for calculating optimal GWG as that used in 2009 IOM recommendation, constructing the guideline based on the GWG values with lowest prevalence of interested outcomes. The difference was that we considered the GWG as a quantitative variable in our model instead of an interval variable in that of 2009 IOM. A same analytical approach as ours has been used by Xin Ee^[23] for determining the optimal GWG in a multiethnic Asian population,

Table 4
Optimal GWG range from our study and 2009 IOM recommendation.

Pre-pregnancy weight category	2009 IOM		Present study	
	BMI (kg/m ²)	Optimal GWG (kg)	BMI (kg/m ²)	Optimal GWG (kg)
Underweight	<18.5	12.5–18	<18.5	16.7 (12.0–21.5)
Normalweight	18.5 to <25	11.5–16	18.5 to <23.9	14.5 (9.5–19.5)
Overweight	25 to <30	7–11.5	24 to <27.9	11.5 (7.0–16.5)
Obese	≥30	5~9	≥28	8.0 (5.0–13.0)

BMI = body mass index, GWG = gestational weight gain, IOM = Institute of Medicine.

Table 5

Comparison the rates of different GWG levels between patients adhere to standards of present study and 2009 IOM.

Items	Present study	2009 IOM standards	χ^2	P value
Inadequate GWG	545 (6.14%)	1036 (11.68%)	1416.05	<.0001
Optimal GWG	5529 (62.34%)	3027 (34.13%)		
Excessive GWG	2796 (31.52%)	4807 (54.19%)		

GWG = gestational weight gain, IOM = Institute of Medicine.

although that study only set combination of delivery type and size for gestational age as the interested outcome.

Our study showed that the optimal GWG of each BMI category were all in the ranges proposed by 2009 IOM, but our optimal ranges were wider than that of IOM. We hypothesize that 3 main reasons may explain the differences between our GWG estimates and the IOM guidelines. First, a new statistical technique by setting the GWG as a continuous variable in logistic model, which is different from 2009 IOM as we mentioned earlier.^[38] Second, prepregnancy BMI cut-off points utilized in our study were calculated and categorized based on Chinese Adult BMI criteria,^[29] while the IOM recommendation were based on the WHO international BMI cut-off points.^[30] Finally, intrinsic ethnic and cultural differences probably have an effect on the GWG of Chinese pregnant women. Several prior studies indicated various recommendations for different populations which showed different range from that of 2009 IOM.^[23,33,41,42] Based on these optimal GWG ranges established in our study, the rates of inadequate, optimal, and excessive GWG were significantly different ($\chi^2=1416.05$, $P<.0001$) from those defined by the IOM standards. It also implied the GWG should be different according to demographic characteristics.

There were several inherent limitations to our study. Data of pre-pregnancy weight was self-reported, potentially could be affected by unavoidable recall bias. According to previous literature, pregravid overweight and obese women are more tending to underreport their prepregnancy weight.^[43,44] Secondly, our study was not examining the long-term effects of abnormal GWG, such as postpartum weight retention and childhood obesity. Finally, the high cesarean section rate (CSR) in our study population could affect the statistical analysis results.

To the best of our knowledge, our study is the first English publication which propose a proper GWG recommendation in pregnant Chinese women based on the Chinese adult BMI categories. Moreover, our sample size was relatively large and many detailed information on demographic factors, medical histories have been recorded, which allowed us to adjust for important confounding factors. Our recommendation seems to be more realistic and practical. This recommendation may help more pregnant Chinese women to get an ideal GWG and reduce peripartum adverse complications at the mean time.

In conclusion, our study supports the hypothesis that GWG should be different by different demographic characteristics. This study, determined optimal GWG in a northwest Chinese population, agrees partially with the IOM 2009 guidelines. Our optimal ranges were wider than those recommended by IOM 2009 and it seem to be realistic, with more adherence compared to that of 2009 IOM. Further research including a larger number of women, their neonatus and more adverse perinatal outcomes, for instance, postpartum weight retention, childhood obesity, is needed to eventually determine optimal GWG for Chinese women.

Author contributions

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