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Original Research

Restricted gestational weight gain in overweight/obese women with gestational diabetes mellitus and pregnancy outcomes

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Summary

Purpose of Investigation: Obesity and gestational diabetes mellitus (GDM) are risk factors for adverse pregnancy outcomes. This retrospective study examined the effects of GDM treatment on pregnancy outcomes and gestational weight gain (GWG) among overweight/obese women. *Materials and Methods:* This study included 1,936 women with singleton pregnancies. Multivariate logistic regression analysis and Pearson's chi-square tests were performed to the association of interest. *Results:* Overweight/obese women had higher rates of adverse outcomes than normal weight women. In overweight/obese group, women with GDM had a lower risk of primary cesarean section, instrumental delivery, and admission to neonatal intensive care unit (NICU) than women without GDM. Overweight/obese women with GDM had lower GWG than those without GDM and the prevalence of excessive GWG was also lower among overweight/obese women with GDM than those without GDM. *Conclusion:* Diet and exercise interventions improved pregnancy outcomes and limited GWG in overweight/obese women with GDM. Lower GWG limits may be more applicable to GDM population.

Key words: Gestational diabetes mellitus; Gestational weight gain; Obesity; Overweight; Pregnancy outcomes.

Introduction

In recent years, the prevalence of obesity among women of childbearing age has risen, which has made obesity the most common medical problem in pregnancy [1, 2]. Previous studies have shown that pre-pregnancy obesity increases maternal and neonatal morbidity, and is strongly associated with a variety of adverse reproductive outcomes, including increased rate of gestational diabetes mellitus (GDM), hypertensive disorders of pregnancy (HDP), cesarean section and instrumental deliveries, preterm birth, fetal growth disorders, and admission to a neonatal intensive care unit (NICU) [2-8]. GDM is of particular concern in pregnancy because it increases the risk of a number of pregnancy complications, including preeclampsia, fetal macrosomia, and cesarean delivery [9]. Compared to normal weight women, obese women have a two- to ten-fold increased risk for GDM [10, 11]. GDM and maternal obesity often coexist and are associated with increased perinatal complications [12].

The previous report from the Hyperglycemia and Adverse Pregnancy Outcomes (HAPO) study has shown that both maternal GDM and obesity are independently associated with adverse pregnancy outcomes. The combination of these two factors shows a greater risk of adverse pregnancy outcomes than either one alone [3]. The one-step new International Association of the Diabetes and Pregnancy Study Groups (IADPSG) criteria is well-established for GDM screening and diagnosis [13].

Several previous studies have assessed the relation between obesity and pregnancy outcomes in diet and exercise-treated GDM [13-15], yet few were conducted on overweight/obese women in China. Women who are overweight or obese before pregnancy tend to have excessive gestational weight gains (GWG), and GWG is an independent risk factor for negative obstetric outcomes [16-18]. After GDM is diagnosed, diet plus exercise intervention can be effective in helping limit weight gain during pregnancy in overweight or obese women. Although previous reports have shown that lower GWG is associated with improved outcomes for women with obesity [19, 20], scant data exist to demonstrate the interaction between GDM treatment and GWG in overweight/obese women with GDM. The present authors conducted a retrospective analysis to determine whether standardized management to GDM could reduce adverse maternal and neonatal outcomes in overweight/obese women with GDM in China. They also assessed the associations between GDM treatment and GWG, and evaluated what was the optimal GWG to have better maternal and neonatal outcomes in overweight/obese Chinese women with GDM.

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Materials and Methods

This investigation conforms to the principles outlined in the Declaration of Helsinki. The protocol was approved by the Ethics Committee of Qingdao Municipal Hospital, Qingdao, China, No. 2018linshenzi-007. All participants provided written informed consent.

From January 2014 to September 2017, 7,824 pregnant women received prenatal medical care and delivered at the Obstetrics and Gynecology Department of Qingdao Municipal Hospital. This study is a retrospective analysis of data collected prospectively from these women. All pregnant women were eligible to participate in this study unless they had one or more of the following exclusion criteria: [1] incomplete medical data available, [2] multiple pregnancy, [3] a history of miscarriage or medical abortion before 28 weeks of gestation, [4) a history of smoking, [5] uterine scaring, [6] a history of hypertension, diabetes, cardiac disease, renal disease, systemic lupus erythematosus, thyroid disease, or psychosis. Finally, a total of 1,936 pregnant women were included in this retrospective analysis. The maternal pre-pregnancy body mass index (PPBMI), maternal age, parity, gestational age (GA) at delivery, glycosylated hemoglobin (HbA1c) in the third trimester, GWG, and birth weight were recorded.

PPBMI was defined as the maternal pre-pregnancy weight in kilograms divided by the square of the height in meters. Mean PPBMI was calculated based on participants' self-reported pre-pregnancy weight. Overweight and obesity were defined according to the Group of China Obesity Task Force recommended body mass index (BMI) classification reference [21]: underweight (BMI < 18.5 kg/m^2), normal weight (BMI 18.5–23.9 kg/m^2), overweight (BMI 24–27.9 kg/m^2), or obese (BMI ≥ 28 kg/m^2). Participants were categorized into two groups according to the values of PPBMI: normal-weight (PPBMI < 24.0 kg/m^2) and overweight/obese (PPBMI ≥24.0 kg/m^2). Considering the number of participants in underweight and obese groups were small, women with PPBMI <18.5 kg/m^2 were included in normal weight group and women with PPBMI ≥ 28 kg/m^2 were included in overweight/obese group. GWG was calculated as the difference between documented weight at last prenatal visit and self-reported pre-pregnancy weight. According to the guidelines issued by U.S. Institute of Medicine (IOM) [22], underweight women (BMI < 18.5 kg/m^2) should gain 12.5–18 kg during pregnancy, normal weight women (BMI 18.5–23.9 kg/m^2) should gain 11.5–16 kg during pregnancy, overweight women should gain 7–11.5 kg, and obese women should only gain 5–9 kg during pregnancy.

Participants underwent a one-step oral glucose-tolerance test (OGTT) at 24–28 gestational weeks in accordance with the consensus guidelines issued by IADPSG [23). A 75-gram glucose load was administered after fasting glucose, and plasma glucose levels were measured at fasting, one and two hours after administration. GDM was diagnosed if any of the glucose values were at or above the specific glucose threshold (≥ 5.1 mmol/L at fasting, ≥ 10.0 mmol/L at one hour and ≥ 8.5 mmol/L at two hours). The normal weight and overweight/obese groups were subdivided into GDM and non-GDM groups according to the results of OGTT.

Maternal outcomes were HDP, primary cesarean section, and instrumental delivery. Neonatal outcomes were large for gestational age (LGA) infant (birth weight > 90th percentile for gestational age), small for gestational age (SGA) infant (birth weight < 10th percentile for gestational age), premature delivery (before 37 weeks of gestation), admission to NICU, and a low Apgar score at one minute after birth (Apgar score < 7).

Women diagnosed with GDM received dietary recommendations and were encouraged to increase aerobic physical activities, which could help them to achieve optimal blood glucose control (BGL) (fasting 3.3–5.6 mmol/L; two-hour postprandial 4.4–6.7 mmol/L, and night 4.4–6.7 mmol/L). For those women with fasting BGL ≥ 5.3 mmol/L and/or two-hour postprandial BGL ≥ 6.7 mmol/L despite dietary and exercise intervention, insulin therapy was initiated. Women without GDM received standard prenatal care.

Table 1. — *Characteristics of the participants and their newborns.*

	Normal weight	Overweight/obese	*p*
n (%)	1491 (77.0)	445 (23.0)	
PPBMI (kg/m^2, mean ± SD)	20.0±2.2	26.8±2.8	0.009
Age (years, mean ± SD)	29.1±3.0	30.3±3.2	0.124
< 35, n (%)	1319 (83.1)	327 (16.9)	
> 35, n (%)	226 (77.9)	64 (22.1)	
Parity (mean ± SD)	1.8±1.2	1.9±1.4	0.682
Primiparus, n (%)	1271 (80.7)	304 (19.3)	
GA at delivery (weeks, mean ± SD)	39.1±1.1	38.6±1.4	0.050
HbA1c in the third trimester (%, mean ± SD)	5.1±1.1	5.7±1.0	0.031
GWG (kg, mean ± SD)	13.9±4.9	10.1±5.5	0.018
Birth weight (g, mean ± SD)	3280±160	3506±480	0.008

n: number; PPBMI: pre-pregnancy body mass index; SD: standard deviation; GA: gestational age; HbA1c: glycosylated hemoglobin; GWG: gestational weight gain.

SPSS version 17.0 was used for statistical analysis. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as number and percentage. Independent samples *t*-test and analysis of variance were employed to evaluate the difference in means between two groups. Pearson's chi-square test was used for testing relationships on categorical variables. *P* values of less than 0.05 were considered statistically significant.

After adjusting for the potential confounding factors, the associations between GDM treatment and adverse pregnancy outcomes (HDP, LGA, SGA, primary cesarean section, instrumental delivery, premature delivery, Apgar score < 7 at one minute, and admission to NICU) were assessed with multivariate logistic regression analysis. Adjusted odds ratios (AORs) and 95% confidence intervals (CIs) were computed for each pregnancy outcome, in order to measure the odds of each outcome occurring in women with GDM treatment relative to those without GDM treatment.

All ORs were adjusted for maternal age, GA at delivery, and PPBMI. Additional adjustments were made as follows: parity and HbA1c in the third trimester for LGA, SGA, premature delivery; parity, birth weight, and HbA1c in the third trimester for primary caesarean section and instrumental delivery, and birth weight for Apgar score < 7 at one minute and admission to NICU.

Results

The clinical characteristics of the study cohort are shown in Table 1. The mean age of the 1,936 pregnant women at delivery was 30.6 years and the mean PPBMI was 22.7 kg/m^2. Among the participants, 1,575 women were primi-

Table 2. — *Variation of the obstetric and neonatal outcomes in each of the pre-pregnancy body mass index groups.*

	n	Normal weight	Overweight/obese	X^2/F	*p*
		n (%)	n (%)		
n (%)	1936	1491 (77.0)	445 (23)		
GDM	223	147 (9.9)	76 (17.1)	17.526	<0.001
HDP	117	67 (4.5)	50 (11.2)	27.437	<0.001
LGA	174	107 (7.2)	67 (15.1)	26.015	<0.001
SGA	15	12 (0.8)	3 (0.7)	0.076	0.783
Caesarean section	669	406 (27.2)	263 (59.1)	153.934	<0.001
Instrumental delivery	234	158 (10.6)	76 (17.1)	13.550	<0.001
Premature delivery	84	57 (3.8)	27 (6.1)	4.160	0.041
Apgar score at < 7 at 1 minute	59	46 (3.1)	13 (2.9)	0.031	0.861
Admission to NICU	118	60 (4.0)	58(13)	48.604	<0.001

n: number; GDM: gestational diabetes mellitus; HDP: hypertensive disorders of pregnancy; LGA: large for gestational age; SGA: small for gestational age; NICU:neonatal intensive care unit

para and 361 were multipara. According to PPBMI, 1,491 (77.0%) women were normal weight (PPBMI < 24.0 kg/m^2) and 445 (23.0%) were overweight/obese (PPBMI ≥ 24.0 kg/m^2). Compared with normal weight group, overweight/obese group had significantly lower GWG (13.9 ± 4.9 kg *vs*. 10.1 ± 5.5 kg, $p = 0.018$), higher level of HbA1c in the third trimester (5.7 ± 1.0 *vs*. 5.1 ± 1.1, $p = 0.031$), and higher birth weight (3506 ± 480 g *vs*. 3280 ± 160 grams, $p = 0.008$). No significant difference in age, parity, and GA at delivery was observed between normal weight and overweight/obese groups. Table 2 summarizes adverse obstetric and neonatal outcomes occurring in each PPBMI group. In comparison to normal weight group, overweight/obese group had significantly higher incidence of GDM ($p < 0.001$), HDP ($p < 0.001$), cesarean section ($p < 0.001$), instrumental delivery ($p < 0.001$), premature delivery ($p = 0.041$), LGA ($p < 0.001$), and admission to NICU ($p < 0.001$). However, there was no significant difference in the incidence of SGA and Apgar score < 7 at one minute between the two PPBMI groups.

Table 3 shows the effects of GDM treatment on pregnancy outcomes. GDM treatment appeared to be a protective factor that limited adverse pregnancy outcomes. Compared to normal weight women without GDM treatment, normal weight women with GDM treatment had a significantly lower incidence of cesarean section (AOR 0.435, 95% CI 0.246–0.701, $p < 0.001$), and compared to overweight/obese women without GDM treatment, those with GDM treatment had a significantly lower incidence of cesarean section (AOR 0.320, 95% CI 0.150–0.556, $p < 0.001$), instrumental delivery (AOR 0.562, 95% CI 0.153–0.877, $p = 0.034$), and admission to NICU (AOR 0.432, 95% CI 0.197–0.871, $p = 0.020$).

The effects of GDM treatment on GWG are shown in Table 4 and Figure 1. Overweight/obese women had markedly lower GWG than normal weight women (10.1 ± 5.5 kg vs. 13.9 ± 4.9 kg, $p = 0.018$), while the prevalence of excessive GWG in overweight/obese group was significantly higher than that in normal weight group (57.1% *vs.* 36.4%, $p < 0.001$). Overweight/obese women with GDM gained less weight than those without GDM during pregnancy (5.0±4.6 kg *vs.* 14.5±5.2 kg, $p = 0.021$).

The prevalence of excessive GWG was significantly lower in overweight/obese women with GDM than those without GDM (32.9% *vs*. 67.1%, $p < 0.001$). In contrast, the prevalence of insufficient GWG was significantly higher in overweight/obese women with GDM than those without GDM (23.7% *vs*. 9.2%, $p < 0.001$). Lower prevalence of

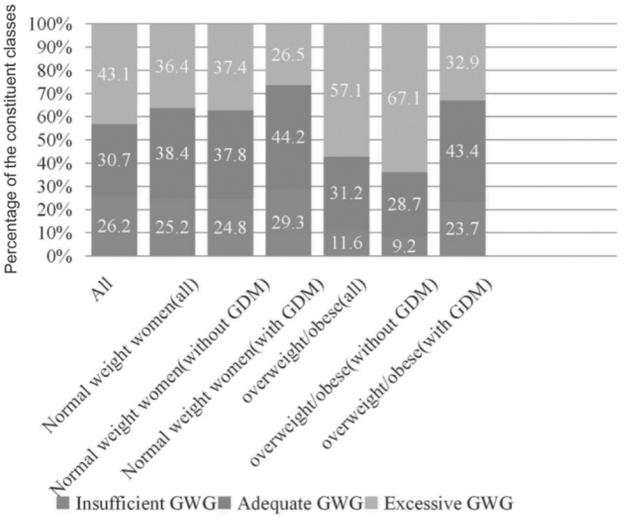

Figure 1. — Variation of gestational weight gain in each of the pre-pregnancy body mass index groups. GDM represents gestational diabetes mellitus. GWG represents gestational weight gain.

Table 3. — *Effects of gestational diabetes mellitus treatment on pregnancy outcomes.*

	Normal-weight (n = 1491)			Overweight/obese (n = 445)		
	n (%)	AOR (95% CI)	*p*	n (%)	AOR (95% CI)	*p*
HDP*	67			50		
with GDM	2 (1.4)	0.301 (0.096-1.520)	0.059	4 (5.3)	0.509 (0.145-1.328)	0.068
without GDM	65 (4.8)	1.0 (reference)		46 (12.5)	1.0 (reference)	
LGA**	107			67		
with GDM	9 (6.1)	0.990 (0.310-1.897)	0.623	6 (7.9)	0.343 (0.180-0.997)	0.050
without GDM	98 (7.3)	1.0 (reference)		61 (15.7)	1.0 (reference)	
SGA**	12			3		
with GDM	1 (0.7)	0.830 (0.106-7.274)	0.859	1 (1.3)	2.006 (0.219-23.520)	0.386
without GDM	11 (0.8)	1.0 (reference)		2 (0.5)	1.0 (reference)	
Caesarean section***	406			263		
with GDM	21 (14.2)	0.435 (0.246-0.701)	<0.001	25 (32.9)	0.320 (0.150-0.556)	<0.001
without GDM	385 (28.6)	1.0 (reference)		238 (64.5)	1.0 (reference)	
Instrumental delivery***	158			76		
with GDM	14 (9.5)	0.877 (0.445-1.862)	0.672	6 (7.9)	0.562(0.153-0.877)	0.034
without GDM	144 (10.7)	1.0 (reference)		70 (17.8)	1.0 (reference)	
Pemature delivery**	57			27		
with GDM	4 (2.7)	0.702 (0.213-2.010)	0.496	24 (6.5)	0.582 (0.192-2.842)	0.420
without GDM	53 (3.9)	1.0 (reference)		3 (3.9)	1.0 (reference)	
Apgar score <7 at 1 minute****	46			13		
with GDM	3 (2.0)	0.735 (0.166-2.447)	0.465	2 (2.6)	0.980 (0.291-6.051)	0.892
without GDM	43 (3.2)	1.0 (reference)		11 (3.0)	1.0 (reference)	
Admission to NICU****	60			58		
with GDM	4 (2.7)	0.743 (0.230-2.010)	0.701	3 (3.9)	0.432 (0.197-0.871)	0.020
without GDM	56 (4.2)	1.0 (reference)		55 (14.9)	1.0 (reference)	

AOR: adjusted odds ratio; CI: confidence interval; HDP: hypertensive disorders of pregnancy; GDM: gestational diabetes mellitus; LGA: large for gestational age; SGA: small for gestational age; NICU: neonatal intensive care unit.

* Adjusted for maternal age, gestational age at delivery, and pre-pregnancy body mass index.

** Adjusted for maternal age, parity, gestational age at delivery, pre-pregnancy body mass index, and glycosylated hemoglobin in the third trimester.

*** Adjusted for maternal age, parity, gestational age at delivery, birth weight, pre-pregnancy body mass index, and glycosylated hemoglobin in the third trimester.

**** Adjusted for maternal age, gestational age at delivery, birth weight, and pre-pregnancy body mass index.

excessive GWG was also found in normal weight women with GDM, compared with those without GDM (26.5% *vs*. 37.4%, $p = 0.009$).

Discussion

In the present retrospective analysis, the authors found that overweight/obese women had an increased risk of adverse maternal and neonatal outcomes, including GDM, HDP, primary cesarean section, instrumental delivery, premature delivery, LGA, and admission to NICU. However, diet plus exercise treatment among pregnant women with GDM could reduce the risk of adverse outcomes, especially significantly reduce the incidence of primary cesarean section, instrumental delivery, and admission to NICU in overweight/obese women. Subgroup analysis of data for the various GWG categories illustrated that diet and exercise intervention could help limit weight gain during pregnancy in women complicated with GDM, which may be a key factor for better outcomes. Furthermore, in overweight/obese group, the prevalence of excessive GWG was significantly lower in pregnancy women with GDM than those without GDM, whereas the prevalence of insufficient GWG was significantly higher in women with GDM than those without GDM.

The rate of overweight or obesity among women of reproductive age is increasing worldwide [24]. According to the Group of China Obesity Task Force recommended BMI classification reference [21], 23% (445/1,936) of all women in this cohort were overweight or obese. This incidence of overweight or obesity was similar to other studies in Chinese and Asian populations [15, 25, 26]. Obesity is a multifactorial chronic disease, leading to the release of pro-inflammatory cytokines from adipose tissue [27]. During pregnancy and the postpartum period, the levels of serum pro-inflammatory cytokines in obese women were significantly higher than those in normal weight women [28]. And excessive inflammation during pregnancy alters the homeostatic mechanisms of fetal growth and is associated with a variety of adverse pregnancy outcomes including GDM, gestational hypertension, premature delivery, and caesarean section delivery [29-33]. Consistent with previous studies, the present results showed that the incidences of HDP, GDM, LGA, primary cesarean section, instrumental delivery, premature delivery, and admission to NICU were markedly high in overweight/obese women,

Table 4. — *Effects of gestational diabetes mellitus treatment on gestational weight gain.*

	n	GWG (kg)	Excessive GWG	Adequate GWG	Insufficient GWG
		mean ± SD	n (%)	n (%)	n (%)
n	1,936	12.1±3.2	834(43.1)	595(30.7)	507(26.2)
Normal weight (all)	1,491	13.9±4.9	542(36.4)	573(38.4)	376(25.2)
with GDM	147	8.0±5.6	39(26.5)*	65(44.2)	43(29.3)
without GDM	1344	18.2±5.2	503(37.4)	508(37.8)	333(24.8)
Overweight/obese (all)	445	10.1±5.5	254(57.1)**	139(31.2)	52(11.6)
with GDM	76	5.0±4.6	25(32.9)***	33(43.4)	18(23.7)****
without GDM	369	14.5±5.2	229(67.1)	106(28.7)	34(9.2)

n: number; GWG: gestational weight gain; SD: standard deviation; GDM: gestational diabetes mellitus.
* Compared with normal weight without GDM, $X^2 = 6.798$, $p = 0.009$.
** Compared with normal weight (all), $X^2 = 60.814$, $p < 0.001$.
*** Compared with overweight/obese without GDM, $X^2 = 21.880$, $p < 0.001$.
****Compared with overweight/obese without GDM, $X^2 = 12.786$, $p < 0.001$.

compared to normal weight women.

These findings indicated that pre-pregnancy overweight or obesity increases the risk of adverse pregnancy outcomes. Therefore, overweight/obese women should attempt to be within a normal weight range before getting pregnant and reducing PPBMI is a primary prevention approach for pregnancy complications. Since January 2014, the present group (the Obstetrics and Gynecology Department of Qingdao Municipal Hospital) have adopted the new IADPSG diagnostic GDM criteria based on the HAPO study [23], a one-step 75-gram OGTT was performed at 24–28 weeks gestation in all women who were not previously diagnosed with overt diabetes. Using the new IADPSG criteria, a previous study in a Chinese population revealed that the risk of GDM was about two-fold higher among overweight or obese women compared to normal weight or underweight women [11]. Consistently, in the present study, the incidence of GDM in overweight/obese and normal weight groups were 17.1% and 9.9%, respectively. Obesity and hyperglycemia are two important factors influencing the likelihood of adverse pregnancy outcomes [3]. Several studies have demonstrated that GDM treatment can decrease the rates of adverse maternal and neonatal outcomes [13, 14], but few studies specifically addressed the effects of GDM management on overweight/obese women with GDM. The present authors conducted this retrospective analysis and found that after following diet and exercise strategies for achieving optimal BGL, overweight/obese women with GDM had a significantly lower risk of primary cesarean section (32.9%, AOR 0.320, 95% CI 0.150-0.556), instrumental delivery (7.9%, AOR 0.562, 95% CI 0.153-0.877), and admission to NICU (3.9%, AOR 0.432, 95% CI 0.197-0.871), compared to those without GDM (primary cesarean section 64.5%, instrumental delivery 17.8%, and admission to NICU 14.9%). In normal weight group, women with GDM also had a lower risk of primary cesarean section (14.2%, AOR 0.435, 95% CI 0.246-0.701), compared to those without GDM (28.6%). These finding suggested that tailored interventions for GDM management did improve pregnancy outcomes and may be required for overweight and obese women to improve health outcomes.

Nonetheless, dietary and physical activity-based interventions during pregnancy have also been related to GWG outcomes [34]. It is documented that limiting GWG, independent of GDM treatment, can help decrease the risk of LGA [24, 35]. A study by Assaf-Balut *et al.* [36] revealed that excess weight women (BMI ≥ 25.0 kg/m^2) with GDM had similar odds of adverse maternal and neonatal outcomes to normal weight women without GDM after GDM treatment. However, this study did not include the data of GWG and could not determine whether women with GDM benefit from tailored weight gain recommendations. In this retrospective study, the authors found that pregnant women with GDM had less weight gain than women without GDM during pregnancy, regardless of PPBMI.

Overweight/obese women gained less weight than normal weight women (10.1±5.5 kg *vs*. 13.9±4.9 kg) during pregnancy, but the rate of excessive GWG in overweight/obese women was significantly higher than that in normal weight women (57.1% *vs*. 36.4%, $p < 0.001$).

In overweight/obese group, more than half of pregnant women had excessive GWG (57.1%), while the prevalence of excessive GWG decreased to 32.9% after GDM treatment, which was similar to the rate of excessive GWG in normal weight group. The prevalence of insufficient GWG in overweight/obese women with GDM (23.7%) was markedly higher than that in overweight/obese women without GDM (9.2%), however, no significant difference in the odds of SGA was observed between overweight /obese women with and without GDM (Table 3). In normal weight group, the rate of excessive GWG in women with GDM (26.5%) was also found significantly deceased, compared to women without GDM (37.4%). These findings indicated that GDM treatment limited weight gain during pregnancy, especially among overweight/obese women, which may improve pregnancy outcomes. At the present study, only a total of 76 women were classified as overweight/obese with GDM (Table 4).

The present cohort was further subcategorized according to GWG in respect to the IOM recommendations [22] and

the number of participants in each GWG subgroup was even smaller. Therefore, the authors were not able to compare pregnancy outcomes between the different GWG subgroups in overweight/obese women with GDM. Further studies with larger sample size are needed. In addition, these results showed that the mean GWG in normal weight and overweight/obese women with GDM were 8.0 kg and 5.0 kg (Table 4), respectively, which were lower than the IOM recommendations [22]. These women had better pregnancy outcomes as compared with those without GDM (Table 3). This result raised a question as to whether the IOM guidelines for GWG apply to women with GDM, as the IOM guidelines were based on PPBMI without taking into consideration pregnancy complications.

A large epidemiological study on the risk of adverse outcomes along the whole range of maternal weight gain revealed that lower weight gains outside the IOM's ranges were associated with better pregnancy outcomes, especially among obese women [20]. The PPBMI-specific limits for lower cutoff levels for GWG may be more applicable to women with GDM. Further studies need to be performed to establish optimal GWG more in line with the characteristics of women with GDM. Several limitations exist in this study. This was a retrospective single-center study and the enrolled cohort may be not representative of the Chinese population. Most participants with mild hyperglycemia were diagnosed with GDM by IADPSG criteria and had satisfactory blood glucose control. Therefore, selection bias cannot be ruled out. Moreover, pre-pregnancy weight was self-reported by participants and may be inaccurate. Finally, the effects of GDM treatment on GWG were assessed based on the total GWG instead of the weight gain after the initiation of dietary and exercise therapy. Considering dietary and exercise therapies may have important influences on GWG, the effects of GDM treatment on GWG may be underestimated.

Conclusion

In conclusion, the present findings suggested that maternal obesity was a risk factor for adverse pregnancy outcomes in the Chinese population. It is important for overweight/obese women to lose weight before pregnancy to decrease the risk of pregnancy complications. Overweight/obese women with GDM had better pregnancy outcomes than those without GDM when it was diagnosed and treated, which may benefit from the restricted weight gain by diet and exercise in overweight/obese women with GDM. Weight gain monitoring combined with standard glycemic control during pregnancy may improve obstetric and neonatal outcomes.

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