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The association between gestational weight gain and substantial weight retention 1-year postpartum

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Abstract
Purpose Postpartum weight retention contributes to obesity development of women in their reproductive age. The studies about the association between gestational weight gain (GWG) and substantial weight retention are lacking. This study examined the association between GWG and substantial postpartum weight retention (SPPWR).
Methods The participants (n = 1,122) in the study were healthy, mature and fed their infants whose ages were 3, 6, 9, 12 months (2010–2012), respectively. They self-reported their socio-demographic, clinical prenatal and behaviors characteristics via questionnaires. We collected their weight data including pre-pregnancy and prior to delivery, as well as weight at 3, 6, 9, and 12 months postpartum. The major outcomes included weight retention and substantial weight gain 1 year postpartum.
Results Of the 1,122 women, the median weight retention was 3.0 (IQR = 5.5) kg 12 months postpartum. 35.7 % of them reported substantial weight retention (≥4.55 kg). GWG categories were established as follows: inadequate weight gain (n = 366, 33 %), adequate weight gain (n = 596, 53 %), and excessive weight gain (n = 160, 14 %). Adjusted odds ratios of SPPWR were 0.59 (95 % CI 0.43, 0.81) for inadequate weight gain and 4.05 (95 % CI 2.75, 5.95) for excessive weight gain versus adequate weight gain ($P < 0.001$).
Conclusions Excessive GWG would increase the risk of substantial weight retention 1-year postpartum. The interventions to prevent postpartum obesity should consider the strategies how to attain optimal maternal GWG.

Keywords Obesity · Gestational weight gain · Postpartum weight retention · Pre-pregnancy · Body mass index

Introduction

The world health organization (WHO) reported that the increased consumption of more energy-dense, nutrient-poor foods, combined with reduced physical activity, has led to widespread obesity. Obesity has reached epidemic proportions globally, with high prevalence rates of overweight and obesity in adults and children throughout the world [1]. Obesity posed a major risk for chronic diseases, such as stroke, cardiovascular disease, and certain forms of cancer, in addition to increasing death rates [2].

Excessive gestational weight gain (GWG) and postpartum weight retention (PPWR) in women have the strongest risk factor for obesity later in their life [3]. Rooney and Schauberger [4] found that women with PPWR were 3.5 times heavier than women without retained weight at 8.5-year follow-up. Keppel and Taffel [5] reported that the association between weight gain and retained weight was not substantially changed after controlling for parity, breastfeeding, or employment status. Increasing GWG has been reported in several industrialized countries [6–8], which might contribute to the increasing prevalence of overweight and obesity in women.

To reduce possible adverse pregnancy outcomes related to high or low GWG, such as preeclampsia, complications

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during labor and delivery, and large- or small-for-gestational-age infants, the American Institute of Medicine guidelines (IOM) published guidelines for a healthy GWG [9], which were slightly revised in 2009 [10]. Although there were a number of evidences on the effect of GWG in accordance with the IOM guidelines on weight retention up to 1-year postpartum [11, 12], the studies about the effect of GWG on substantial weight retention 1-year postpartum are sparse.

Therefore, the aim of this study was to examine the association between GWG and substantial postpartum weight retention (SPPWR), defined as a gain of 4.55 kg or more above preconception body weight 1 year after delivery.

Methods

Subjects

The women who participated in the study of health, growth and feeding of their infants at the age of 3, 6, 9, 12 months were chosen as subjects from 2010 to 2012 in Hefei Maternal and Child Health Centre, Anhui Province, China. The eligibility criteria included absence of chronic diseases such as diabetes, hypertension, osteoporosis etc., no history of multiple gestation, no disability, no epilepsy and residence in the study area. In addition, women who smoked and did not feed their infants themselves were excluded. All mothers provided written informed consent, and all procedures were in accordance with ethical standards for human experimentation. Institutional review boards of participating sites approved this study.

A total of 1,399 women who delivered infants were enrolled in this research. Recruitment and retention details have been summarized [13]. We excluded women who smoked during or after pregnancy ($n = 17$), dropped out ($n = 53$), or were lost to follow-up ($n = 40$). Of 1,289 women remaining, we excluded 68 women who lost data of weight pre-pregnancy and 99 women who lost data of weight 1-year postpartum. Therefore, the analytical sample included 1,122 women. The women who excluded were more likely to be less educated, but age, pre-pregnancy body mass index, and GWG were similar.

Data collection

Participants reported socio-demographic, clinical prenatal and behavioral characteristics via self-administered questionnaires at in-person interviews at 3, 6, 9 and 12 months postpartum. All maternal pre-pregnancy weight was self-reported, and the last clinically weight recorded prior to delivery was abstracted from medical records. Their current weight at 3, 6, 9 and 12 months postpartum was measured.

Maternal BMI and gestational weight gain

We obtained maternal self-reported pre-pregnancy weight and height at enrollment, from which we calculated pre-pregnancy BMI. The height and weight of each subject were measured using a digital scale with the examinees wearing light gowns and no shoes at 3, 6, 9 and 12 months postpartum. We defined total GWG as the difference between self-reported pre-pregnancy weight and the last clinically measured weight recorded prior to delivery. We also categorized participants as having gained inadequate, adequate, or excessive weight according to Institute of Medicine guidelines [10]. These guidelines recommend that women with a "normal" pre-pregnancy BMI (18.5–24.9) should gain 11.5–16 kg, women with a BMI < 18.5 should gain 12.5–18 kg, women with a BMI of 25.0–29.9 should gain 7–11.5 kg, and women with a BMI of ≥30.0 should gain 5–9 kg.

To determine the reporting error using self-reported pre-pregnancy weight, we compared the weights for 200 participants who had clinic visit measurements recorded within 3 months of their last menstrual period for the index pregnancy with self-reported pre-pregnancy weight at the first trimester visit. The correlation coefficient between the two weights was 0.99, with underreporting of pre-pregnancy weight averaging 1 kg. Correlation coefficients and reporting error did not differ by weight itself or gestational age at enrollment into the study.

PPWR

Postpartum weight retention in kilograms was defined as the difference between self-reported pre-pregnancy body weight, as reported in the prenatal questionnaire, and measured weight at 3, 6, 9 and 12 months postpartum. The 3, 6, 9 and 12 months questionnaires were intended to target mothers with infants of a specific age. We also defined SPPWR as retaining 4.55 kg or more than the pre-pregnancy weight. This definition was chosen for comparison with previous research [14, 15].

One-year PPWR should maintain the rank order of individuals for actual weight change, assuming that the underreporting bias did not vary over time within an individual. We should have minimized any potential bias from self-report by dichotomizing the variable for PPWR, because weight before delivery was self-reported.

Other covariates

Women reported both pre-pregnancy weight and height during early pregnancy, and these data were used to calculate body mass index [weight (kg)/height (m^2)]. Pre-pregnancy body mass index was categorized as underweight

(<18.5), normal weight (18.5–24.9), overweight (25.0–29.9), and obese weight (≥30.0) on the basis of Institute of Medicine guidelines [10]. Socio-demographic variables self-reported during pregnancy included age (≤24, 25–34, or ≥35 years), education background (college or lower, graduate, or postgraduate), and household income (<2,000, 2,000–4,999, >5,000 yuan RMB/month).

We also abstracted mode of delivery and gestational age at delivery (weeks) from medical records. We categorized mode of delivery as vaginal and cesarean. The gestational age at delivery (weeks) was categorized as <37 and 37 weeks.

During in-person visit at 12-month postpartum, participants completed questionnaires regarding lifestyle behaviors. They reported information about intentional dieting, weight loss and physical activity/inactivity levels. We assessed physical activity or inactivity on the basis of the leisure-time activity section of the physical activity scale for the elderly [16]. We modified these questions for postpartum cohort by asking women to recall the average hours of their activity/week over the previous months instead of the previous 7 days. The physical activity has been associated with PPWR [17]. In addition, breastfeeding practices at 6 months postpartum were also investigated and they were categorized as exclusive breastfeeding, mixed feeding and bottle feeding.

Statistical methods

Preliminary analysis involved description of participant characteristics using means and standard deviations (SD) of age, GWG, and PPWR. We also examined the mean of PPWR and other maternal characteristics across categories of GWG using analysis of variance. We described frequency distributions by number and percent for GWG categories by SPPWR and used Chi-square statistics to assess the overall association between levels of maternal characteristics and SPPWR. We calculated odds ratios (OR) and 95 % confidence intervals (CI) of each level of a given characteristic in relation to a selected referent group. *P* values were obtained from two-sided tests (significance is <0.05).

Multivariable logistic regression models were used to estimate the association between GWG and SPPWR. Covariates associated with SPPWR based on bivariate analysis were included in multivariable models to control confounding and to assess their individual association with SPPWR. A parsimonious model was developed by selecting covariates on the basis of their impact on OR of SPPWR for GWG categories as well as *P* values. Of postpartum behavioral attributes, we defined breastfeeding practices at 6 months postpartum as potential confounder. We constructed three logistic regression models to demonstrate the separate impact of socio-demographic, clinical prenatal and postpartum behavioral attributes on the OR for SPPWR among GWG categories (models 1, 2, and 3). Goodness-of-fit for the logistic regression models was assessed by log likelihood.

Results

Of the total 1,122 women with available data on pre-pregnancy weight, weight at term and at least one self-reported postpartum weight assessment, the mean of age was 27.8 (SD 3.2) years, the mean of pre-pregnancy BMI was 20.4 (SD 2.7) kg/m^2 and relatively few women had education backgrounds lower than college (6 %) or had monthly household incomes below 2,000 Yuan RMB (5.3 %).

The mean pre-pregnancy weight was 52.8 (SD 6.4) kg, and the mean weight was 69.5 (SD 8.4) kg, 60.2 (SD 8.7) kg, 58.5 (SD 8.6) kg, 57.1(SD 8.3) kg and 55.8 (SD 7.7) kg at term, 3, 6, 9 and 12 months postpartum respectively, that is to say, the mean weight gain was 16.7 (SD 5.7) kg during pregnancy, and the median weight retention was 8.0 (IQR 6.5) kg at 3 months postpartum, 5.0 (IQR7.0) kg at 6 months postpartum, 4.0 (IQR 6,9) kg at 9 months postpartum and 3.0 (IQR 5.5) kg at 12 months postpartum (Fig. 1). The maternal weight patterns changed by GWG categories are shown in Fig. 2. The GWG categories were distributed as follows: inadequate GWG (n = 366, 33 %); adequate GWG (n = 596, 53 %); excessive GWG (n = 160, 14 %). Figure 3 showed 1-year PPWR across categories of GWG at 12 months postpartum with the mean of 1.7 kg for inadequate GWG, 3.2 kg for adequate GWG, and 7 kg for excessive GWG.

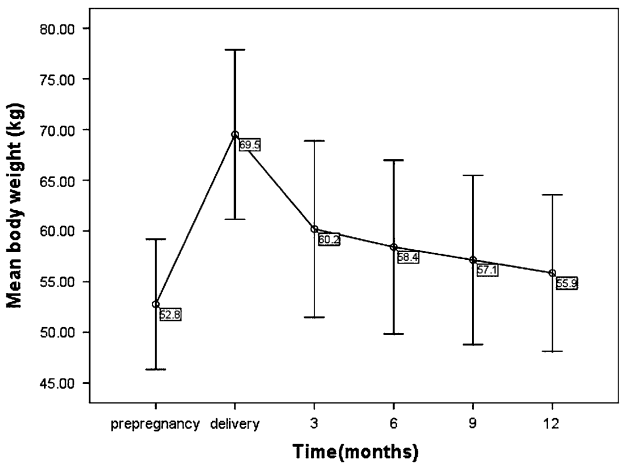

Fig. 1 The mean body weight from pre-pregnancy to 1-year postpartum. Values represent unadjusted means in different time

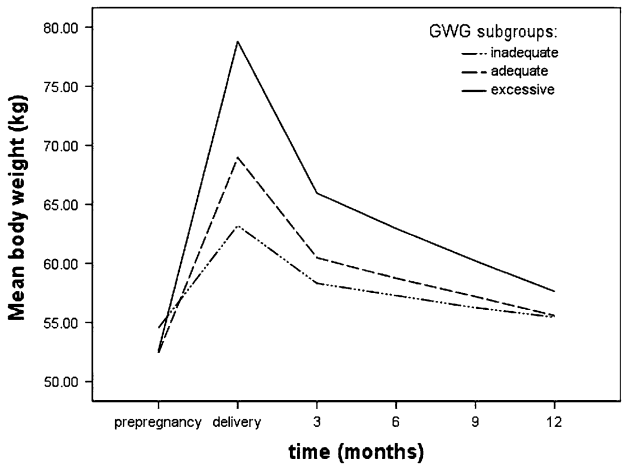

Fig. 2 The mean body weight from pre-pregnancy to 1-year postpartum by gestational weight gain categories. Values represent unadjusted means in different groups classified by gestational weight gain. *GWG* gestational weight gain

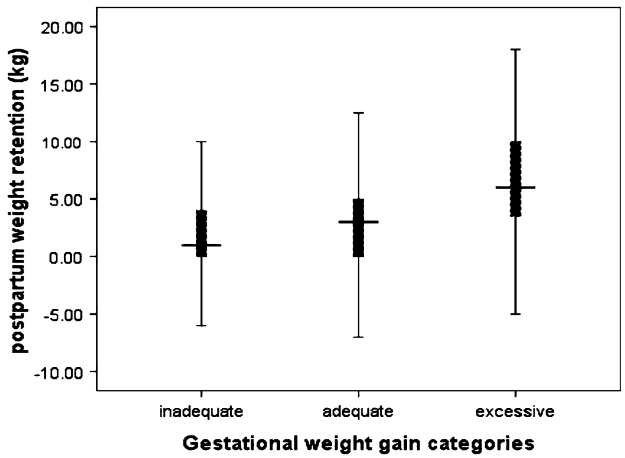

Fig. 3 Mean (95 % CI) postpartum weight retention for categories of gestational weight gain at 12 months postpartum

Table 1 showed the maternal socio-demographic and prenatal characteristics, which were examined as potential confounders of the association between GWG and SPPWR. In unadjusted logistic models, excessive GWG (excessive versus adequate OR = 4.01, 95 % CI 2.26, 5.83) was directly associated with SPPWR and inadequate GWG (inadequate versus adequate: OR = 0.52, 95 % CI 0.39, 0.70) varied indirectly associated with SPPWR. In addition, obesity before pregnancy was also associated with SPPWR. The maternal behaviors' characteristics strongly associated with SPPWR in unadjusted analyses (Table 2), such as mixed feeding at 6 months postpartum, bottle-feeding at 6 months postpartum, dieting intentionally and unintentional weight loss.

In multivariable models (Table 3), we examined the association of GWG at 12 months postpartum and SPPWR after taking into account maternal socio-demographic, prenatal, and behavioral attributes. The socio-demographic and prenatal attributes slightly confounded the crude odds ratio for excessive GWG and SPPWR (unadjusted OR = 4.01 versus ORs = 4.00 and 4.01 respectively, from models 1 and 2). In model 3, the adjusted odds ratio for excessive GWG versus adequate GWG was strengthened from 4.00 to 4.05 (95 % CI 2.75, 5.95) with the addition of postpartum behaviors (physical inactivity and breastfeeding at 6 months postpartum); the adjusted odds ratio for inadequate GWG versus adequate GWG was 0.59 (95 % CI 0.43, 0.81).

Discussion

The objective of this study was to examine the association of GWG and substantial weight retention 1-year postpartum, we found that women who gained excessive weight during pregnancy were 4.05 times more likely to retain at least 4.55 kg at 1-year postpartum independent of potential confounders including maternal socio-demographics, pre-pregnancy body mass index, gestational age, mode of delivery, and postpartum behaviors. Conversely, inadequate weight gain (OR 0.59, 95 % CI 0.43, 0.81) was negatively associated with SPPWR. Thus, our findings indicated that both excessive weight gain and inadequate weight gain were associated with substantial weight retention at 1-year postpartum.

Our findings were consistent with previous studies. Although underlying mechanisms of the association between GWG and PPWR was unknown, numerous studies have reported that GWG [18–21] strongly influenced PPWR. For example, a study conducted with a group of 274 low-income Canadian women [22] showed that GWG ≥12 kg explained 65 % of the PPWR, whereas it was shown in a sample of 7,116 American women that the GWG independent influenced the first pregnancy and explained 21 % of the weight variation between subsequent pregnancies [18]. In addition, there is a study suggested that inadequate GWG impacted PPWR, both short term and long term [23]. This association was independent of the postpartum follow-up time; however, the potential beneficial effect of inadequate GWG on PPWR needed to be balanced against their potential risks [24].

In our study, we found that 20.2 % of women who had inadequate GWG had SPPWR. For these women, we know that they have a higher level of knowledge and might know breastfeeding is a benefit for their infants' growth [25], therefore it is possible that to exclusively breastfeed their infants, their diet mainly based on fat to promote breast milk in China. In addition, women who did not intentionally diet had decreased odds for SPPWR. For these women,

Table 1 Frequencies and unadjusted associations of maternal characteristics with substantial postpartum weight retention at 1-year postpartum

Characteristics	Not SPPWR ($n = 722$)		SPPWR ($n = 400$)		*P* value[§]	SPPWR	
	No.	%	No.	%		Unadjusted OR	95 % CI
Age (years)							
<25	108	15.0	45	11.2	0.211	0.72	0.50, 1.04
25–34	571	79.1	331	82.8		1.00	Referent
≥35	43	5.9	24	6.0		1.04	0.61, 1.75
Education							
Some college or less	36	5.0	31	7.8	0.170	1.58	0.94, 2.65
College degree	415	57.5	221	55.2		0.98	0.75, 1.26
Postgraduate degree	271	37.5	148	37.0		1.00	Referent
Incomes							
<¥2,000	39	5.4	20	5.0	0.696	0.87	0.49, 1.54
¥2,000–¥5,000	393	54.4	209	52.2		0.90	0.70, 1.16
>¥5,000	290	40.2	171	42.8		1.00	Referent
Pre-pregnancy BMI (IOM)							
Underweight (<18.5)	167	23.2	77	19.2	0.017	0.77	0.57, 1.04
Normal (18.5–24.9)	468	64.8	291	72.8		1.00	Referent
Overweight (25–29.9)	52	7.2	24	6.0		0.77	0.47, 1.28
Obese (≥30)	35	4.8	8	2.0		1.45	1.23, 2.34
Gestational weight gain (IOM)							
Inadequate	285	39.5	81	20.2	<0.001	0.52	0.39, 0.70
Adequate	386	53.5	210	52.5		1.00	Referent
Excessive	51	7.0	109	27.3		4.01	2.76, 5.83
Gestational age (weeks)							
<37	81	11.2	36	9.0	0.244	0.78	0.52, 1.18
≥37	641	88.8	364	91.0		1.00	Referent
Mode of delivery							
Vaginal	425	58.9	246	61.5	0.388	1.00	Referent
Cesarean	297	41.1	154	38.5		0.90	0.71, 1.16

SPPWR substantial postpartum weight retention, *IOM* Institute of Medicine, *BMI* body mass index, *OR* odds ratio, *CI* confidence interval

§ *P* values from global Chi-square

Table 2 Frequencies and unadjusted associations of maternal postpartum behaviors with substantial postpartum weight retention at 1-year postpartum

Characteristics	Not SPPWR ($n = 722$)		SPPWR ($n = 400$)		*P* value[§]	SPPWR	
	No.	%	No.	%		Unadjusted OR	95 % CI
Breastfeeding at 6 months postpartum							
Exclusive breastfeeding	372	51.5	162	40.5	<0.001	1.00	Referent
Mixed feeding	266	36.8	160	40.0		1.38	1.06, 1.81
Bottle feeding	84	11.7	78	19.5		2.31	1.49, 3.05
Physical activity (quartiles)							
1 (lowest)	91	12.6	41	10.2	0.239	1.00	Referent
2	129	17.9	62	15.5		1.07	0.67, 1.72
3 (highest)	502	69.5	297	74.3		1.31	0.88, 1.95
Intentional weight loss							
Yes	327	45.3	105	26.2	<0.001	1.00	Referent
No	395	54.7	295	73.8		2.32	1.78, 3.04
Intentional dieting							
Yes	402	55.7	295	73.8	<0.001	1.00	Referent
No	320	44.3	105	26.2		0.45	0.34, 0.58

SPPWR substantial postpartum weight retention, *OR* odds ratio, *CI* confidence interval

§ *P* values from global Chi-square

Table 3 Unadjusted and multivariable-adjusted odds ratios of substantial postpartum weight retention at 1-year postpartum according to categories of gestational weight gain

Gestational weight gain categories	Unadjusted		Model 1		Model 2		Model 3	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Inadequate	0.52	0.39, 0.70	0.51	0.38, 0.67	0.51	0.36, 0.69	0.59	0.43, 0.81
Adequate	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Excessive	4.01	2.76, 5.83	4.00	2.75, 5.84	4.01	2.75, 5.85	4.05	2.75, 5.95

Model 1 includes education, age, and incomes

Model 2 includes model 1 plus pre-pregnancy body mass index (continuous), mode of delivery and gestational age

Model 3 includes model 2 plus behaviors (physical inactivity and breastfeeding at 6 months postpartum)

OR odds ratio, *CI* confidence interval

we found that women who did not intentionally diet had lower incomes and levels of knowledge, that was to say, the intensity of their labor may be relatively higher. In addition, one study [35] showed that lack of sufficient sleep may compromise the efficacy of typical dietary interventions for weight loss.

There were a number of known determinants of PPWR, such as breastfeeding [25–28], diet patterns [17], physical activity [15] and other lifestyle factors [29, 30]. In clinical practices, mothers have generally been informed that full-time breastfeeding is helpful to revert to pre-pregnancy weight, and this study also showed that lactation increases the weight loss after delivery. It appears reasonable to assume that the adipose tissue deposition during pregnancy serves as a nutritional reserve to ensure an adequate energy supply to the newborn, thus facilitating weight loss. Adjustment of smoking status [19] and parity [34] did not change the results considerably. It was unclear whether other potential confounders might be more relevant. Because we could not exclude residual confounding, the effect of GWG in accordance with IOM recommendations might not be an authentic risk factor of PPWR, but reflected a common cause of high or low GWG and PPWR. As recently shown, GWG may be reduced by interventions based on dietary counseling and physical activity [31].

There is an abundant proof that indicates that women do experience difficulty in losing weight postpartum [32]. It is possible that women who are metabolically prone to obesity gain excessive weight during pregnancy and continue to gain weight after pregnancy. Perhaps these women have subtle changes in appetite regulatory mechanisms, differences in basal metabolic rate that make them susceptible to excessive GWG, and these issues may continue throughout their lifespan, thus contributing to long-term weight gain. However, because we did not have adequate dietary data, we could not exclude the possibility that poor dietary behavioral patterns followed by mothers during pregnancy may continue postpartum, thereby contributing to weight retention.

The findings of our current study should be assessed in consideration of the strengths and limitations of the data. Available data were based on self-reported weights, which might introduce some bias because women of higher BMI have a tendency to underreport their weights [33]. Because any bias reported in the pre-pregnancy weight should be similar with the bias measured and recorded prior to delivery, the difference between pre-pregnancy and the last clinically measured weight recorded prior to delivery should be relatively unbiased [34]. This study also did not collect data about diet. In addition, the high educational level might limit the generalizability of our findings. The strengths of our study included its prospective nature, a relatively large sample size, examination of socio-demographic, clinical, and behavioral parameters that influence maternal postpartum weight changes, and collection of weight data before, during, and after pregnancy.

In conclusion, given among several factors which determined PPWR, GWG was considered the most important; there was an urgent need of the development of interventions that could successfully help women to avoid excessive weight gain during pregnancy. Further studies are needed to assess whether dietary and physical activity interventions known to reduce PPWR will have a similar effect on GWG control.

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Conflict of interest We declare that we have no conflict of interest.

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