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Maternal Weight Levels Before and During Gestation as Indicators of Pregnancy Outcomes in Zibo, China

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To examine the correlation of maternal weight gain before and during pregnancy with the health of mother and child, and to provide guidelines on weight control during pregnancy among Chinese women.
Study Design: Subjects were grouped according to pre-pregnancy body mass index (BMI) and gestational weight gain, and then evaluated based on their risks of pregnancy complications. The birth outcomes were also recorded to study the influence of mothers' weight gain on the health of their children.
Place and Duration of Study: Department of Obstetrics, Zibo Central Hospital, between August and December 2016.
Methodology: We included a total of 808 primiparous women who finished all periodic examinations in Zibo Central Hospital, China during the study period. Incidences of multiple common pregnancy complications were recorded to evaluate the health risk of each group. After delivery, the nutritional conditions of newborns were evaluated with their body weights.
Results: Observation to subjects reveals the positive correlation between pre-pregnancy BMI and the incidence of gestational hypertension (1.3% vs. 7.7% between low body weight group and obese group). On the other hand, gestational body weight gain was found to be associated with multiple unfavorable pregnancy outcomes including hypertension disorder complicating pregnancy (2.6% vs. 8.9% between weight gain $\Delta W \leq 10$kg and $\Delta W \geq 20$kg), gestational diabetes mellitus (9.0% vs. 23.6% between weight gain $\Delta W \leq 10$kg and $\Delta W \geq 20$kg) and premature rupture of membranes (3.9% vs. 6.7% between weight gain $\Delta W \leq 10$kg and $\Delta W \geq 20$kg). Both pre-pregnancy BMI and gestational body weight correlate positively with infant body weights.
Conclusion: Both pre-pregnancy BMI and gestational weight gain are indicators of pregnancy

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outcomes. Particularly, gestational weight increase between 10 and 15 kg is recommended to counteract negative influence of non-optimal pre-pregnancy BMI and lead to satisfactory pregnancy outcomes.

Keywords: Body mass index; pregnancy outcome; nutrition.

ABBREVIATIONS

BMI : Body Mass Index
GDM : Gestational Diabetes Mellitus
PROM : Premature Rupture of Membranes
HDCP : hypertension Disorder Complicating Pregnancy

1. INTRODUCTION

Rapid growth of the overweight/obese population has become a public health issue in China. Such growth is a result of improved nutrition and the influence of a Western-style diet that came with the economic growth [1]. During pregnancy, women usually have an even more excessive intake of nutrients. The lack of awareness for exercise also contributes to this problem. It has been reported [1,2] that the increase in BMI and weight gain during pregnancy both contribute to adverse perinatal outcomes. However, no universally accepted standard regarding an appropriate weight gain during pregnancy has been provided to clinical practitioners in this country. In this research, body weight data from a total of 808 pregnant women who completed periodic examinations and deliveries at Zibo Central Hospital from August to December 2016 were analyzed to determine the optimal weight gain during pregnancy.

2. METHODOLOGY

2.1 Subjects

808 primiparous women with a single-fetus pregnancy who gave birth at Zibo Central Hospital, China, from August 1st to December 31st, 2016. Inclusion criteria: Health before pregnancy. No cardiac, hepatic, nephritic and thyroid diseases. No chronic diseases such as diabetes and hypertension. No placenta previa, placental abruption or intrahepatic cholestasis during pregnancy. No history of alcohol addiction, drug abuse or smoking habit. Natural conception. Profile created in our obstetrical department at the beginning of pregnancy. Detailed periodic check-up records available. Upon voluntary and informed consent, women who met all the above requirements were recruited for this study.

2.2 Methods

The weight before pregnancy was considered as the pre-pregnancy weight. Pre-pregnancy body mass index (BMI) is defined as BMI = pre-pregnancy weight (kg)/height (m^2). Gestational weight gain was defined as the different between weight at the end of pregnancy and weight before pregnancy. According to BMI classification for Chinese adults proposed by the Working Group on Obesity in China [3], the participants were classified as low weight group (<18.5 kg/m^2), normal weight group (18.5 - 23.9 kg/m^2), overweight group (24 - 27.9 kg/m^2) and obese group (≥ 28 kg/m^2) based on pre-pregnancy BMI. Based on the analysis by Lv [4], the participants were put in four groups based on weight gain levels during pregnancy (ΔW): ΔW ≤ 10 kg, 10 kg < ΔW≤15 kg, 15 kg < ΔW≤20 kg, and ΔW > 20 kg.

2.3 Outcome Evaluation

Outcome of pregnancy was evaluated based on the morbidity of gestational hypertension, gestational diabetes mellitus (GDM), premature rupture of membranes (PROM), gestational anemia, low/high birth weight, and the average weight of the infant.

2.4 Statistics Analysis

All data were entered into Excel and analyzed using SPSS. Measurements were expressed in the form of mean ± standard deviation. Comparison among groups was done by ANOVA. Qualitative data were expressed as percentages. The chi-square test was also used to test group data. The significance level was set as $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1 The Influence of Pre-pregnancy BMI on Pregnancy Outcomes

The incidences of unfavorable pregnancy outcomes in women with different pre-pregnancy BMI were summarized in Table 1. Positive correlation was found between the risk of gestational hypertension and BMI. On the other

hand, highest possibility of gestational diabetes was observed in women with normal weight or being overweight before pregnancy, while low weight and obese women showed lower risk. As for other symptoms, normal or obese women showed highest risk of PROM, whereas the highest ratio of gestational anemia was observed in the low weight group.

3.2 The Effects of Pre-pregnancy BMI on Newborn Infant Weight

Analysis of the newborn weights was summarized in Table 2. The newborns were categorized based on the pre-pregnancy BMI groups that their mothers belong to. There were significant differences in the newborn infants' weights among groups with different pre-pregnancy BMI. We used the LSD test to compare the infant weights for every two groups. The results indicate the presence of positive correlation between the pre-pregnancy BMI of mother and birth weight of her newborn, in that newborns delivered by mothers from low BMI and normal BMI groups had lower birth weight than those delivered by overweight or obese mothers.

3.3 The Influence of Gestational Weight Gain on Pregnancy Outcomes

Chi-square test was done to determine the correlation between gestational weight gain and perinatal outcomes. The results indicated

Table 1. The incidence of unfavorable pregnancy outcomes in women with different pre-pregnancy BMI

Group	N	Gestational hypertension (percentage)	GDM (percentage)	PROM (percentage)	Gestational anemia (percentage)
Low weight	78	1 (1.3)	4 (5.1)	1 (1.3)	2 (2.6)
Normal weight	489	19 (3.9)	77 (15.7)	30 (6.1)	6 (1.2)
Overweight	176	11 (6.3)	28 (15.9)	8 (4.5)	2 (1.1)
Obese	65	5 (7.7)	7 (10.7)	4 (6.1)	1 (1.5)
$\chi 2$	37.845				
P	<0.001				

Table 2. The influence of maternal BMI on birth weight of newborn

Group	N	Newborn birth weight (g)	F	P	MS
Low weight (BMI ≤ 18.5)	78	3214.81±402.830	6.330	<0.001	1227827.75
Normal (18.5 < BMI ≤ 23.9)	489	3336.83±443.878			
Overweight (24 ≤ BMI ≤ 27.9)	176	3516.35±432.280			
Obese (BMI ≥ 28)	65	3530.77±463.474			

Table 3. The incidence of unfavorable pregnancy outcomes in women with different gestational weight gain

Group	HDCP (Percentage)	GDM (Percentage)	PROM (Percentage)	Gestational anemia (Percentage)
ΔW < 10 kg	2 (2.6)	7 (9)	3 (3.9)	2 (2.6)
10 kg ≤ ΔW < 15 kg	6 (1.8)	33 (9.8)	13 (3.9)	5 (1.5)
15 kg ≤ ΔW < 20 kg	12 (5.5)	34 (15.7)	15 (6.9)	3 (1.4)
ΔW ≥ 20 kg	16 (8.9)	42 (23.6)	12 (6.7)	1 (0.6)
$\chi 2$	57.989			
P	<0.001			

Table 4. The influence of gestational weight gain on birth weight of newborn

Group	N	Newborn infant weight gain			$\chi 2$	P
		<2500	2500-3950	≥4000		
ΔW≤10 kg	77	10 (13.0)	59 (76.6)	8 (10.4)	12.965	0.001
10 kg <ΔW≤15 kg	337	11 (3.3)	292 (86.6)	34 (10.1)		
15 kg<ΔW≤20 kg	216	12 (5.5)	161 (74.5)	43 (20.0)		
ΔW > 20 kg	178	8 (4.5)	132 (74.2)	38 (21.3)		

significant differences. The group with ΔW > 20 kg had greater incidence of hypertension disorder complicating pregnancy (HDCP) and gestational diabetes mellitus (GDM) than did other groups. See Table 3.

3.4 The Influence of Maternal Weight Gain on Newborn Weight

As gestational weight gain and newborn birth weight are both ranked data, we used a nonparametric test for this analysis. The results indicated differences in the birth weights of newborns. We then used the Mann-Whitney U test to determine whether there was a correlation between newborn birth weights and maternal weight gain. The correlation coefficient was 0.141, p = 0.001, indicating a low correlation, i.e. a higher level of gestational weight gain may implicate a higher newborn birth weight (Table 4).

3.5 Discussion

3.5.1 Influence of maternal pre-pregnancy BMI on pregnancy outcomes

Pre-pregnancy BMI was regarded as an important risk factor of pregnancy complications. For example, it was reported to be positively correlated with the risk of gestational hypertension [5]. A pilot research including 16,000 pregnant women showed that obese women had 150% and 60% increase respectively in the risk of gestational hypertension and preeclampsia [6]. We observed the positive correlation between pre-pregnancy BMI and incidence of gestational hypertension. However, different from the conclusion by Torloni et al. that positive correlation also presents between pre-pregnancy BMI and GDM [7], our data suggested higher incidence of GDM in normal weight pregnant women versus obese group. These two groups should similar levels of body weight increase during pregnancy (15.46±3.09 kg vs.15.65±5.39 kg). It seems that a higher ratio of body weight increase may still bring negative influence to women regardless of their normal pre-pregnancy BMIs. The lower percentage of body weight increase observed in obese women may result from their intentional weight control during pregnancy.

3.5.2 Correlation of maternal pre-pregnancy BMI with infant birth weight

Maternal nutritional status and weight gain during pregnancy are important indicators of maternal health and fetal growth. Adverse impact of maternal obesity before and during pregnancy on the health of both mothers and infants has been reported [8]. Currently, possible factors such as maternal BMI that directly or indirectly affect birth weight are attracting increasing research interests. Infants with higher birth weights were more likely to be delivered by obese mothers with higher pre-pregnancy weight or higher during-pregnancy weight gain than those mothers with normal or low weight [8]. Our data suggested positive correlation between fetal birth weight and maternal pre-pregnancy BMI. The pre-pregnancy BMI indicates the nutritional status before pregnancy; a low pre-pregnancy BMI reflects lack of maternal nutrition storage, resulting in slow fetal growth and even undesirable outcomes. Therefore, proper weight gain during pregnancy is desirable for women with low pre-pregnancy BMI.

3.5.3 Influence of gestational weight gain on pregnancy outcomes

Studies have shown that angiotensin II induces vasoconstriction in the human placental vasculature. Concentrations of Angiotensin II and angiotensin-converting enzyme were also found to increase at blood circulation in the placenta during preeclampsia, meanwhile the concentrations of angiotensin I and angiotensin 1-7 remain unchanged. Therefore, angiotensin II can sufficiently maintain placental vascular tension and hence plays a critical role in hypertension in preeclampsia [9]. Gaining excessive weight during pregnancy results in abnormal subcutaneous fat deposition, thus promoting estrogen overproduction. The excessive estrogen further induces increased aldosterone, which enhances rental distal tubule absorption via regulating renin-angiotensin system, causing persistence of water-sodium retention that increases the risk of gestational hypertension. This study shows that the risks of gestational hypertension and GDM increase along with gestational weight gain with highest risk found when weight gain during pregnancy exceeds 20 kg. Excessive weight gain during pregnancy has been identified as a major risk factor for GDM, in particular excessive weight gain in the early stage of pregnancy is a significant risk factor for adverse pregnancy outcomes [10]. Therefore, maintenance of optimal body weight before and during early stage of pregnancy is an important measure to prevent pregnancy complications, especially GDM.

3.5.4 Influence of gestational weight gain on infant birth weight

Infants are physiologically sensitive. In addition to genetic factors, exposure to different environmental conditions during pre-pregnant, antenatal and perinatal periods also directly influences their current physiological and even future reproductive health [11,12]. Birth weight of infants reflects the level of growth and development before delivery, which is an important index for health assessment. It was found that abnormal birth weight indicated adverse outcomes to the health of both mother and infant, and was closely associated with infant disease and death, and even long-term health risks [13-15]. Our data show a positive correlation exist between weight gaining during pregnancy and birth weight. Weight gaining ΔW at the range between 10-15 kg suggests optimal birth weight, meanwhile higher incidences of low birth weight or overweight infant were found when ΔW is smaller than 10 kg or beyond 20 kg, respectively. This correlation is consistent with previous studies on women with various ethnic backgrounds. The analysis by Pongcharoen et al. showed that mothers with excessive weight gaining during pregnancy had 8 folds higher risk of delivering overweight infant than those with normal increase in weight [16]. Mathematical fitting work published by Murai has further indicated that mothers who gain less than 8.5 kg during pregnancy are more likely to give birth to infants with a low weight, but there was no statistically significant correlation between maternal weight gain and low birth weight when the mother gained 10.5 to 12.0 kg during pregnancy [17]. Another study that focused on the positive correlation between birth weight and weight gaining during pregnancy further divided pregnancy into certain stages. According to their data, 1 kg weight increase in early stage of pregnancy predicts 31 g increase of birth weight, whereas an increase of 26 g is expected for every 1 kg weight increase at medium stage [18].

4. CONCLUSION

Body weight levels before and during pregnancy are both indicators of pregnancy outcomes. However, it is a pity that no clinical guideline has been issued so far on optimal weight gain during pregnancy for Chinese population. The current clinical practice refers to the protocol made by US Institute of Medicine and National Research Council in 2009 [19], which recommends weight gain of 12.8 - 18.0 kg for women with low pre-pregnancy body weight (BMI < 18.5 kg/m^2), 11.5 - 16.0 kg for normal pre-pregnancy body weight (18.5 kg/m^2 ≤ BMI < 25.0 kg/m^2), 7.0 - 11.5 kg for overweight (25.0 kg/m^2 ≤ BMI < 30.0 kg/m^2) and only 5.0 - 9.0 kg for obese women (BMI ≥ 30.0 kg/m^2). Whether such recommend-dations are representative enough for Chinese women is uncertain. Therefore, we started this study trying to observe the overall influence of pre-pregnancy BMI and gestational weight gain on pregnancy outcomes. Our data suggest that not all undesirable pregnancy outcomes may have their incidences following strict positive correlation with these two indices. According to our observation, excessive weight gain during pregnancy may be followed by increasing possibility of undesirable pregnancy outcomes regardless of normal pre-pregnancy BMI. On the other hand, negative influence from abnormal pre-pregnant body weight may be remedied by proper weight level during pregnancy. Our observations reveals that gestational weight gain may be a particularly important index to evaluate nutritional status during pregnancy, as it mainly comes from increscent uterus and breasts, increased fat storage as well as the fetus and its appendages such as amniotic fluid and placenta. Our preliminary study does not aim to provide detailed recommendation on weight gain during pregnancy for pregnant women with different body weights; instead, we tried to analyze the data and summarize comparatively safe range of weight gain during pregnancy for all women. Our observation suggests that ΔW between 10 and 15 kg may be a good range for satisfactory pregnancy outcomes. In practice, nutritionally adequate diet and optimal amount of physical activity are hence needed to achieve optimal weight gain with the help of advice by medical staff to achieve favorable pregnancy outcomes. The goal of such body weight management is to maintain gestational weight increase at proper level, minimize risk of pregnancy complications and encourage favorable perinatal outcomes.

The significance of our study is limited by source of subjects as they are recruited from pregnant women admitted to Zibo Central Hospital only. Therefore, future larger size study is hereby needed to determine the specific recommended gestational weight gain levels for different pre-pregnancy BMIs, which will be more widely applicable in medical practices.

CONSENT

All authors declare that written informed consent was obtained from the subjects for

publication of this case report and accompanying images.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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