

The influence of pre-pregnancy body mass index and gestational weight gain on pregnancy outcomes in two-child women

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Abstract

Background Pre-pregnancy body mass index and gestational weight gain were related to perinatal outcomes. It was not known the changes of pre-pregnancy body mass index, weight gain during pregnancy and its effect on perinatal outcomes in two-child women.

Methods This was a retrospective study. Data of single term women delivered in the First Affiliated Hospital of Sun Yat-sen University were collected from July 2017 to June 2018. Gestational weight gain criteria of the American Institute of Medical Research and pre-pregnancy body mass index classes were used to evaluate the effects on pregnancy outcomes.

Results A total of 3049 cases were enrolled in the study. Overweight cases were 9.0% and obesity was 2.4%. The weight gain of the two-child women was less than that of primipara (12.4 ± 3.9 vs 13.3 ± 4.0 kg, $P < 0.001$). The proportion of primipara with excessive weight gain was higher compared to two-child women (20.1% versus 17.3%, $P < 0.001$). There were 40.0% overweight primipara and 55.2% of two-child women had excessive weight gain. And 40.5% primipara and 54.5% two-child women of obesity had excessive weight gain during pregnancy. Obese primipara increased the risk of pre-eclampsia (aOR 2.38, 95%CI 0.76-7.46). And the odds of diabetes mellitus and large for gestational age also increased in this group (aOR 3.49, 95%CI 1.46-8.35 and aOR 7.65, 95%CI 1.83-31.97, respectively). Two-child women had similar results. Underweight primipara with excessive weight gain increased the pre-eclampsia risk (aOR 2.26, 95%CI 0.29-17.46). Normal weight and overweight/obese primipara also had similar results. But in two-child women, only overweight/obesity increased the risk of pre-eclampsia (aOR 2.01, 95%CI 0.41-9.98). Underweight two-child women with less weight gain increased the risk of diabetes (aOR 2.06, 95%CI 0.43-9.8). Two-child women with overweight/obese increased the odds of LGA even if they had less weight gain (aOR 2.58, 95%CI 0.11-63.22). Normal weight primipara and two-child women with overweight and obese with excessive weight gain had similar results. On the other way, underweight primipara with less weight gain increased the risk of SGA (aOR 1.74, 95%CI 0.81-3.76).

Conclusions Gestational weight gain of two-child women was less than primipara. Overweight/obese women with excessive weight gain of two-child women increased the risk of adverse outcomes.

Background

Obesity is one of the most important health problems nowadays. The global incidence of overweight and obesity among adult women was 40.0% and 15.0%, respectively^[1]. The incidence of overweight and obesity in China was 19.1% in single-birth pregnant women^[2]. A retrospective study showed that overweight women before pregnancy was 9.0%, 2.2% of obesity and 14.0% of underweight^[3]. Another research showed that the rate of overweight/obese was 12.3%^[4]. However, these studies did not identify the incidence of different body mass index classes in primipara and multipara women.

Body mass index before pregnancy were associated with pregnancy outcomes. Overweight/obese increased the risk of adverse pregnancy outcomes including pre-eclampsia, gestational diabetes mellitus (GDM), large for gestational age (LGA), stillbirth. On the other hand, underweight increased the risk of placental abruption, small-for-gestational age (SGA)^[3-5], and low birth weight (LBW)^[3].

Unsuitable weight gain during pregnancy were also related to adverse pregnancy outcomes. Studies have shown that excessive gestational weight gain (GWG) during pregnancy increased the risk of preterm birth, pregnancy related hypertensive disorder, cesarean section^[2]. Cesarean section risk increased 13.0% when GWG raised every 5 kg^[6]. Research from Asvanarunat including 3683 cases had showed that 36.5% of pregnant women had excessive gestational weight gain, and the risk of cesarean section, LGA, macrosomia increased^[7]. By contrast, insufficient weight gain increased the risk of SGA and LBW^[3]. Therefore, it is very important to control suitable weight gain during pregnancy. According the suggestion from American Institute of Medicine^[8], weight gain of nulliparous women and multipara women were not distinguish. It was unclear whether similar criterion of weight gain during pregnancy also exist in two-child women.

Obesity increased as the times of pregnancies increased^[9]. Pre-pregnancy obesity were also associated with age^[10]. With the implementation of two-child policy, two-child pregnant women with older, overweight and obese were increasing. Advanced maternal age increased the risk of preterm birth^[11], cesarean section, pre-eclampsia^[12], gestational diabetes mellitus^[13]. However, there were few studies on the characteristics of pre-pregnancy BMI, GWG of two-child pregnant women, and the effect of BMI before pregnancy and weight gain on perinatal outcomes of the second-child pregnant women after the opening of the two-child policy. Therefore, the purpose of this study was to analyze the changes of pre-pregnancy BMI, gestational weight gain and its influence on pregnancy outcomes in the second-child pregnant women.

Methods

Data were collected in the First Affiliated Hospital of Sun Yat-sen university from July 2017 to June 2018. Single term women over 18 years old who delivered in this hospital were included in this study. Exclusion criteria including: premature birth; twin or multiple pregnancies; third or more times deliveries; incomplete basic data; chronic hypertension, type 1 or type 2 diabetes, severe medical complications such as cardiac failure or uncontrolled asthma, active systemic lupus erythematosus, and uncontrolled nephrotic syndrome; etc. This study has been approved by the Ethics Committee of the First Affiliated Hospital, Sun yat-sen University ((2017)296).

Demographic data were collected including age, marital status, smoking, husband smoking, socioeconomic status, height, weight, body mass index before pregnancy, times of delivered, gestational weight gain, number of abortion, mode of delivery, gestational age, etc. Pregnancy complications data were collected from Electronic Medical Record (EMR) including pregnancy related hypertensive disease, gestational diabetes mellitus, postpartum hemorrhage, premature rupture of membranes (PROM), placental abruption, shoulder dystocia, fetal growth restriction (FGR), etc. Neonatal outcomes including weight,

Apgar score, neonatal asphyxia, fetal distress, neonatal pathological jaundice, neonatal hypoglycemia, small for gestation age, low birth weight, large for gestation age, macrosomia were also collected.

According to the American Institute of Medicine guidelines^[6], for low-, normal-weight, overweight, and obese pregnant women, GWG ranges from 12.5 to 18kg, 11.5 to 16kg, 7 to 11.5kg, and 5 to 9kg, respectively. Weight gain during pregnancy were classified into three categories: less GWG, normal GWG and excessive GWG.

The statistical analysis were carried out by SPSS19.0 (SPSS, Inc., Chicago, IL). Continuous variables were presented as mean and standard deviation (SD) which compared by student *t* test. Categorical variables were calculated as percentage and frequencies which compared by chi-square test or Fisher's exact test. Multiple logistics regression analysis was used to evaluate the effect of pre-pregnancy BMI and GWG on pregnancy outcomes. A *P* value less than 0.05 was statistically significant.

Results

A total of 3,180 cases of single term women delivered from July 2017 to June 2018 in this hospital. There were excluded 20 cases of chronic hypertension, 8 cases of type 1 or type 2 diabetes, 76 cases of third or more times delivery, 27 cases of incomplete basic data. A total of 3,049 cases were included in this study. Maternal age was 32.5 ± 4.8 years (18-51 years), and average weight gain during pregnancy was 12.8 ± 3.9 kg (-4-32kg). The gestational age was 39.2 ± 1.0 weeks (37-41⁺⁶ weeks). There were 1023 cases (33.6%) had less weight gain during pregnancy and 566 cases (18.6%) had excessive weight gain. There were 1380 cases (45.3%) of primipara and 1669 cases (54.7%) of two-child women. Gestational weight gain of primipara was higher compared to the second-child women (13.3 ± 4.0 vs 12.4 ± 3.9 kg, *P* < 0.001). The proportion of less weight gain of primipara was lower than that of two-child women (30.0% vs 36.5%, *P* < 0.001), and the proportion of excessive weight gain of primipara was higher than that of two-child women (20.1% vs 17.3%, *P* < 0.001). Birthweight between the two groups were no difference (3201.4 ± 379.3 vs 3224.4 ± 373.6 g, *P* = 0.093). The demographic data of the two groups were shown in table 1.

Table 1. Demographic data of the two groups

Items	Primipara N=1380	Two-child women N=1669	T value	P value
Age(year)	30.0±4.1	34.6±4.2	-30.593	0.001
Pre-pregnancy Wt(kg)	53.1±7.9	54.9±7.9	-6.168	0.001
Pre-pregnancy BMI(kg/m ²)	20.7±2.8	21.5±2.8	-8.512	0.001
GWG(kg)	13.3±4.0	12.4±3.9	6.515	0.001
Gestational age(wks)	39.4±1.0	39.0±0.9	12.664	0.001
Birth weight(g)	3201.4±379.3	3224.4±373.6	-1.681	0.093
Age			X2 value	
≤35years	1197(86.7%)	880(47.9%)	503.387	0.001
>35years	183(13.3%)	869(52.1%)		
Mode of pregnancy				
Natural	1200(87.0%)	1598(95.7%)	77.2499	0.001
In vitro	180(13.0%)	71(4.3%)		
Marital status				
Married	1366(99.0%)	1660(99.5%)	2.279	0.131
Unmarried	14(1.0%)	9(0.5%)		
Socioeconomic				
Status				
≥10,000	1290(93.5%)	1580(94.7%)	1.933	0.164
<10,000	90(6.5%)	89(5.3%)		
Pre-pregnancy BMI (kg/m ²)				
≤18.5	296(21.4%)	197(11.8%)	57.254	0.001
18.5-24.9	995(71.4%)	1297(77.7%)		
25-27.9	70(5.1%)	131(7.8%)		
≥28.0	29(2.1%)	44(2.6%)		
Smoking in pregnancy	8(0.6%)	10(0.6%)	0.005	0.944
Husband smoking	198(14.3%)	275(16.5%)	2.613	0.106
GWG				
less	414(30.0%)	609(36.5%)		
Normal	688(49.9%)	772(46.3%)	14.921	0.001
Excessive	278(20.1%)	288(17.3%)		

BMI: body mass index, GWG: gestational weight gain

The perinatal outcomes of the two groups were showed in table 2. The incidence of GDM of the two-child women group was higher than that of the primipara group (19.8%versus14.5%, P < 0.001). The incidence of FGR of the two-child women group was lower than that of primipara (1.5%versus2.5%, P = 0.04). There was no difference between the two groups in the incidence of shoulder dystocia, postpartum hemorrhage, hydramnios and pre-eclampsia(P > 0.05). The perinatal outcomes of the two groups were shown in table 2.

Table 2. Prenatal outcomes between the two groups

Items	Primipara N=1380	Two-child women N=1669	χ^2 value	P value
Way of delivery				
Spontaneous labor	655(47.5%)	754(45.2%)	106.806	0.001
Cesarean section	579(42.0%)	878(52.6%)		
Forceps	146(10.6%)	37(2.2%)		
pregnancy related hypertensive disease	1327(96.2%)	1623(97.2%)	2.828	0.093
GDM	200(14.5%)	330(19.8%)	14.662	0.001
PPH	117(8.5%)	158(9.5%)	0.899	0.343
Polyhydramnios	41(3.0%)	56(3.4%)	0.362	0.547
Oligohydramnion	15(1.1%)	20(1.2%)	0.083	0.774
FGR	35(2.5%)	25(1.5%)	4.222	0.040
Fetal distress	330(23.9%)	126(7.5%)	159.032	0.001
Shoulder dystocia	13(0.9%)	21(1.3%)	0.685	0.408
Macrosomia	33(2.4%)	46(2.8%)	0.398	0.528
LGA	50(3.6%)	85(5.1%)	3.856	0.050
LBW	36(2.6%)	34(2.0%)	1.100	0.294
SGA	157(11.4%)	123(7.4%)	14.544	0.001
Neonatal asphyxia	42(3.0%)	21(1.3%)	11.897	0.001
Newborn transferred to paediatrics	277(20.1%)	208(12.5%)	32.703	0.001
Pathological jaundice of newborn	152(11.0%)	122(7.3%)	12.677	0.001
Neonatal hypoglycemia	59(4.3%)	113(6.8%)	8.835	0.003

GDM: gestational diabetes mellitus, PPH: Postpartum hemorrhage, FGR: fetal growth restriction, LGA: large for gestation age, LBW: low birth weight, SGA: small for gestation age

The influence of pre-pregnancy BMI and GWG on pregnancy outcomes were showed in table 3. The proportion of normal weight primipara with excessive GWG was higher compared to the second-child group (19.8%versus15.2%, $P < 0.001$). The incidence of less or excessive weight gain during pregnancy between the two groups in the underweight, overweight and obese classes were no difference. Gestational weight gain of the first-child women with normal weight was higher than that of two-child women (13.4 ± 3.9 versus 12.5 ± 3.8 kg, $P < 0.001$), but there was no difference between the two groups in neonatal birth weight (3228.4 ± 371.5 versus 3229.4 ± 366.3 g, $P = 0.953$). The incidence of pre-eclampsia, anemia, polyhydramnios between the two groups in all BMI classes were no difference($P > 0.05$).

Table 3. The influence of pre-pregnancy BMI and GWG on pregnancy outcomes

	Underweight			Normal weight			Overweight			obese	
	primipara	Two-child women	<i>P</i> value	primipara	Two-child women	<i>P</i> value	primipara	Two-child women	<i>P</i> value	primipara	Two-child women
N	296	197		985	1297		70	131		29	4
GWG	14.0±3.6	13.5±3.2	0.104	13.4±3.9	12.5±3.8	0.001	11.3±3.9	11.0±4.3	0.578	10.2±5.7	10.2±5.7
GWKs	39.4±1.1	38.9±1.0	0.001	39.4±1.0	39.0±0.9	0.001	39.4±1.0	38.9±0.9	0.001	39.2±0.9	39.2±0.9
BW	3066.9±366.6	3099.5±364.4	0.333	3228.4±371.5	3229.4±366.3	0.953	3324.4±413.5	3307.4±394.3	0.775	3356.6±342.8	3356.6±342.8
GWG											
Less	105(35.5%)	74(37.6%)		297(30.2%)	513(39.6%)		8(11.4%)	19(14.5%)		4(13.8%)	4(13.8%)
Normal	152(51.4%)	109(55.3%)	0.103	493(50.1%)	587(45.3%)	0.001	34(48.6%)	59(45.0%)	0.800	9(31.0%)	9(31.0%)
Excess	39(13.2%)	14(7.1%)		195(19.8%)	197(15.2%)		28(40.0%)	53(40.5%)		16(55.2%)	16(55.2%)
PE	8(2.7%)	1(0.5%)	0.093	36(3.7%)	30(2.3%)	0.058	5(7.1%)	10(7.6%)	0.900	4(13.8%)	4(13.8%)
GDM	21(7.1%)	13(6.6%)	0.832	149(15.1%)	256(19.7%)	0.004	21(30.0%)	42(32.1%)	0.764	9(31.0%)	9(31.0%)
PPH	20(6.8%)	13(6.6%)	0.945	86(8.7%)	125(9.6%)	0.459	10(14.3%)	17(13.0%)	0.795	1(3.4%)	1(3.4%)
Polyhydramnios	6(2.0%)	3(1.5%)	0.682	27(2.7%)	41(3.2%)	0.559	4(5.7%)	9(6.9%)	0.751	4(13.8%)	4(13.8%)
Anemia	111(37.5%)	89(45.2%)	0.089	382(38.8%)	475(36.6%)	0.292	22(31.4%)	51(38.9%)	0.292	9(31.0%)	9(31.0%)
FGR	15(5.1%)	4(2.0%)	0.086	18(1.8%)	19(1.5%)	0.497	2(2.9%)	2(1.5%)	0.434	0	0
Fetal Distress	69(23.3%)	14(7.1%)	0.001	241(24.5%)	100(7.7%)	0.001	17(24.3%)	10(7.6%)	0.001	3(10.3%)	3(10.3%)
LBW	19(6.4%)	5(2.5%)	0.050	16(1.6%)	27(2.1%)	0.426	1(1.4%)	2(1.5%)	0.722	0	0
SGA	58(19.6%)	29(14.7%)	0.164	89(9.0%)	88(6.8%)	0.046	7(10.0%)	5(3.8%)	0.076	3(10.3%)	3(10.3%)
LGA	3(1.0%)	5(2.5%)	0.276	38(3.9%)	64(4.9%)	0.218	6(8.6%)	11(8.4%)	0.966	3(10.3%)	3(10.3%)
Macrosomia	1(0.3%)	3(1.5%)	0.307	29(2.9%)	33(2.5%)	0.561	3(4.3%)	6(4.6%)	0.615	0(0.0%)	0(0.0%)
Asphyxia	6(2.0%)	3(1.5%)	1.000	30(3.0%)	16(1.2%)	0.002	4(5.7%)	1(0.8%)	0.051	2(6.9%)	2(6.9%)
Jaundice	30(10.1%)	11(5.6%)	0.073	110(11.2%)	93(7.2%)	0.001	8(11.4%)	14(10.7%)	0.873	4(13.8%)	4(13.8%)
Hypoglycemia	5(1.7%)	9(4.6%)	0.059	43(4.6%)	84(6.5%)	0.051	4(5.7%)	14(10.7%)	0.239	5(17.2%)	5(17.2%)

GWG, gestational weight gain, GWK, gestational weeks, PE, pre-eclampsia, GDM: gestational diabetes mellitus, PPH: Postpartum hemorrhage, FGR: fetal growth restriction, LBW: low birth weight, SGA: small for gestation age, LGA: large for gestation age

The results of multiple logistic regression analysis in pre-pregnancy BMI and GWG on perinatal outcomes are shown in table 4. The two-child women with overweight and obese increased the odds of pre-eclampsia (aOR3.14, 95%CI 1.42-6.92, aOR5.02, 95%CI 1.71-14.74, respectively), and the primipara obese group had similar results. Excessive weight gain increased the odds for pre-eclampsia in the two groups. The overweight and obese primipara increased the risk of LGA (aOR3.10, 95% CI 0.81-11.88, aOR7.65, 95%CI 1.83-31.97), while the odds of LGA for the two-child overweight and obese groups were not increased.

Table 4. Adjusted odds ratios and 95% confidence interval for prenatal outcomes of pre-pregnancy body mass index and gestational weight gain

	Pre-pregnancy BMI				GWG	
	underweight	normal weight	overweight	obese	less	normal
PE	reference				reference	
Primipara	0.88(0.40-1.94)		1.31(0.48-3.52)	2.38(0.76-7.46)	0.30(0.12-0.75)*	2.17(1.15-4.08)*
Two-child women	0.24(0.03-1.76)		3.14(1.42-6.92)*	5.02(1.71-14.74)*	1.24(0.61-2.55)	1.68(0.75-3.76)
GDM						
Primipara	0.42(0.25-0.68)**		2.89(1.62-5.15)**	3.49(1.46-8.35)*	1.94(1.37-2.73)**	0.64(0.40-1.02)
Two-child women	0.30(0.17-0.54)**		2.73(1.78-4.18)**	5.40(2.76-10.56)**	2.13(1.62-2.80)**	0.66(0.43-0.99)*
PPH						
Primipara	0.77(0.45-1.30)		1.53(0.71-3.26)	0.42(0.05-3.23)	0.61(0.37-0.99)*	0.79(0.48-1.32)
Two-child women	0.67(0.37-1.23)		1.53(0.87-2.72)	0.79(0.23-2.70)	0.94(0.65-1.35)	0.63(0.37-1.06)
Shoulder dystocia						
Primipara	0.39(0.05-3.07)		0.93(0.20-4.41)	-	0.69(0.14-3.41)	1.46(0.40-5.34)
Two-child women	0.50(0.06-3.96)		0.47(0.04-5.04)	-	1.32(0.51-3.45)	0.37(0.08-1.79)
FGR						
Primipara	1.07(0.44-2.58)		1.88(0.31-11.58)	-	0.97(0.39-2.39)	0.57(0.16-2.00)
Two-child women	0.96(0.25-3.73)		1.66(0.16-17.19)	-	0.38(0.11-1.25)	2.07(0.46-9.31)
LGA						
Primipara	0.67(0.17-2.66)		3.10(0.81-11.88)	7.65(1.83-31.97)	0.79(0.27-2.31)	1.71(0.68-4.27)
Two-child women	0.62(0.17-2.31)		1.17(0.46-3.00)	0.78(0.14-4.25)	0.82(0.39-1.74)	2.24(1.07-4.69)
Macrosomia						
Primipara	0.19(0.02-1.82)		0.41(0.07-2.40)	-	0.76(0.20-2.87)	1.58(0.53-4.73)
Two-child women	1.26(0.23-6.79)		1.03(0.30-3.56)	3.18(0.48-21.17)	0.57(0.19-1.73)	1.45(0.55-3.80)
SGA						
Primipara	1.81(1.18-2.78)*		1.45(0.57-3.72)	-	1.69(1.10-2.60)*	1.04(0.60-1.83)
Two-child women	2.87(1.70-4.84)**		0.47(0.15-1.49)	-	1.61(1.00-2.58)*	1.28(0.65-2.51)
LBW						
Primipara	2.26(0.95-5.40)		0.47(0.04-5.04)	-	1.33(0.51-3.47)	2.33(0.72-7.49)
Two-child women	0.51(0.15-1.74)		0.84(0.08-8.78)	-	0.96(0.35-2.61)	0.38(0.07-1.95)

PE: pre-eclampsia, GDM: gestational diabetes mellitus, PPH: postpartum hemorrhage, FGR: fetal growth restriction, LGA: large for gestation age, SGA: small for gestation age, LBW: low birth weight. *: ≤ 0.05 , **: ≤ 0.001 , -: no case

In adjusted multinomial analyse with normal weight pregnant women, underweight primipara with excessive gestational weight gain increased the odds of pre-eclampsia (aOR 2.26, 95% CI 0.29-17.46). While the two-child women with insufficient weight gain increased the odds of GDM for all BMI classes. The effect of different BMI and GWG on pregnancy outcomes were shown in table 5.

Table 5. Adjusted odds ratios and 95% confidence interval for pregnancy outcome in multinomial logistic regression for pre-pregnancy body mass index and gestational weight gain

	PE		GDM		PPH		FGR	
	Primipara	Two-child women	Primipara	Two-child women	Primipara	Two-child women	Primipara	Two-child women
Underweight								
less	0.40(0.06-2.85)		-1.89(0.64-5.60)	2.06(0.43-9.8)	1.89(0.55-6.55)	2.39(0.61-9.28)	0.78(0.18-3.44)	-
normal	reference							
excess	2.26(0.29-17.46)		-1.86(0.49-7.14)		-1.34(0.18-11.16)	1.89(0.18-20.14)	0.70(0.07-7.41)	-
Normal weight								
less	0.23(0.07-0.72)*	1.13(0.50-2.54)	2.30(1.55-3.43)**	2.32(1.69-3.17)**	0.61(0.33-1.14)	0.91(0.60-1.38)	1.12(0.33-3.75)	0.45(0.11-1.83)
normal	reference							
excess	2.06(0.95-4.46)	1.37(0.45-4.00)	0.57(0.31-1.06)	0.72(0.43-1.21)	1.09(0.58-2.04)	0.54(0.27-1.07)	0.46(0.08-2.80)	1.29(0.20-8.43)
Overweight/obese								
less	-	0.82(0.09-7.15)	0.57(0.12-2.80)	2.54(0.81-7.98)		-0.24(0.03-2.40)		-
normal	reference							
excess	2.86(0.38-21.48)	2.01(0.41-9.98)	0.29(0.09-0.92)*	0.64(0.28-1.45)	0.05(0.00-0.62)*	0.75(0.23-2.43)		-

PE: pre-eclampsia, GDM: gestational diabetes mellitus, PPH: postpartum hemorrhage, FGR: fetal growth restriction, *: ≤ 0.05 , **: ≤ 0.001 , -: no case or too few case

Normal weight primipara women with excessive GWG increased the odds of LGA (aOR2.40, 95%CI 0.79-7.31), and normal weight and overweight or obese two-child woman with excessive weight gain during pregnancy had similar results. For underweight nulliparous women with less GWG increased the odds of LBW(aOR2.66, 95%CI 0.59-12.04), when they had excessive weight gain also increased the odds of LBW(aOR4.29, 95%CI 0.38-48.20). Underweight primipara women with less weight gain during pregnancy increased the odds of SGA(aOR1.74,95%CI 0.81-3.76). Even if overweight or obese two-child woman who had insufficient weight gain during pregnancy, the odds of LGA also increased (aOR2.58, 95%CI 0.11-63.22). The influence of pre-pregnancy BMI and GWG on neonatal outcomes were shown in table 6.

Table 6. Adjusted odds ratios and 95% confidence interval for neonatal outcomes in multinomial logistic regression for pre-gestational body mass index and gestational weight gain

	LGA		Macrosomia		LBW		SGA	
	Primipara	Two-child women	Primipara	Two-child women	Primipara	Two-child women	Primipara	Two-child women
Underweight								
less	1.57(0.09-26.25)	-	-	-	2.66(0.59-12.04)	0.40(0.03-5.04)	1.74(0.81-3.76)	1.60(0.57-4.50)
normal	Reference							
excess	-	-	-	-	4.29(0.38-48.20)	-	0.36(0.07-1.78)	-
Normal weight								
less	0.99(0.29-3.43)	0.90(0.40-1.99)	0.72(1.71-3.05)	0.42(0.12-1.49)	0.79(0.19-3.21)	1.18(0.35-3.99)	1.79(1.01-3.18)*	1.55(0.88-2.72)
normal	Reference							
excess	2.40(0.79-7.31)	1.96(0.80-4.81)	1.62(0.47-5.66)	1.57(0.50-4.99)	1.55(0.33-7.34)	0.57(0.08-3.90)	1.23(0.62-2.44)	1.18(0.54-2.60)
Overweight/obese								
less	-	2.58(0.11-63.22)	-	-			-0.75(0.04-14.70)	-
normal	Reference							
excess	0.75(0.06-9.08)	7.61(0.81-71.79)	0.18(0.01-6.33)		-	-	-1.25(0.16-9.95)	-

LGA: large for gestation age, LBW: low birth weight, SGA: small for gestation age, -: no cases or too few cases, *: ≤ 0.05 , -: no case or too few case

Discussion

Pregnancy period itself is an ideal time to maintain and start a healthy lifestyle^[14]. However, the traditional concept of Chinese thought that women should add large amount of nutrients, and the more weight gained during pregnancy, the better it will be for the pregnant woman and the fetus. Therefore, pregnant women usually consume a large amount of nutrients during pregnancy period, leading to excessive weight gain. With the opening of the two-child policy in China, elderly and high-risk women increased, and weight gain also increased, which increased the risk of adverse pregnancy outcomes. Research from Hung and colleagues showed that the incidence of overweight women before pregnancy was 8.9% and 1.8% in obese^[15]. Results from study of Hora Soltani and colleagues showed that 21.7% women were overweight and obese 5.3%, obese increased the risk of LGA(OR3.46)^[16]. Study from Haugen et al. showed that obesity rate was 8.1% in primipara and 9.7% in multipara, and the incidence of LGA was higher both in primipara and multipara with obesity (15.0% and 27.1%, respectively)^[17]. The results of this study showed that overweight rate was 9.0%, and 2.4% of obesity. The overweight rate of the two-child women was 7.8%, which was higher compared to primipara. The incidence of overweight and obese women of this study were lower than those literature reported.

Overweight or obese increased the risk of postpartum hemorrhage, LGA, macrosomia^[18–20]. A study reported 23.9% of pregnancy complications were closely related to overweight and obesity^[21]. A meta-analysis also had similar conclusions that overweight or obese increased the risk of LGA and macrosomia^[22]. Research from Ferraro et al. showed that pre-pregnancy overweight and obese women increased the risk of LGA even if they had normal weight gain during pregnancy (OR 1.99 and 2.64, respectively)^[23]. This study had similar results. The results of this study showed that even if overweight or obese two-child woman who had insufficient weight gain during pregnancy, the odds of LGA also increased (aOR2.58, 95%CI 0.11–63.22). Pre-pregnancy obese increased the risk of pre-eclampsia both in primipara and the two-child pregnant women. Overweight or obese women, especially for the two-child pregnant women with higher rate of overweight or obesity, were closely associated with adverse outcomes. At the same time, underweight was associated with adverse neonatal outcomes. Results from the research of Haugen et al. showed that the incidence of SGA was higher (16.5% and 9.4%) both in underweight primipara and multipara pregnant women^[17]. However, the study did not analyze the odds of SGA for underweight primipara and multipara. A study including 2521 cases showed that the risk of SGA increased in underweight women(OR1.9)^[24]. The results of this study found that the proportion of SGA decreased with pre-pregnancy BMI increasing both in nulliparous and two-child pregnant women. While the incidence of SGA of normal weight primipara was higher compared to the second-child women (9.0%versus6.8%, $P = 0.046$). And the odds of SGA both in nulliparous and two-child pregnant women with underweight were increased (aOR 1.81 and 2.87, respectively), which were similar with literature.

Gestational weight gain were also associated with pregnancy outcomes. Study from lan-pidhainy et al. showed that the mean weight gain of primipara was higher than that of multipara (15.9 vs 13.5kg, $P < 0.001$), weight gain decreased with pre-pregnancy BMI increasing^[25]. A retrospective study reviewed 11203 singleton cases showed that 57.2% women had excessive weight gain with LGA rate of 8.7% and the incidence of SGA was 9.6%^[26]. The results of this study showed that gestational weight gain of the two-child women was less than primipara (12.4versus13.3kg, $P < 0.001$), which was similar with literature. Over 30.0% of underweight and normal weight primipara and the second-child women was less weight gain, while over 40.0% of overweight and obese nulliparous and two-child women had excessive weight gain. Excessive weight gain increased the odds of LGA both in primipara and two-child women, specially for overweight and obese two-child women. The results of study from Ferraro and colleagues showed that more than 55% of women gained too much during pregnancy, overweight and obese pregnant women with excessive weight gain raised the risk of LGA (OR 3.59)^[23], while less gestational weight gain increased the risk of SGA. Research from Johnson et al. showed that more than 70% of women gained weight too much during pregnancy, and the risk of pregnancy related hypertensive disorder was increased for all BMI classes^[27]. Nucci and colleague showed that the risk of macrosomia(OR2.56) increased in women with excessive weight gain, but it did not analyze the difference between primipara and multipara^[28]. Results of this study showed that although normal weight nulliparous had more weight gain than that of normal weight two-child women(13.4vs12.5 kg, $P < 0.001$), neonatal birth weight of the two groups were no difference (3228.4 versus3229.4 g, $P > 0.05$), however, the incidence of SGA was higher than that of the second-child women (9.0%vs6.8%, $P = 0.046$). Although the weight gain of other BMI classes between nulliparous and two-child women were no difference, it decreased with BMI increasing. The odds of LGA increased in the two-child women with excessive gestational weight gain(aOR2.24). However, for nulliparous women with excessive weight gain, even if they were underweight before pregnancy, the risk of pre-eclampsia was increased (aOR2.26). While the risk of pre-eclampsia was increased in overweight/obesity two-child women(aOR2.01). Therefore, the weight gain during pregnancy in difference BMI may have difference range, and it should be also had difference rang between nulliparou and multipara women.

A research have shown that less weight gain during pregnancy increases the risk of GDM^[29]. This contradicts the previous understanding that excessive weight gain during pregnancy was associated with GDM. The results of this study also had similar results. Although the weight gain of the first-child women with normal weight was more than that of the second-child women, the rate of GDM was lower (15.1%versus19.7%, $P = 0.004$). And underweight primipara increased the odds of GDM with less weight gain during pregnancy(aOR1.89). But less weight gain raised the risk of GDM in the second-child women with underweight(aOR2.06). This may be due to these studies were retrospective research. In most countries, pregnant women were diagnosed GDM by oral glucose tolerance test at 24–28 gestation weeks. After the diagnosis of GDM, pregnant women had diet control and exercise, these would control the gestational weight gain strictly. However, the risk of SGA was not increased in the primipara and the two-child women with overweight/obese who had less weight gain. But the risk of pre-eclampsia and LGA was increased both in overweight/obese nulliparous and two-child women even they had less gestational weight gain. And the risk of LGA significantly increased in the overweight/obese two-child women with excessive weight gain. While the odds of LGA raise only in the normal weight primipara with excessive gestational weight gain. These results suggested that overweight and obese two-child women should control their weight gain more strictly to reduce adverse pregnancy outcomes. And the pre-pregnancy body mass index maybe more closely related to adverse outcomes than weight gain during pregnancy. It would be better to decrease their body mass index reasonably before they were pregnancy.

Conclusion

In conclusion, prenatal body mass index and gestational weight gain is related to adverse pregnancy outcomes. Weight gain during pregnancy should be reasonably controlled according to prenatal body mass index to improve pregnancy outcomes. Multicenter randomized studies were need to ensure the range of gestational weight gain during pregnancy in both primipara and multipara women to reduce adverse pregnancy outcomes.

Abbreviations

LGA: large for gestational age

SGA: small for gestational age

OR: odds rate

CI: confidence interval

GDM: gestational diabetes mellitus

BMI: body mass index

GWG: gestational weight gain

EMR: Electronic Medical Record

LBW: low birth weight

PROM: premature rupture of membranes

SD: standard deviation

FGR: fetal growth restriction

PPH: Postpartum hemorrhage

Declarations

Ethics approval and consent to participate

This study has been approved by the Ethics Committee of the First Affiliated Hospital, Sun yat-sen University ((2017)296).

Consent for publication

Not applicable

Availability of data and material

All data generated or analyzed during this study are included in this published article and its supplementary information files.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Hanqing Chen and Suhua Zou contributed to the conception of this article, the analysis and interpretation of data, and drafting the article. Suhua Zou collected the data. Jianbo Yang contributed to the analysis and interpretation of clinical data. Zhuyu Li and Jian Cai helped to analyze the data. Zilian Wang raised the idea of this article and contributed to the study design and manuscript revision. All authors have read and approved the manuscript.

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