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Association Between Gestational Weight Gain and Pregnancy Complications or Adverse Delivery Outcomes in Chinese Han Dichorionic Twin Pregnancies: Validation of the Institute of Medicine (IOM) 2009 Guidelines

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Background: Excessive or insufficient gestational weight gain (GWG) is associated with increased risks of pregnancy complications and adverse delivery outcomes in dichorionic twin pregnancies. The provisional Institute of Medicine (IOM) 2009 guidelines suggested the optimal GWG based on limited epidemiological data collected from Western populations. However, such a recommendation has not yet been validated in a Chinese Han population, the world's largest ethnic group. The objective of this study was to assess the effect of IOM guidelines by determining the neonatal and maternal outcomes associated with gaining weight below, within, and above the IOM provisional guidelines on GWG in Chinese Han twin pregnancies.

Material/Methods: A historical cohort study of 350 twin-conceiving Han women in Chongqing Women and Children's Health Center delivering liveborn twin infants between January 2015 and November 2016 was conducted. The participants were divided into 3 groups according to the 2009 Institute of Medicine recommendations of GWG: a low GWG group, an adequate GWG group, and a high GWG group. The incidence of pregnancy complications and the delivery outcomes were compared between the groups, and the correlation of GWG and pregnancy complications or delivery outcome was investigated by logistic regression analysis.

Results: In Han Chinese people, the gestational age (GA) at delivery was significantly different among various GWG groups, and low maternal GWG is associated with shorter GA. Although low GWG increased the incidence of VPTD, it did not impact PTD in twin pregnancies. Moreover, GWG was negatively correlated with the incidence of PPROM and was positively correlated with GHP development in twin pregnancies.

Conclusions: The recommendations of the 2009 IOM guidelines about GWG is beneficial in reducing the incidence of VPTD and PPROM in Han Chinese dichorionic twin pregnancies, but failed to eliminate the development of PTD, PROM, GDM, PE, ICP, and SGA.

MeSH Keywords: Pregnancy Complications • Pregnancy, Twin • Weight Gain

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Background

Appropriate pregravid weight and gestational weight gain (GWG) are essential to obtaining a favorable delivery outcome and promoting mother and infant health. Previous studies have reported that inadequate gestational weight gain is associated with low birth weight and preterm births [1,2], while excessive gestational weight gain increases the risks for not only gestational diabetes mellitus, preeclampsia, macrosomia, postpartum weight retention, and offspring obesity [3–5], but also for non-pregnancy-related diseases, such as asthma, during pregnancy [6]. Since twin birth rates have been increasing worldwide in recent decades due to improvements in assisted reproductive technology, the greater number of women conceiving at older ages, and the differences in the special physiological characteristics with singleton pregnancy, it is necessary to study the correlations of GWG with the pregnancy complications and pregnancy outcome of twin pregnancies. Nonetheless, the reports on the impact of GWG on the pregnancy outcome of twin pregnancies are limited, although twin pregnancies have a higher risk of preterm delivery and perinatal mortality than singleton pregnancies, and thus are particularly concerning in terms of gestational weight gain.

As the result, the Institute of Medicine (IOM) released a guideline of recommendations for optimal weight gain in singleton and twin pregnancies in 2009, which is termed "provisional", as they are based on limited data. Therefore, its effectiveness and accuracy have been examined in various regions or nations [7,8]. Many studies have since attempted to validate the adequacy of IOM GWG guidelines for twins; however, no consensus has yet been achieved, probably due to ethnic heterogeneity in different studies. Thus, more studies to guide optimal GWG in twin pregnancies are needed for specific populations.

China is the most populous country in the world, and the Han ethnic group predominant in China, accounting for 91.51% of the total Chinese population, but so far, studies of the effect of GWG on twin pregnancies in Han Chinese people are rare. Since the body mass index (BMI) and body composition are apparently different between Chinese and people of Western nations, it is important to assess the Institute of Medicine (IOM) guidelines for twin pregnancy GWG in the Chinese population.

With the use of data from a retrospective cohort of normal, pregravid-weight Chinese women with dichorionic twin pregnancies, the objectives of this study were to determine the neonatal and maternal outcomes associated with gaining weight below, within, and above the IOM provisional guidelines on gestational weight gain in twin pregnancies, and thereby validate the eligibility of recommended adequate GWG by IOM guidelines for Han Chinese people.

Material and Methods

This retrospective study was conducted at the Chongqing Women's and Children's Health Center. Han women with twin pregnancies who were admitted for delivery between January 2015 and November 2016 were considered for inclusion. Inclusion criteria were as follows: women with a prepregnancy body mass index of 18.5–24.9 kg/m^2 and no chronic disease prepregnancy and women who delivered live twins after 28 weeks of gestation. Exclusion criteria were as follows: malformation of one of the twins; intrauterine intervention during pregnancy; incomplete prenatal records regarding weight gain; and an unclear pregnancy outcome.

Study data collected from medical records included information on demographics, pregnancy complications, and pregnancy outcomes. Participants were asked to provide their height and prepregnancy weight. Weight prior to delivery was measured by a medical assistant. Total gestational weight gain was calculated by subtracting the prepregnancy weight from the weight prior to delivery. The IOM recommendation of total weight gain for women with a prepregnancy BMI of 18.5–24.9 during twin pregnancy is 16.8–24.5 kg. Thus, low GWG, adequate GWG and high GWG were defined as a total weight gain less than 16.8 kg, 16.8–24.5 kg, and more than 24.5 kg, respectively.

The primary pregnancy outcomes were preterm delivery (PTD) at <37 weeks, very preterm delivery (VPTD) at <32 weeks, premature rupture of membranes (PROM) at <37 weeks, and preterm premature rupture of membranes (PPROM) at <32 weeks. Secondary maternal outcomes were rates of gestational diabetes (GDM), gestational hypertension (GHP), preeclampsia (PE), and intrahepatic cholestasis of pregnancy (ICP). Secondary neonatal outcome was the rate of small for gestational age fetuses (SGA).

All data were analyzed using SPSS 17.0. Continuous data are expressed as the mean ±SD and subjected to one-way ANOVA. Categorical variables were assessed with the chi-square test or Fischer's exact test. Binary logistic regression analysis was used to assess the correlation of GWG with pregnancy complications and delivery outcome. A $p<0.05$ was considered statistically significant.

Results

Clinical characteristics

Over the 2-year study period, 655 pregnant women delivered twins in Chongqing Women's and Children's Health Center. Of these women, 350 met the inclusion criteria for participation in this study. There were 145 (41.4%) participants in the low GWG group, 170 (48.6%) in the adequate GWG group, and 35

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Table 1. Participant demographics.

Group	Cases	Age at delivery ($\bar{\chi}$±s)	Nulliparity (n (%))	Conceived by ART (n (%))
Low GWG	145	30.28±4.25	124 (85.51)	114 (78.62)
Adequate GWG	170	30.29±4.23	153 (90)	139 (81.76)
High GWG	35	30.30±4.25	33 (94.29)	26 (74.28)
Statistics		F=1.182	χ^2=2.808	χ^2=1.187
p-Value		0.308	0.246	0.552

GWG – gestational weight gain.

Table 2. Participant pregnancy outcomes among the 3 groups.

Group	Cases	GA at delivery ($\bar{\chi}$±s)	PTD (n (%))	VPTD (n (%))	PROM (n (%))	PPROM (n (%))	Elective termination <37 wk (n (%))	Spontaneous PTD (n (%))
Low GWG	145	35.29±2.25	89 (61.38)	15 (10.34)	29 (20)	9 (6.2)	10 (6.90)	79 (54.48)
Adequate GWG	170	36.32±1.33	108 (63.53)	3 (1.76)	28 (16.47)	1 (0.5)	27 (15.88)	81 (47.65)
High GWG	35	36.50±0.94	22 (62.85)	0 (0)	5 (14.29)	0 (0)	2 (5.71)	20 (57.14)
Statistics		F=15.854	χ^2=0.156	χ^2=13.918	χ^2=0.982	χ^2=10.045	χ^2=7.539	χ^2=1.972
p-Value		<0.001	0.925	0.001	0.612	0.007	0.023	0.373

GA – gestational age; PTD – preterm birth; VPTD – very preterm birth; PROM – premature rapture of membrane; PPROM – preterm premature rupture of membranes.

(10%) in the high GWG group. The participant characteristics of the study population are shown in Table 1. The average maternal age of the participants was 30.28±4.26 years, the ratio of nulliparity was 88.57%, and the proportion of conception by *in vitro* fertilization was 79.71%. No significant differences were observed between the groups for maternal characteristics.

Low GWG is associated with shorter GA

Firstly, we found the mean gestational age (GA) at delivery was significantly different among groups (Table 2): GA was shortest in the low GWG group (35.29±2.25 wks) and longest in the high GWG group (36.50±0.94 wks), while adequate GWG group demonstrated a slightly shorter but comparable GA with high GWG group. These data indicate that low maternal GWG is associated with shorter GA, and thus might be a risk factor for PTD in twin pregnancies.

Low GWG increases the risk for VPTD rather than PTD in twin pregnancies

To ascertain the relationship between low GWG and PTD in twin pregnancies, the incidences of PTD and VPTD in the present cohort were calculated and compared between groups. Interestingly, the adequate GWG group demonstrated the most PTD cases in this study, although the incidence of PTD was comparable among low GWG, adequate GWG, and high GWG groups (61.38%, 63.53%, and 62.85%, respectively). Because the rate of non-medical elective termination was relatively higher in China than in other countries, we then calculated the rate of elective terminations <37 gestational weeks without pregnancy complications in each group. As expected, 27 pregnant women in the adequate GWG group (15.88%) had chosen to terminate gestation prior to 37 weeks for non-medical causes, while only 10 pregnant women in the low GWG group (6.90%) and another 2 pregnant women in the high GWG group (5.71%) chose preterm elective termination. After excluding elective termination-caused PTD cases, the incidence of spontaneous PTD was 79(54.48%, 81(47.65%), and 20 (57.14%) in the low, adequate, and high GWG groups, respectively. However, there was still no statistically significant difference in PTD incidence among groups, although adequate GWG exhibited the lowest rate of PTD. Nevertheless, the incidence of VPTD was 10.34% and 1.76% in the low GWG and adequate GWG groups, respectively, while no VPTD case was observed in the high GWG group. Further analysis demonstrated that

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Table 3. Correlation between GWG, pregnancy complications, and delivery outcomes.

Logistic regression	GHP	VPTD	PPROM
OR	1.089	0.838	0.800
95% CI	(1.012, 1.172)	(0.760, 0.925)	(0.720, 0.889)
p-value	0.023*	0.000*	0.000*

OR – odds ratio; CI – confidential interval.

Table 4. Relationship between GWG and pregnancy complications.

Group	Cases	GDM (n (%))	GHP (n (%))	PE (n (%))	ICP (n (%))	SGA (n (%))
Low GWG	145	52 (35.86)	4 (2.76)	11 (7.59)	30 (20.69)	25 (17.24)
Adequate GWG	170	46 (27.06)	16 (9.41)	21 (12.35)	20 (11.76)	21 (12.35)
High GWG	35	10 (28.58)	4 (11.43)	6 (17.14)	5 (14.29)	2 (5.71)
Statistics		χ^2=2.938	χ^2=6.696	χ^2=3.425	χ^2=4.766	χ^2=3.684
p-Value		0.230	0.035	0.180	0.092	0.159

GDM – gestational diabetes mellitus; GHP – gestational hypertension; PE – preeclampsia; ICP – intrahepatic cholestasis of pregnancy; SGA – small for gestational age.

the logistic regression odds ratio between GWG and VPTD was 0.838 (Table 3), strongly suggesting that GWG was negatively correlated with VTPD in twin pregnancies.

GWG was negatively correlated with the incidence of PPROM in twin pregnancies

The correlations between GWG and PROM or PPROM were examined among groups. Our data show that the incidences of PROM and PPROM were highest in the low GWG group (20% and 6.2%, respectively), medium in the adequate GWG group (16.47% and 0.5%, respectively), and lowest in the high GWG group (14.29% and 0%, respectively), with significant differences observed in the incidences of PPROM (p=0.007). Furthermore, logistic regression analysis showed that the odds ratio was 0.800 between GWG and PPROM (Table 3), strongly suggesting that GWG was negatively correlated with the incidence of PPROM in twin pregnancies.

GWG is correlated with the morbidity of GHP in twin pregnancies

To investigate the effects of GWG on the secondary maternal/neonatal outcomes, the incidences of GDM, GHP, PE, ICP, and SGA were calculated for each group. As shown in Table 4, the difference in GWG did not impact the incidences of GDM (p=0.23), PE (p=0.180), ICP (p=0.092), or SGA (p=0.159) in twin pregnancies. However, the incidence of GHP was 2.76%, 9.41%, and 11.43% in the low, adequate, and high GWG groups, respectively, which was a significant difference (p=0.035). Moreover, the odds ratio of logistic regression was 1.089 between GWG and the incidence of GHP (Table 3), indicating that GWG is positively correlated with the morbidity of GHP, and excessive GWG might be a risk factor for GHP development in Chinese twin pregnancies.

Discussion

Based on the results of this retrospective study, we suggest that inadequate gestational weight gain is associated with an increased risk of very preterm delivery and preterm premature rupture of membranes. Furthermore, we found that excessive gestational weight gain was positively correlated with the morbidity of gestational hypertension.

Previous studies have shown that inadequate gestational weight gain is associated with preterm delivery in singleton pregnancies; however, there are conflicting results regarding the association between GWG and preterm delivery in twin pregnancies [9–12]. In the present study, the mean gestational week at delivery was lowest in the low GWG group and highest in the high GWG group. The incidences of VPTD and PPROM were also lowest in the low GWG group and highest in the high GWG group. These findings are consistent with those of Pettit et al. [12], who showed that an inadequate mid-pregnancy weight gain was related to preterm birth before 32 weeks, and the results of Gonzalez-Quintero showing that patients with normal pregravid BMI and GWG below IOM recommendations were correlated with a high risk for PTB and VPTB [10]. These findings contradict those of a 2017observational study that reported a negative correlation between GWG and the duration

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of pregnancy at delivery [11]. Interestingly, our results showed that the incidence of PTD was similar among different GWG groups. To validate this result, we excluded elective terminations at <37 gestational weeks without pregnancy complications, but the data did not show any difference in spontaneous PTD incidence among these groups.

To explore the relationship between total GWG and the incidence of other pregnancy complications, we then focused on the rates of GDM, GHP, PE, and ICP during pregnancy. The results showed that no differences in the rates of GDM, PE, or ICP were found between different groups. In previous studies of non-Asian populations, there were no differences in the rate of GHP found between inadequate and adequate GWG [12], whereas excessive GWG was associated with higher risks of GHP in twin pregnancies [13]. We are unaware of any study reporting the relationship of the incidence of GHP with high GWG. However, it has been reported that prepregnancy obesity is a high-risk factor for GHP, given the changes in maternal hormones and the internal environment [14]. Furthermore, Triunfo and Lanzone showed that the high-GWG group had a higher risk for GHP than the low and adequate groups. This finding is consistent with those of previous reports on singleton pregnancies [15]. Inappropriate pregnancy weight gain is a high-risk factor for GHP. Lisa et al. reported that with each pregnancy weight increase of 5 pounds, the incidence of GHP increases by 14–15% [16]. When compared with weight gain in mid-late pregnancy, weight gain in the first trimester is more closely related to the incidence of GHP [17]. The results in our study suggest that high GWG is correlated with a high risk for gestational hypertension.

Moreover, we determined the relationship between GWG and neonatal outcome. Previous studies have reported that pregnant women with adequate or high GWG are more likely to show a better gain of birth weight in twin neonates [10,18]. In contrast, other studies have shown no relationship between GWG and twin birth weight [11,19]. In the present study, we focused on the ratio of small for gestational age (<10th percentile) of any neonate in different groups, and the results were consistent with the report by Katarzyna et al. [11], who found no association between GWG and SGA of at least one neonate. The discrepancies among studies may be derived from the difference not only in race, but also statistical approaches; for instance, logistic regression or generalized estimating equations (GEE) have been utilized in different studies [7].

Conclusions

In summary, this is the largest study that has assessed the effect of the 2009 IOM weight gain recommendations on the incidence of pregnancy complications or delivery outcomes in Chinese twin pregnancies. Our study results showed that low GWG is negatively correlated with high risks for VPTD and PPROM, whereas high GWG is associated with a high risk for GHP, and maintaining an adequate GWG during twin pregnancy demonstrated a benefit in preventing the development of VPTD and PPROM, but not other complications. Hence, further studies with larger sample size are warranted to optimize the GWG recommendation for Chinese twin pregnancies.

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Conflicts of interest

None.

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