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Effects of pre-pregnancy body mass index and gestational weight gain on neonatal birth weight*#

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Abstract: To evaluate the effects of maternal pre-pregnancy body mass index (pre-BMI) and gestational weight gain (GWG) on neonatal birth weight (NBW) in the population of Chinese healthy pregnant women, attempting to guide weight control in pregnancy. A retrospective cohort study of 3772 Chinese women was conducted. The population was stratified by maternal pre-BMI categories as underweight (<18.5 kg/m^2), normal weight (18.5–23.9 kg/m^2), overweight (24.0–27.9 kg/m^2), and obesity (≥28.0 kg/m^2). The NBW differences were tested among the four groups, and then deeper associations among maternal pre-BMI, GWG, and NBW were investigated by multivariate analysis. NBW increased significantly with the increase of maternal pre-BMI level (P<0.05), except overweight to obesity (P>0.05). The multivariate analysis showed that both pre-BMI and GWG were positively correlated with NBW (P<0.05). Compared with normal pre-BMI, underweight predicted an increased odds ratio of small-for-gestational-age (SGA) and decreased odds ratio for macrosomia and large-for-gestational-age (LGA), and the results were opposite for overweight. With the increase of GWG, the risk of SGA decreased and the risks of macrosomia and LGA increased. In addition, in different pre-BMI categories, the effects of weight gain in the first trimester on NBW were different (P<0.05). NBW is positively affected by both maternal pre-BMI and GWG, extreme pre-BMI and GWG are both associated with increased risks of abnormal birth weight, and maternal pre-BMI may modify the effect of weight gain in each trimester on NBW. A valid GWG guideline for Chinese women is an urgent requirement, whereas existing recommendations seem to be not very suitable for the Chinese.

Key words: Pre-pregnancy body mass index; Gestational weight gain; Neonatal birth weight; Appropriate weight gain pattern
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1 Introduction

Weight management in pregnancy is gaining more and more attention, since women's gestational weight gain (GWG) and pre-pregnancy body mass index (pre-BMI) are both closely associated with gestational complications, adverse pregnancy outcomes, and offspring's long-term health problems (Ensenauer *et al.*, 2013; Johnson *et al.*, 2013; Li *et al.*, 2013). Abnormal birth weight (BW), as one of the adverse outcomes, often manifests as low BW (LBW), small-for-gestational-age (SGA), large-for-gestational-age (LGA), and macrosomia, always predicting increased risks for short- and long-term complications. Many studies reported that infants of small size were associated with higher morbidity and mortality (McIntire *et al.*, 1999; Mathews and MacDorman, 2011; U.S. Department of Health and Human Services, Health Resources and Services Administration, Maternal and Child Health Bureau, 2011). It has also been found that there is a clear association between

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abnormal BW and increased risks later in life for a variety of diseases covering the endocrine, cardiovascular, respiratory, urinary, and nervous-mental systems, and so on (Negrato and Gomes, 2013; Johnsson *et al.*, 2015). Specifically, LBW has been reported to be associated with increased risks for diseases including cardiovascular disease, type 2 diabetes, end-stage renal disease, and schizophrenia (Negrato and Gomes, 2013; Alexander *et al.*, 2014; Zhang *et al.*, 2014). Jancevska *et al.* (2012) reported that SGA people had an increased incidence of metabolic syndrome, coronary artery disease, stroke, low bone density, and osteoporosis. A high BW has been regarded as associated with increased risks of type 2 diabetes and obesity (Johnsson *et al.*, 2015).

When it comes to the etiology of abnormal BW focus on mothers, maternal pre-BMI and GWG have attracted a lot of attention. Epidemiological studies have demonstrated that both extreme pre-BMI and extreme weight gain increase the risk of abnormal neonatal BW (NBW) (Liu *et al.*, 2012; Li *et al.*, 2013; Kim *et al.*, 2014; Shin and Song, 2015; Wen and Lv, 2015), so a guideline validly guiding women in pregnancy or to be in pregnancy to control their BMI and GWG is always in demand. In 2009, a revised edition of the Institute of Medicine (IOM) guideline for GWG was developed for American women, advising the optimal GWG for women in different categories of pre-BMI according to the WHO classification (Institute of Medicine and National Research Council, 2009). However, there have so far been no official recommendations for Chinese women. The population of Chinese women, which is the largest in the world, is in urgent need of a guideline to manage their weight in pregnancy and pre-pregnancy. The biggest challenge for the application of IOM guidelines on Chinese is the difference of official BMI categories between America and China, which reflects the somatotype distribution deviation from American to Chinese (National Health and Family Planning Commission of the People's Republic of China, 2013). Nevertheless, the IOM guidelines have been much investigated as to their clinical suitability for Chinese women. Some studies found them suitable, among which a large population-based cohort study showed increased risks for adverse pregnancy outcomes in Chinese women with inadequate or excessive GWG based on the IOM recommendations, especially in women with extreme BMI (Liu *et al.*, 2012). Two other studies came to similar conclusions, except for some adjustments in pre-BMI categories to ease the somatotype distribution deviation between American and Chinese (Yang and Yang, 2012; Li *et al.*, 2013). In contrast, Yang *et al.* (2015) reported that more than 50% normal weight children in their study cohort were born from women with GWG above the IOM recommendations, suggesting that the IOM recommendations are not perfectly suitable for Chinese women. Li *et al.* (2015) also pointed out that the pre-BMI categories in the IOM guidelines were not the best for Chinese women. One aspect that is more important is that either the existing guidelines or previous studies always simultaneously focus on the pregnancy complications or adverse perinatal outcomes, so that these researches are more useful to women with complications or with a tendency towards complications, while there are always many more women without complications in the entire gestation in real life (Institute of Medicine and National Research Council, 2009; March of Dimes, 2010; Li *et al.*, 2013). Therefore, it is very important to discover what associations there might be among pre-BMI, GWG, and NBW in the Chinese population, so that a GWG guideline derived from and suitable for Chinese women can be produced.

In the present study, the clinical data of 3772 women, as a sample, were used to analyze the effects of pre-BMI and GWG on NBW, and the suitability of existing GWG recommendations is discussed among the population.

2 Material and methods

2.1 Participants

Ninghai is a county with over 600 thousand residents in Zhejiang Province, China, and more than 5000 infants are born in a year. Most pregnant women in Ninghai choose Ninghai Maternity and Child Health Care Hospital for prenatal management and delivery, and obstetrical information from other hospitals in this county will be submitted to Ninghai Maternity and Child Health Care Hospital. In other words, the obstetrical data of all the county are stored in this hospital. The present study was conducted using data from this hospital, it was restricted to women with uncomplicated full-term singleton gestation and delivery dates during the period from Oct.1, 2013 to Sept. 30, 2014, and the included women needed to have experienced well-recorded normative prenatal visits, which means the first prenatal visit and registering within the first 12 weeks, two visits in the next 16 weeks, at least one visit after the 36th week, and not fewer than five visits in the whole gestation (National Health and Family Planning Commission of the People's Republic of China, 2011). Women who before gestation had heart, liver, kidney, or thyroid disease or other complications, positive human immunodeficiency virus antibody, or any history of smoking or drug abuse were excluded.

Approval from the Institutional Ethics Committee in Women's Hospital, School of Medicine, Zhejiang University, China and the informed consents from all patients were obtained before the study started.

2.2 Data extraction and related definitions

The baseline characteristics and pregnancy outcomes of patients were obtained retrospectively from the clinical medical records by specially trained medical staff. Data included age, gestational age at delivery, times of prenatal test, height, pre-pregnancy weight, the weight at the 12th week, the 28th week, and the end of gestation, and their babies' BW and sex. Then the pre-BMI was calculated as weight in kilograms divided by the square of height in meters. The pre-BMI was categorized into four groups based on the standard in China (National Health and Family Planning Commission of the People's Republic of China, 2013): <18.5 kg/m^2 (underweight), 18.5–23.9 kg/m^2 (normal weight), 24.0–27.9 kg/m^2 (overweight), and ≥28.0 kg/m^2 (obesity). The total GWG was defined as weight at delivery minus pre-pregnancy weight, and the same went for weight gain in the first, second, and third trimesters, respectively. As defined by the World Health Organization (WHO), BW was divided into LBW (<2500 g), normal BW (2500–4000 g), and macrosomia or high BW (>4000 g). In addition, SGA was defined as BW less than the 10th percentile with the same gestational age, and LGA as BW more than the 90th percentile, in terms of the Chinese population (Zhu *et al.*, 2015).

2.3 Statistics

The data were analyzed using Software SPSS Version 22.0 and the graphics were obtained from Graphpad Prism 6.0. The measurement data and enumeration data were used in descriptive statistics to analyze the general characteristics of the population, with the measurement data expressed as medians and quartiles. The outcomes were focused on NBW and the proportion of abnormal NBW. The Kruskal-Wallis and chi-square tests were used to detect the difference of these variables among the four groups. Based on maternal pre-BMI and GWG, a general multivariate linear model and a multiple logistic regression model controlling for potential confounders were established, to analyze the role of maternal pre-BMI and GWG in determining NBW, especially abnormal NBW. Statistical significance was considered to be established when the P value was less than 0.05.

3 Results

3.1 Comparisons of clinical characteristics of participants

As shown in Table 1, the age, gestational age, and GWG were significantly different among the four groups based on pre-BMI categories (P<0.05), while the prenatal test time and height were not significantly different (P>0.05).

3.2 BW of neonates from women in the four groups

As shown in Fig. 1, the BW of neonates from women with higher pre-BMI, such as overweight women and obese women, was greater than that from women with normal or low pre-BMI (P<0.05 for all), and the BW of neonates from underweight women was lower than that from normal weight women (P<0.05). However, the BW of neonates of overweight women did not differ from that of obese women (P>0.05).

3.3 Multivariate linear regression analysis of NBW by adjusted coefficients of pre-BMI and GWG

As shown in Table 2, maternal pre-BMI was positively correlated with NBW (P<0.05), and the weight gain in each trimester was also significantly positively correlated with NBW (P<0.05 for all). Each kilogram of weight gain in the three trimesters for the whole population meant a statistically significant increase in NBW of 25.76, 30.52, and 10.82 g,

Table 1 Clinical characteristics of enrolled subjects

Group	*N*	Age (year)	Prenatal test (times)	Height (cm)	Gestational age (d)	GWG (g) Total	Trimester I	Trimester II	Trimester III
Underweight	691	27 (25, 29)	12 (10, 14)	160 (158, 163)	278 (272, 283)	14.7 (12.5, 17.5)	1.7 (0.6, 3.0)	7.0 (5.8, 8.8)	5.8 (4.3, 7.4)
Normal weight	2473	28 (26, 30)	12 (10, 13)	160 (157, 163)	278 (272, 283)	14.5 (12.0, 17.3)	1.5 (0.5, 2.5)	7.0 (5.4, 8.5)	5.8 (4.2, 7.4)
Overweight	494	30 (27, 34)	12 (10, 14)	160 (156, 163)	276 (271, 282)	12.6 (9.9, 15.7)	1.3 (0.4, 2.2)	6.0 (4.8, 7.7)	5.0 (3.6, 6.8)
Obesity	114	30 (27, 35)	12 (10, 14)	159 (156, 163)	274 (270, 281)	10.5 (8.0, 13.9)	1.0 (0, 2.5)	4.7 (3.0, 6.6)	4.5 (3.1, 6.1)
P		<0.05	>0.05	>0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Data are expressed as the median and quartile interval, except *N* and *P* values. Trimesters I, II, and III mean the first, second, and third trimesters, respectively. *N*: number; GWG: gestational weight gain. The Kruskal-Wallis test was used to analyze the difference among the four groups

Table 2 Effects of maternal pre-BMI and GWG on NBW analyzed by multivariate linear regression

Parameter	Unstandardized coefficient *B*	Unstandardized coefficient SE	Standardized coefficient	*P*
Pre-BMI (kg/m^2)	42.37	2.84	0.28	<0.05
WG in Trimester I (kg)	25.76	3.52	0.12	<0.05
WG in Trimester II (kg)	30.52	2.53	0.19	<0.05
WG in Trimester III (kg)	10.82	2.15	0.08	<0.05
WG in Trimester I in different pre-BMI categories (kg)*				
Underweight–normal weight	12.89	6.30	0.04	<0.05
Overweight–normal weight	−23.25	8.20	−0.05	<0.05

Results were adjusted by age, gestational age, height, and gender; data of obesity were excluded. Trimesters I, II, and III mean the first, second, and third trimesters, respectively. Pre-BMI: pre-pregnancy body mass index; GWG: gestational weight gain; NBW: neonatal birth weight; SE: standard error; WG: weight gain. * Interaction effect of pre-BMI category and WG in the first trimester, with pre-BMI category as the dummy variable

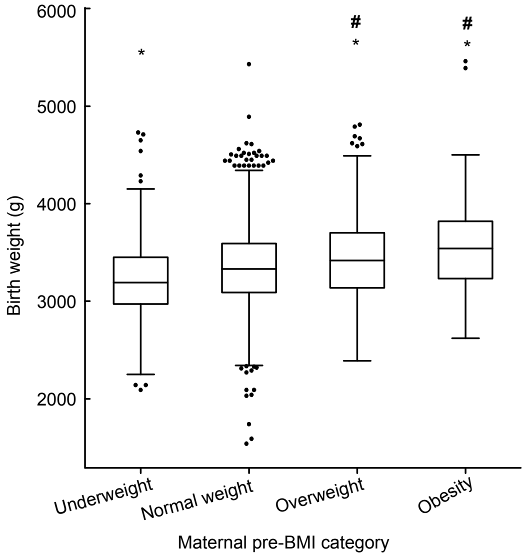

Fig. 1 Birth weight (BW) of neonates from women in the four groups
* P<0.05 when compared with the normal weight group; # P<0.05 when compared with the underweight group. Pre-BMI: pre-pregnancy body mass index. Data are expressed as the median and quartile interval

respectively. In the first trimester, compared with normal weight women, the NBW increased by 12.89 g for each kilogram weight gain for underweight women, and decreased by 23.25 g for overweight women.

3.4 Relationship of pre-BMI and GWG with macrosomia, SGA, and LGA

As shown in Table 3, for SGA, in comparison with normal weight before pregnancy, underweight predicted (odds ratio (OR)=1.86, 95% confidence interval (CI)=1.39–2.50) an increased risk, and overweight (OR=0.43, 95% CI=0.25–0.74) and obesity (OR=0.54, 95% CI=0.21–1.40) meant a decreased risk, with the CI of obesity including the null value. In contrast, underweight women had a decreased risk for giving birth to a macrosomia (OR=0.38, 95% CI=0.21–0.68) and LGA baby (OR=0.41, 95% CI=0.27–0.63), overweight women had an increased risk for giving birth to a macrosomia (OR=2.90, 95% CI=1.99–4.23) and LGA baby (OR=2.23, 95% CI=1.66–2.99), and obese women had the highest risks for macrosomia (OR=6.27, 95% CI=3.42–11.4) and LGA baby (OR=3.99, 95% CI=2.41–6.60). With every kilogram of increased GWG, the risk of SGA decreased by 9% (OR=0.91, 95% CI=0.88–0.94), while the risks of macrosomia (OR=1.13, 95% CI=1.10–1.16) and LGA (OR=1.10, 95% CI=1.08–1.13) increased by 13% and 10%, respectively. Among the four groups, similar results for the influence of pre-BMI on abnormal BW could be found (Fig. S1).

Table 3 Odds ratios for macrosomia, SGA, and LGA by weight gain and pre-BMI

Parameter	Adjusted ORs		
	Macrosomia	SGA	LGA
BMI categories			
Underweight	0.38 (0.21, 0.68)	1.86 (1.39, 2.50)	0.41 (0.27, 0.63)
Overweight	2.90 (1.99, 4.23)	0.43 (0.25, 0.74)	2.23 (1.66, 2.99)
Obesity	6.27 (3.42, 11.47)	0.54 (0.21, 1.40)	3.99 (2.41, 6.60)
Normal weight	1	1	1
Total GWG	1.13 (1.10, 1.16)	0.91 (0.88, 0.94)	1.10 (1.08, 1.13)

Results were adjusted by age, gestational age, height, and gender in the logistic regression model. Pre-BMI: pre-pregnancy body mass index; GWG: gestational weight gain; OR: odds ratio; SGA: small-for-gestational-age; LGA: large-for-gestational-age

3.5 Suitability of the 2009 IOM recommendations for Chinese women

As shown in Table S1 and Fig. 2, the quartile interval (25th to 75th percentiles) of GWG based on pre-BMI categories from the population was calculated as one comparison recommendation. On the one hand, it was able to predict some risks for abnormal BW in some aspects. On the other hand, the proportions of women with inappropriate weight gain (excessive or below) according to the quartile intervals in women with normal BW babies and women with appropriate gestational age (AGA) babies were both less than those according to the three other recommendations (the IOM recommendations, modified IOM recommendations in the study by Yang and Yang (2012), and modified IOM recommendations in the study by Li *et al*. (2013); $P<0.05$ for all), while there was no significant difference among the three other recommendations ($P>0.05$), which suggests that the IOM recommendations are not suitable.

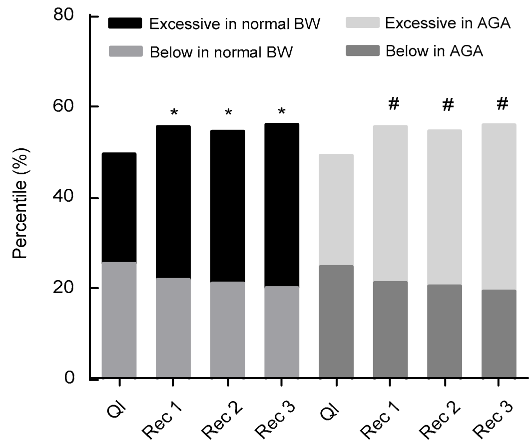

Fig. 2 Proportions of women with gestational weight gain (GWG) beyond the recommendations in women with normal birth weight (BW) baby and appropriate gestational age (AGA) baby

Data are presented as percentages. QI: the quartile interval of GWG from the present study; Rec 1: IOM recommendations in 2009; Rec 2: modified IOM recommendations in the study of Li *et al.* (2013); Rec 3: modified IOM recommendations in the study of Yang and Yang (2012). Excessive in AGA: the proportion of women with excessive GWG in women with AGA baby; Below in AGA: the proportion of women with inadequate GWG in women with AGA baby; Excessive in normal BW: the proportion of women with excessive GWG in women with normal BW baby; Below in normal BW: the proportion of women with inadequate GWG in women with normal BW baby. $^{*}P<0.05$ when compared with QI for normal BW; $^{\#}P<0.05$ when compared with QI for AGA

4 Discussion

In the present study of a population of Chinese women at term and without complications, we found that women with higher pre-BMI or more GWG more likely gave birth to heavier infants, also with higher risks for LGA and macrosomia, and vice versa. Weight gain in the first trimester meant different things to women in different pre-BMI categories, e.g. lower pre-BMI, stronger positive effect on NBW.

As one of the primary outcomes, NBW increased with the increase of pre-BMI level, although there was no significant difference between overweight women and obese women. Adjusted by confounders, pre-BMI was positively correlated with NBW. SGA, macrosomia, and LGA, as the concrete manifestations of abnormal NBW, are also associated with abnormal pre-BMI. Both the chi-squared analysis and the logistic regression analysis for the frequencies of SGA, macrosomia, and LGA based on pre-BMI showed that low pre-BMI was a risk factor for SGA and a preventive factor for macrosomia and LGA, and high pre-BMI was associated with increased risks for macrosomia and LGA, while it might evade SGA to some extent. Compared with normal weight women, women with low or high BMI are more likely to give birth to small or large babies, respectively, which was consistent with previous studies (Li *et al.*, 2013; Yu *et al.*, 2013; Fukuda *et al.*, 2015; Sharifzadeh *et al.*, 2015).

In addition to pre-BMI, GWG also plays an important role in determining NBW. In studies of the association of GWG and NBW, it has been widely found that the former positively influenced the latter (Institute of Medicine and National Research Council, 2009), and some studies have further discovered that each kilogram of weight gain in the second trimester has the strongest effect among the three trimesters (Abrams and Selvin, 1995; Institute of Medicine and National Research Council, 2009; Bayer *et al.*, 2014). The present study came to a similar conclusion that GWG has a positive effect on NBW with weight gain in the second trimester the most prominent. Not only that, we found that the BMI level could modify the relationship between weight gain in the first trimester and NBW. The lower the BMI level, the greater the effect of weight gain in the first trimester. To be specific, each kilogram of weight gain in the first trimester meant 12.89 g more and 23.25 g less NBW for underweight and overweight women, respectively, than that for normal weight women, which would subsequently influence the effects of weight gain in all three trimesters on NBW. The modification suggests that a woman in pregnancy needs not only to control the rate and the amount of weight gain, but also to pay attention to the pattern of weight gain among the three trimesters, according to her pre-BMI. For example, a pregnant woman with overweight pre-BMI should pay more attention to the weight gain in the last two trimesters, instead of the first trimester.

The suitability of the IOM guideline for Chinese women has been widely noted and investigated, resulting in no consensus (Liu *et al.*, 2012; Yang *et al.*, 2015). The present study compared the IOM criterion and two of its modified versions with one criterion just derived from the quartile interval of GWG from the sample, finding that the proportions of women beyond the recommendations of the former three were all significantly higher whether in women with normal BW babies or in women with AGA babies. This did not mean that the criterion just derived from the quartile interval was more suitable for Chinese women, but showed that the IOM guideline was not the best choice.

It is worth noting that the results and conclusions were from the population of women at term and with no complications in pregnancy, in other words, abnormal or adverse pregnancy outcomes in the present study might be more infrequent and more complicated, so that some of the resulting conclusions may present a little differently from similar studies. What is most prominent is that there are only 42 women with LBW infants accounting for only 1.1% of all subjects, none in the obese group, so that the statistical power for LBW is unsatisfactory, let alone provide definitive conclusions. Moreover, there were some non-significant results involved with obese women. Overweight was associated with a decreased risk for SGA while obesity did not follow the trend. The 95% CI of obesity for SGA included the null value with 0.54 as the estimated OR. The abnormal phenomenon was not only observed in the present study. Vesco *et al.* (2011) found that weight gain above the IOM recommendations for obese women was not significantly associated with a decreased risk for SGA. In fact, obesity is associated with fetal overgrowth resulting in macrosomia and LGA; however also it was found to be involved in intrauterine growth retardation, and nutrient exchange abnormity through the placenta was regarded as one of the possible mechanisms (Higgins *et al.*, 2011). The subsequent studies found that some of the placenta functions in obese women were adversely affected, such as the reduction in placental taurine transporter activity and the reduction in placental villous proliferation (Higgins *et al.*, 2013; Ditchfield *et al.*, 2015). Hence it is not so hard to understand the other non-significant results involving obesity, given its negative effect on NBW, and that is also why the data of obese women were not included in the linear regression analysis. Certainly, other factors causing the abnormity cannot be eliminated, such as the small size of obese subjects and unmeasured clinical information as confounders.

Some strengths and limitations need to be noted when interpreting the results of the present study. The chosen subjects are the innovation of the study, who were all with full-term gestation and without complications, which are much more common in pregnant women. The analysis on the pregnant characteristics of these women is more meaningful for women out of medical conditions. To our knowledge, it is the first time that women's pre-BMI has been found to influence the effect of WG on NBW in different trimesters, especially in the first trimester, something which should be considered when drawing up guidelines. Several limitations of the study should also be considered. First, it is a retrospective study, so some biases are inevitable though the data were screened carefully. Also, some other information of the subjects, like parity, is missed. Second, the sample size was not large enough and all subjects were from one hospital. Thus the credibility of the conclusions is limited. However, the women's anthropometric characteristics during the entire gestation were available, which was helpful for more clearly analyzing the relationships among pre-BMI, GWG, and NBW. Third, given the innovation in taking our sample at term for those without complications, the conclusions are limited for pregnant women not at term or with complications.

5 Conclusions

In conclusion, the present study indicated that, for Chinese pregnant women at term and with no complications, their offspring's BW was positively affected both by their pre-BMI and GWG, and both extreme pre-BMI and extreme GWG were associated with an increased risk for abnormal NBW. In addition, the pre-BMI category might modify the effect of WG in the first trimester on NBW. Moreover, the IOM guideline and some modified versions for GWG are not perfectly suitable for Chinese women. Studies of a larger size and better design are needed.

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Compliance with ethics guidelines

Meng-kai DU, Li-ya GE, Meng-lin ZHOU, Jun YING, Fan QU, Min-yue DONG, and Dan-qing CHEN declare that they have no conflict of interest.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5). Informed consent was obtained from all patients for being included in the study.

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List of electronic supplementary materials

Fig. S1 Proportions of LBW, macrosomia, SGA, and LGA in neonates from women in the four pre-BMI categories

Table S1 Odds ratios for macrosomia, SGA, and LGA based on total GWG according to the criterions in the four GWG recommendations

中文概要

题　目：孕前体质量指数与孕期增重对新生儿出生体重的影响

目　的：评估中国健康孕妇人群中，母亲孕前体质量指数

和孕期增重对新生儿出生体重的影响，以期能指导合理的孕期增重。

创新点：选择的人群为健康妊娠的中国孕妇，研究结果可为这一数目庞大的特定人群的孕期甚至孕前体重控制提供一定的理论基础。首次发现了孕前体质量指数可影响孕期各阶段增重与新生儿出生体重之间的关系。

方　法：本文做了一个样本为 3772 例中国孕妇的回顾性研究。根据孕前体质量指数将人群分为四组，分别为低体重组（<18.5 kg/m^2）、正常体重组（18.5–23.9 kg/m^2）、超重组（24.0–27.9 kg/m^2）和肥胖组（≥28.0 kg/m^2）。比较这四组间新生儿出生体重的差异，并用多元分析的方法探究孕前体质量指数、孕期增重和新生儿出生体重之间的关系。

结　论：孕妇孕前体质量指数和孕期增重均与新生儿出生体重呈正相关（表 2），极端的孕前体质量指数和孕期增重均会增加异常新生儿出生体重的风险（表 3）；孕期各阶段增重对新生儿出生体重的影响程度可能还受到孕前体质量指数的影响（表 2）。对中国妇女来说，已有的孕期增重指南似乎并不十分合适（图 2），制定一个有效的指南刻不容缓。

关键词：孕前体质量指数；孕期增重；新生儿出生体重；合理的增重方式