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The association between weight gain during pregnancy and intertwin delivery weight discordance using 2011–2015 birth registration data from the USA

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Abstract

Objective: To assess the effect of weight gain during pregnancy on intertwin delivery weight discordance.

Methods: In the present retrospective cohort study using twin delivery records, data were extracted from the 2011–2015 USA birth registration dataset created by the Centers for Disease Control and Prevention. The outcome variable was delivery weight discordance. The nonlinear association of weight gain during pregnancy with delivery weight discordance was examined using a generalized additive model, adjusting for potential confounders.

Results: A total of 255 627 twin pairs were included in this analysis. Weight gain during pregnancy showed an inverse, yet nonlinear, association with intertwin delivery weight discordance. Women with weight gain of approximately 25 kg exhibited the lowest level of discordance. When stratified by pre-pregnancy body mass index, the association of weight gain with discordance became insignificant among obese women. When categorizing weight gain according to recommendations from the Institute of Medicine, inadequate weight gain was associated with increased risk of discordance among women of any pre-pregnancy body mass index.

Conclusion: Twin pregnancies with maternal weight gain of approximately 25 kg demonstrated the lowest risk of developing intertwin delivery weight discordance, while inadequate weight gain was a risk factor for delivery weight discordance in all pre-pregnancy body mass index categories.

KEYWORDS

Body mass index; Generalized additive model; Gestational weight gain; Intertwin delivery weight discordance; Pregnancy outcome; USA

1 | INTRODUCTION

Weight gain during pregnancy averages 20% or more and this can have implications for both mother and child.[1] Insufficient gestational weight gain has been associated with low delivery weight, whereas excessive weight gain has been linked to macrosomia and maternal postpartum weight retention.[1–5] Weight gain in pregnancy could serve as a good approximation of maternal nutrition, and this measure seems stable across different populations.[1] An international study found that the pattern of weight gain during pregnancy was similar across various populations globally, despite differences in ethnicity, culture, behavior, and healthcare systems.[3]

Gestational weight gain, at least in part, reflects maternal nutritional status, which is the most important determinant of fetal growth. Theoretically, the necessity for weight gain in mothers who carry twins should be different from mothers who carry a single fetus since the nutritional supply for twins may be higher than for a singleton. Therefore, a separate analysis of the impact of gestational weight gain on twin growth is needed.

A unique problem relating to growth in twin pregnancy is intertwin growth discordance, where one twin grows much faster than the other.[6] A clinically significant discordance is usually defined as an 18%–25% difference in delivery weight.[6] Intertwin growth discordance is an adverse event that has been linked to neonatal mortality and morbidity.[6] Although a number of epidemiologic studies have assessed various risk factors for intertwin growth discordance,[7–15] only one small cohort study has examined the impact of gestational weight gain on this complication.[15] The aim of the present study was to assess the effect of weight gain during pregnancy on intertwin delivery weight discordance using a large birth registration dataset from the USA.

2 | MATERIALS AND METHODS

The present retrospective cohort study included delivery data registered in the 50 states of the USA, the District of Columbia, and New York City, collected by the Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS). NCHS receives these data as electronic files, which are prepared from individual records processed by each registration area through the Vital Statistics Cooperative Program. Data from 2011–2015 inclusive were included, and the analysis was restricted to twin deliveries, with a twin set as the unit of analysis. Sets of twins were matched by year and month of the mother's last normal menstrual period; number of prenatal visits; maternal age, race/ethnicity, educational level, body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters), and weight gain during pregnancy; obstetric estimation of gestational age; and year and month of delivery. Twin sets with an incomplete match, any twin categorized as a stillbirth, any twin weighing less than 300 g, or any twin with missing information on delivery weight, gestational age, maternal weight gain during pregnancy or pre-pregnancy BMI were excluded. The Centers for Disease Control and Prevention and the ethical board of the Central South University in China were consulted and the study was considered exempt from ethical approval given the retrospective nature of the study.

The outcome variable was delivery weight discordance, which was calculated as [(delivery weight of larger twin − delivery weight of smaller twin)/delivery weight of larger twin] × 100%.

The potential confounding factors considered were maternal age, race/ethnicity (extracted from birth certificates and coded using with US Centers for Disease Control and Prevention code set), educational level, pre-pregnancy BMI, eligibility for the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), parity, use of assisted reproductive technology (ART), gender of twins (both boys, both girls, boy and girl), diseases prior to or developed during pregnancy (pre-pregnancy diabetes, gestational diabetes, chronic hypertension, gestational hypertension, eclampsia), and sexually transmitted infections including gonorrhea, syphilis, and chlamydia.

Demographic and clinical characteristics of the study population were described. Weight gain during pregnancy and delivery weight discordance were compared among women of different characteristics using analysis of variance (ANOVA). Multiple comparisons across groups were performed using the Least Significant Difference (LSD) *t* test. The preliminary analysis demonstrated a nonlinear association between weight gain during pregnancy and intertwin delivery weight discordance. Therefore, generalized additive models were applied to fit the data. First, discordance (continuous and dichotomized) was modeled in unadjusted models. Continuous discordance was modeled in a generalized additive model with Gaussian distribution. Dichotomized discordance (15%, 20%, and 25%) was modeled in generalized additive models with log link function and binomial distribution. Cubic splines were used for the smoothing. The associations between weight gain and predicted discordance and predicted probabilities of discordance (>15%, 20%, 25%) were plotted.

The analysis was then performed stratified by pre-pregnancy BMI to examine modulating effects. Finally, weight gain during pregnancy was categorized into adequate, inadequate, and excessive, according to the Institute of Medicine (IOM) recommendations,[1] with the exception of underweight women.[2] For twin pregnancies, the recommended ranges for weight gain according to pre-pregnancy BMI are: normal, 16.8–24.5 kg; overweight, 14.1–22.7 kg; obese, 11.3–19.1 kg; underweight, 22.7–28.1 kg. A generalized linear model with log link function and binomial distribution was used to examine the interaction between pre-pregnancy BMI and weight gain. Effect was expressed as relative risk (RR). Both crude and adjusted models were fitted. Potential confounding factors associated with gestational weight gain and delivery weight discordance were included in the adjusted models. Confounders included in the model were categorized as: maternal age younger than 25 years, 25–34 years, and 35 years or older; BMI underweight (<18.5), normal (18.5–24.9), overweight (25.0–29.9), and obese (≥30.0). $P<0.05$ was considered significant. Twin match and data analyses were performed using SAS version 9.4 (SAS Institute, Cary, North Carolina, USA).

3 | RESULTS

A total of 664 493 twin records from 2011 to 2015 were extracted from the original files. Of these, 599 144 (90.2%) were successfully matched and 65 349 (9.8%) records were unmatched or overmatched. A total of 511 254 twin records (or 255 627 pairs of twins) were included in the final analysis (Fig. 1). Overall, 19 899 (7.8%) pairs had delivery weight discordance of greater than 25%. The average weight gain during pregnancy was 16.8 ± 7.8 kg. Pre-pregnancy BMI was inversely associated with weight gain; that is, women of normal pre-pregnancy weight had significantly greater weight gain (18.3 ± 6.8 kg) than overweight (17.0 ± 7.9 kg) and obese women (13.9 ± 8.6 kg,

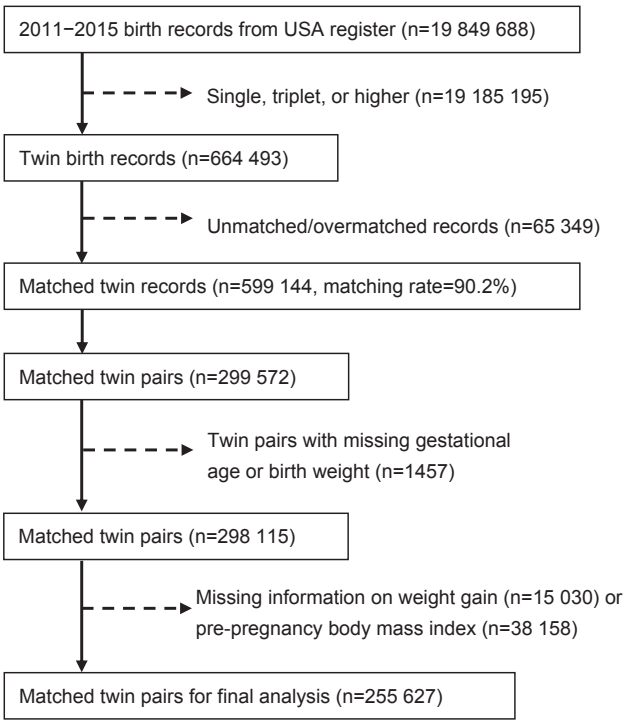

FIGURE 1 Flow chart of twin delivery data included in the study.

P<0.001). According to the LSD *t* test, women younger than 25 years had lower weight gain, whereas women older than 35 years had greater delivery weight discordance (*P*<0.001). Black women had the lowest weight gain (*P*<0.001) yet the highest delivery weight discordance (*P*=0.011). All of the variables listed in Table 1 were significantly associated with both weight gain and delivery weight discordance, and were considered potential confounders.

Weight gain during pregnancy demonstrated a nonlinear association with delivery weight discordance (Fig. 2). Women with weight gain of approximately 25 kg had the lowest level of discordance, while for women with inadequate weight gain there was an increased risk of discordance. When stratified by pre-pregnancy BMI (Fig. 3), weight gain was not significantly associated with delivery weight discordance among obese women. For underweight and normal weight women, weight gain had an inverse association with discordance overall, and weight gain of approximately 25–27 kg was associated with the lowest predicted probability of greater than 25% discordance (when weight gain was above 30 kg, its effect size had wide 95% confidence intervals).

Weight gain was also categorized according to IOM recommendations. Obese women, regardless of weight gain, were at increased risk of intertwin delivery weight discordance above 25% compared with women of normal BMI and experiencing adequate weight gain (Fig. 4). By contrast, inadequate maternal weight gain among women of any pre-pregnancy BMI was significantly associated with an increased risk of discordant delivery weight of over 25% when compared with women of normal BMI and experiencing adequate weight gain. The crude and adjusted models generated similar results.

4 | DISCUSSION

The present study used a large dataset of registered deliveries from the USA and revealed several distinctive features between weight gain during pregnancy and intertwin delivery weight discordance: (1) the occurrence of intertwin delivery weight discordance decreased with increasing weight gain during pregnancy; (2) a nonlinear association was observed and women who gained approximately 25 kg had the lowest level of discordance, whereas inadequate weight gain was associated with an increased risk of discordance; (3) when stratified by pre-pregnancy BMI, the association became insignificant among obese women; (4) obese women, regardless of weight gain, were at higher risk of having intertwin delivery weight discordance compared with women with normal

TABLE 1 Comparison of weight gain during pregnancy and delivery weight discordance among twin deliveries from the demographic and clinical characteristics of the participants using 2011–2015 USA birth registration data (n=255 627 twin pairs).[a]

Variable	Twin pairs	Weight gain, kg	*P* value	Delivery weight discordance, %	*P* value
Delivery weight discordance, %			<0.001		<0.001
≤15.0	187 871 (73.5)	16.8 ± 7.8		6.5 ± 4.3	
15.1–20.0	30 418 (11.9)	16.9 ± 7.8		17.3 ± 1.4	
20.1–25.0	17 439 (6.8)	16.8 ± 7.8		22.3 ± 1.4	
>25	19 899 (7.8)	16.2 ± 7.8		32.8 ± 7.8	
Maternal age, y			<0.001		<0.001
<25	47 506 (18.6)	16.1 ± 8.3		10.7 ± 9.1	
25–34	147 656 (57.8)	16.9 ± 7.8		10.8 ± 9.0	
≥35	60 465 (23.7)	16.9 ± 7.4		11.4 ± 9.4	
Maternal education			<0.001		<0.001
Up to associate degree	149 286 (58.4)	16.1 ± 8.2		10.8 ± 9.1	
Bachelor degree and above	102 846 (40.2)	17.8 ± 7.0		11.0 ± 9.2	

(Continues)

TABLE 1 (Continued)

Variable	Twin pairs	Weight gain, kg	*P* value	Delivery weight discordance, %	*P* value
Maternal race/ethnicity			<0.001		0.011
White	191 490 (74.9)	17.1 ± 7.6		10.9 ± 9.1	
Black	42 673 (16.7)	15.3 ± 8.7		11.1 ± 9.2	
American Indian and Alaska Native	1786 (0.7)	16.1 ± 8.6		10.8 ± 9.2	
Asian and Pacific islander	15 170 (5.9)	16.0 ± 6.5		10.9 ± 9.1	
Multi-race/ethnicity	4508 (1.8)	17.1 ± 8.3		11.0 ± 9.0	
Maternal BMI			<0.001		0.001
Underweight (<18.5)	7295 (2.9)	18.0 ± 6.6		11.0 ± 9.3	
Normal (18.5–24.9)	113 587 (44.4)	18.3 ± 6.8		10.9 ± 9.1	
Overweight (25.0–29.9)	64 938 (25.4)	17.0 ± 7.9		10.9 ± 9.1	
Obese (≥30)	69 807 (27.3)	13.9 ± 8.6		11.0 ± 9.2	
Parity			<0.001		<0.001
Primiparous	96 120 (37.6)	17.5 ± 7.7		11.4 ± 9.5	
Multiparous	159 507 (62.4)	16.3 ± 7.8		10.6 ± 8.9	
WIC eligibility			<0.001		<0.001
No	157 079 (61.4)	17.3 ± 7.4		11.0 ± 9.2	
Yes	94 645 (37.0)	15.9 ± 8.3		10.8 ± 9.1	
Use of ART			<0.001		<0.001
No	227 734 (89.1)	16.6 ± 7.9		10.8 ± 9.1	
Yes	23 153 (9.1)	17.5 ± 7.1		11.6 ± 9.2	
Twin sex			<0.001		<0.001
Both boys	82 432 (32.2)	16.8 ± 7.8		10.6 ± 9.1	
Both girls	81 015 (31.7)	16.5 ± 7.7		10.6 ± 9.1	
Boy + girl	92 180 (36.1)	16.9 ± 7.9		11.5 ± 9.2	
Pre-pregnancy diabetes			<0.001		<0.001
No	253 012 (99.0)	16.8 ± 7.8		10.9 ± 9.1	
Yes	2290 (0.9)	15.2 ± 8.8		12.3 ± 10.1	
Gestational diabetes			<0.001		0.001
No	235 836 (92.3)	16.9 ± 7.8		10.9 ± 9.1	
Yes	19 466 (7.6)	15.6 ± 7.9		11.2 ± 9.2	
Chronic hypertension			<0.001		<0.001
No	249 525 (97.6)	16.8 ± 7.8		10.9 ± 9.1	
Yes	5777 (2.3)	15.6 ± 8.9		12.2 ± 9.9	
Gestational hypertension			<0.001		<0.001
No	227 027 (88.8)	16.5 ± 7.7		10.8 ± 9.1	
Yes	28 275 (11.1)	18.8 ± 8.5		12.0 ± 9.7	
Eclampsia			<0.001		<0.001
No	253 779 (99.3)	16.7 ± 7.8		10.9 ± 9.1	
Yes	1523 (0.6)	18.3 ± 8.7		12.6 ± 10.0	
Sexually transmitted infection[b]			<0.001		0.004
No	251 756 (98.5)	16.8 ± 7.8		10.9 ± 9.1	
Yes	3871 (1.5)	16.1 ± 8.8		10.5 ± 8.7	

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); WIC, the Special Supplemental Nutrition Program for Women, Infants, and Children; ART, assisted reproductive technology.

[a]Values are given as number (percentage) or mean ± SD, unless indicated otherwise.

[b]Sexually transmitted infections included gonorrhea, syphilis, and chlamydia.

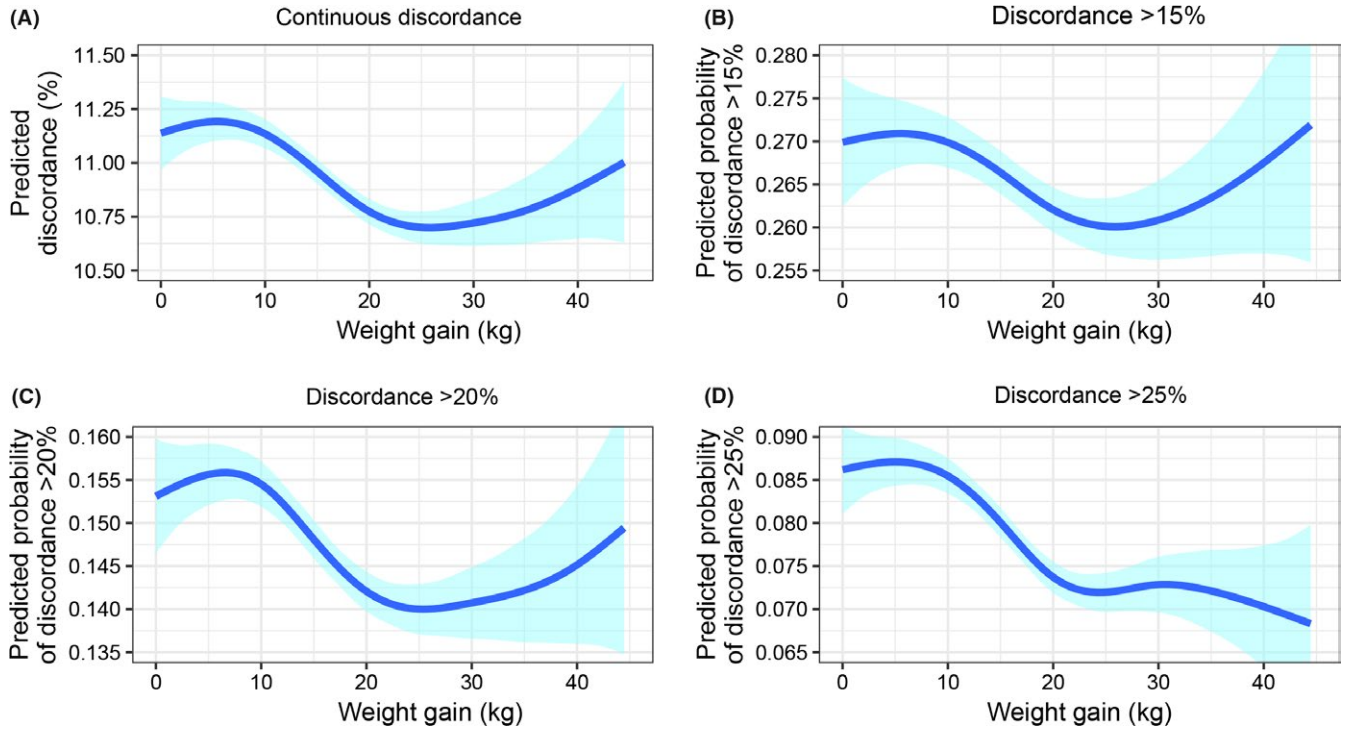

FIGURE 2 Effect of weight gain during pregnancy on intertwin delivery weight discordance, including continuous discordance (a), discordance greater than 15% (b), discordance greater than 20% (c), and discordance greater than 25% (d). Solid lines signify the predicted value or probability of discordance with the blue zone signifying 95% confidence interval.

BMI who experienced adequate weight gain; and (5) inadequate weight gain, among women of any pre-pregnancy BMI, was significantly associated with increased risk of discordant delivery weight, compared with women of normal who had adequate weight gain. These findings have implications for the management of weight gain in twin pregnancies. For obese women, to maintain healthy growth in a twin pregnancy there is no benefit in gaining too much weight. Nevertheless, to maintain healthy and balanced growth for

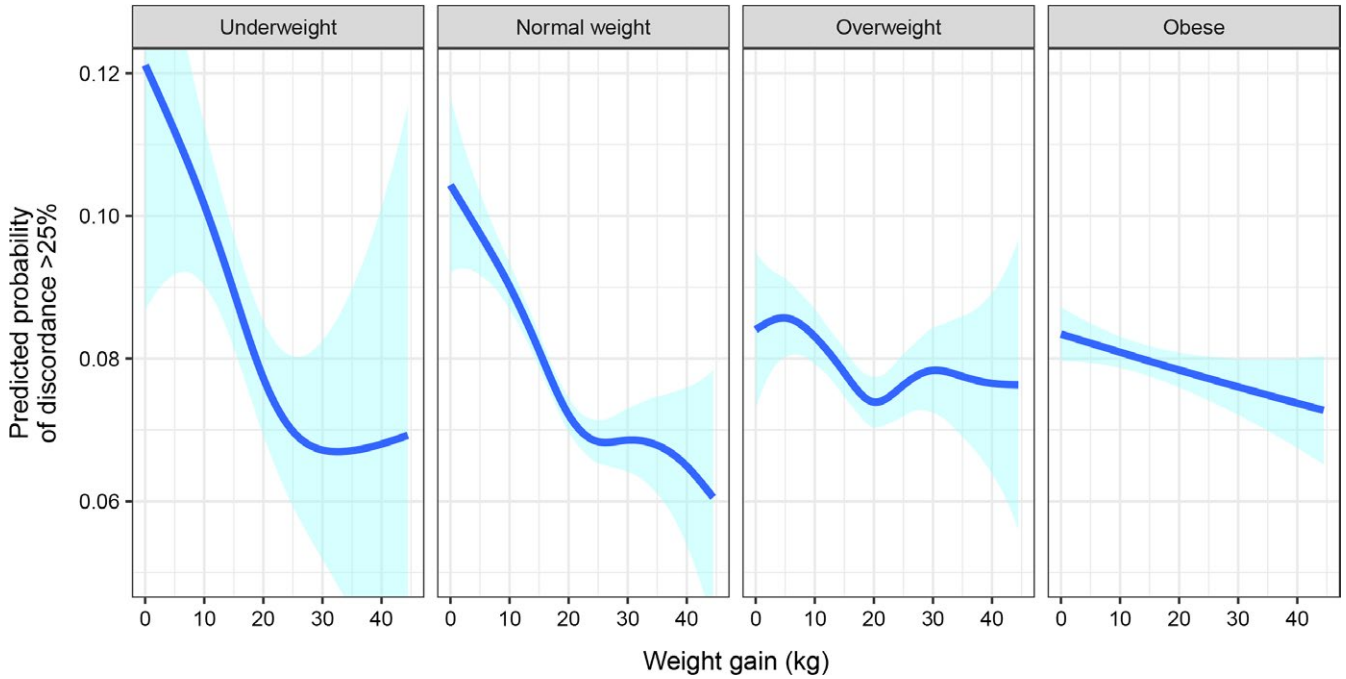

FIGURE 3 Association between weight gain during pregnancy and intertwin delivery weight discordance greater than 25%, stratified by pre-pregnancy body mass index. Solid lines signify the predicted probability of discordance greater than 25% with the blue zone signifying 95% confidence interval.

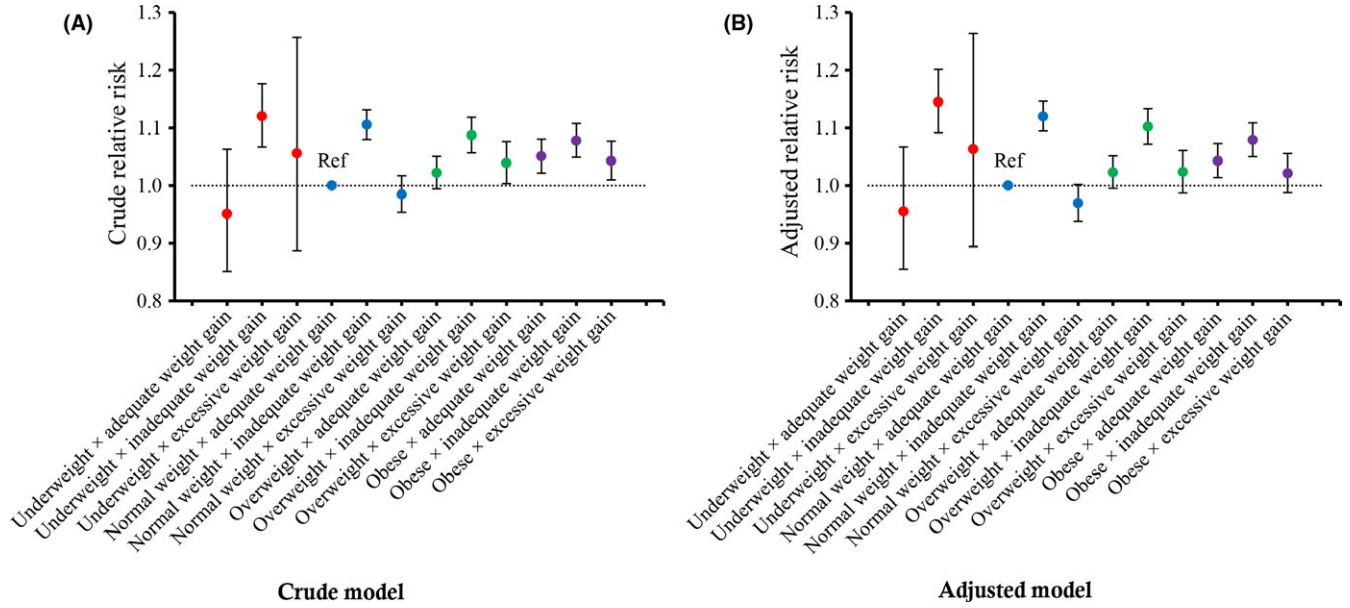

FIGURE 4 Crude and adjusted relative risk intertwin delivery weight discordance greater than 25% with patients stratified using weight gain during pregnancy (adequate, inadequate, or excessive) and pre-pregnancy body mass index. Women with normal pre-pregnancy BMI and adequate weight gain during pregnancy were included as the referent group. Red, blue, green, and purple circles signify underweight, normal weight, overweight, and obese women, respectively; 95% confidence intervals are represented as error bars.

twins, it is critical to gain an adequate amount of weight, regardless of pre-pregnancy BMI.

It was also found that women who gained approximately 25 kg had the lowest level of intertwin delivery weight discordance; however, this figure is higher than the IOM recommended total weight gain of 16.8–24.5 kg for a full-term twin pregnancy for women of normal weight.[1]

A small study of 147 twin pregnancies examined the impact of weight gain on delivery weight discordance at three gestational intervals: before 18 weeks, 18–28 weeks, and 28 weeks to delivery.[15] The authors found that in twin pregnancies with delivery weight discordance of less than 25%, no significant change in maternal weight gain during pregnancy was observed.[15] However, in twin pregnancies with delivery weight discordance greater than or equal to 25%, remarkably elevated maternal weight gain at 28 weeks to delivery was observed.[15] These results suggest that constant maternal weight gain throughout pregnancy is important to reduce the risk of intertwin delivery weight discordance.[15] A number of other studies have examined the effect of weight gain at different gestational periods on fetal growth and delivery weight in twins[2,16] and singletons.[17–24] These studies yielded different results. Differences in gestational periods and measurements used in these studies make reconsolidation of the study findings difficult.

Our study used weight gain across the whole pregnancy and therefore could not analyze the impact of weight gain at different gestational periods. While this could result in loss of some information, it is difficult to obtain weight gain data by gestational period through the national birth registration system. A strength of the present study is that the large sample size and availability of both pre-pregnancy BMI and weight gain during pregnancy allowed us to analyze the association of these two factors on intertwin delivery weight discordance. Furthermore, the number of demographic and pregnancy variables collected in the database enabled us to adjust for potential confounding factors.

The mechanisms of the findings from our analysis are not clearly understood. Here, it is speculated that the need to maintain adequate weight gain in pregnancy to reduce the risk of intertwin delivery weight discordance could be higher than the need for normal fetal growth in individual twins, and that the IOM recommendation could be based on the need to maintain normal growth for an individual fetus in the twin pregnancy, without consideration of the need for balanced growth between the two fetuses. Women with gestational diabetes had lower weight gain than those without, whereas women who conceived using ART or who had eclampsia had higher weight gain than those conceived spontaneously or those without eclampsia. Here, it is speculated that women with gestational diabetes be advised to control their weight gain by their care providers during prenatal care. Conversely, women who conceive using ART tend to be of higher socioeconomic status and are more invested in their pregnancy.[25] As a result, they could have monitored their weight gain more closely and have made necessary adjustment to better maintain their weight gain compared with women who conceived naturally.

While weight gain overall may serve as a good measure of maternal nutritional status, for excessive weight gain the situation may be different. For example, excessive weight gain may not be related to accumulation of nutrition but may be pathological products such as retained water. The issue of weight gain and pathological status is well illustrated by women with eclampsia, where abnormal renal function causes water retention and injury to the kidney is a common observation.[26]

The pathophysiology of discordant growth is different in monochorionic and dichorionic twin pregnancies. While discordant growth in dichorionic twin pregnancy is primarily caused by discordant placental size and function, in monochorionic twin pregnancy the magnitude of discordant growth is influenced not only by abnormal placental sharing but also by the direction of blood flow interchange through the placental anastomoses.[27,28] Owing to the lack of data on chorionicity, it was not possible to propose an explicit hypothesis for the mechanism for discordant growth.

In conclusion, the need for adequate weight gain for balanced twin growth has practical implications for the management of women with twin pregnancies. Further large prospective studies are needed to review the recommendations for adequate weight gain in relation to discordant growth in twins.

AUTHOR CONTRIBUTIONS

YX contributed to the conception of the study and manuscript writing. MS contributed to the conception of the study, data analysis, and manuscript writing. SM and XT contributed to the data analysis and manuscript revision. SWW and HT contributed to the conception of the study, data analysis, and manuscript revision. All authors critically reviewed the manuscript and approved the final version.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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