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Original Article

Postpartum weight retention in relation to gestational weight gain and pre-pregnancy body mass index: A prospective cohort study in Vietnam

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ABSTRACT

Background: The prevalence of maternal overweight and obesity is increasing in Asia. This study prospectively investigated the association between pre-pregnancy body mass index (BMI), gestational weight gain (GWG) and 12-month postpartum weight retention (PPWR) in a large cohort of Vietnamese mothers.
Methods: Of the 2030 pregnant women recruited from three cities in Vietnam at 24–28 weeks of gestation, a total of 1666 mothers were followed up for 12 months after delivery and available for analysis. The outcome variable PPWR was determined by subtracting the pre-pregnancy weight from the 12-month postpartum measured weight, while GWG and pre-pregnancy BMI were classified according to the Institute of Medicine and WHO criteria for adults, respectively. Linear regression models were used to ascertain the association between pre-pregnancy BMI, GWG and PPWR accounting for the effects of plausible confounding factors.
Results: Both pre-pregnancy BMI and GWG were significantly associated with PPWR ($P < 0.001$). The adjusted mean weight retention in underweight women before pregnancy (3.71 kg, 95% confidence interval (CI) 3.37–4.05) was significantly higher than that in those with normal pre-pregnancy weight (2.34 kg, 95% CI 2.13–2.54). Women with excessive GWG retained significantly more weight (5.07 kg, 95% CI 4.63–5.50) on average at 12 months, when compared to mothers with adequate GWG (2.92 kg, 95% CI 2.67–3.17).
Conclusions: Being underweight before pregnancy and excessive GWG contribute to greater weight retention twelve months after giving birth. Interventions to prevent postpartum maternal obesity should target at risk women at the first antenatal visit and control their weight gain during the course of pregnancy.
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Introduction

The prevalence of overweight and obesity has surged worldwide [1]. In Asia, the mean body mass index (BMI) of high-income countries has reached a plateau, but is increasing in adults in lower and middle income countries [2]. Located in Southeast Asia, Vietnam is facing the double burden of simultaneous underweight and overweight/obesity, with an estimated ratio of women overweight to underweight being 0.9 according to a recent systematic review [3].

BMI has a dose response relationship with diabetes mellitus and cancers of the breast, ovary, liver and kidney [4]. A low BMI before pregnancy may pose a higher risk of preterm birth and delivering a small-for-gestational-age infant [5]. On the other hand, a high maternal BMI before pregnancy or excessive gestational weight gain (GWG) is associated with pregnancy complications such as gestational diabetes mellitus (GDM) and preeclampsia [6–9]. To

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balance the benefits and risks for maternal weight before, during and after pregnancy, the Institute of Medicine (IOM) released GWG recommendations in 2009 based on the pre-pregnancy BMI [10]. Such guidelines have since been adopted by many countries worldwide. In Vietnam, a recent study reported that women with GWG below the IOM recommendations were 2.5 times more likely to give birth to a small-for-gestational-age infant when compared to those with normal GWG; however, the effect of GWG on postpartum weight retention (PPWR) remained unknown for Vietnamese women [11].

It has been suggested from a meta-analysis that GWG is related to PPWR [8]. In particular, women with excessive GWG have more PPWR than others with adequate GWG, while inadequate GWG is also inversely associated with PPWR [8]. A prospective study in the USA reported a significant association between pre-pregnancy BMI and weight retention at three months postpartum [12]. Nevertheless, the relationship between pre-pregnancy BMI and PPWR is still unclear [12–15]. Postpartum weight retention significantly contributes to women's weight trajectories and the onset of long-term obesity [16]. Apart from Malaysia [13,17], no other studies have investigated PPWR in relation to either pre-pregnancy BMI or GWG among Southeast Asian women. Compared with Japanese or non-Hispanic white mothers, Southeast Asian women with gestational diabetes mellitus or preeclampsia had an increased odds of adverse delivery outcomes (i.e. macrosomia, preterm or low birth weight) [18]. Besides, the majority of previous studies dichotomised PPWR using different cut-points [11,12,14,15,19], leading to potential misclassification of the outcome.

The present study examined the prospective association between pre-pregnancy BMI, GWG and 12-month PPWR using a large cohort of Vietnamese mothers [20]. We hypothesized that maternal pre-pregnancy BMI and/or GWG are associated with 12-month PPWR. Findings of the study will contribute towards the development of intervention strategies for postpartum obesity prevention and maternal weight management during and after pregnancy.

Materials and methods

Study design and participants

Details of the prospective cohort study design and recruitment procedure had been described elsewhere [20]. Briefly, 2248 pregnant women aged ≥18 years with a singleton pregnancy at 24–28 weeks of gestation were recruited from six participating hospitals in Hanoi, Haiphong and Ho Chi Minh City, Vietnam, and followed up between August 2015 and November 2017. Among them, 2030 women (90%) agreed to participate and signed the written informed consent form at the baseline interview. After delivery, they were followed up before hospital discharge, and then at 1, 3, 6 and 12 months postpartum, with a final response rate of 82% at 12 months. Follow-up surveys and weight measurements of the cohort were conducted at convenient places (mostly at the women's home) by trained interviewers. As shown in Fig. 1, after excluding participants with missing or implausible values for the main variables [21], n = 1666 women were available for the final analysis.

Study variables

Information on maternal demographic characteristics and lifestyle including age, employment, educational level, parity, pre-pregnancy weight, total energy intake and physical activity levels during pregnancy were obtained from the baseline face-to-face interview. Such self-reported data were verified against hospital medical records whenever feasible. Maternal height was measured using a stadiometer to the nearest 1 mm at the baseline interview. A validated food frequency questionnaire for Vietnamese adults was used to assess total energy intake during pregnancy [22]. Physical activity during pregnancy was quantified using the Vietnamese version of the Pregnancy Physical Activity Questionnaire [23]. Gestational diabetes status was ascertained using a 75 g oral glucose tolerance test administered between 24–28 weeks of gestation, and diagnosed in accordance to the International Association of Diabetes and Pregnancy Study Groups for gestational diabetes mellitus, with at least one glucose value above the following thresholds: fasting plasma glucose ≥5.1 mmol/L, 1-h plasma glucose ≥10.0 mmol/L, 2-h plasma glucose ≥8.5 mmol/L [24]. Postnatal information about gestational age (length of gestation), mode of delivery and pre-delivery weight was extracted from hospital medical records.

Pre-pregnancy BMI was calculated by dividing pre-pregnancy weight by the square of maternal height, and categorised according to the WHO criteria: underweight (<18.5 kg/m^2); normal (18.5–24.9 kg/m^2); overweight (25.0–29.9 kg/m^2); and obese (≥30 kg/m^2) [25]. GWG was determined as the difference between pre-pregnancy weight and pre-delivery weight [19], and classified as being below (inadequate), within (adequate) or above (excessive) according to the 2009 IOM recommendations [10]. Maternal weight at 12-month postpartum was measured following the Anthropometry Procedures Manual of the U.S. National Health and Nutrition Examination Survey [26]. The continuous outcome variable PPWR (kg) was calculated by subtracting the (self-reported) pre-pregnancy weight from the 12-month postpartum measured weight [19].

Statistical analysis

Descriptive statistics were used to summarise the sample characteristics. Comparisons of pre-pregnancy BMI and GWG between subgroups of interest were conducted using Chi-square or Fisher's exact test (for independent categorical variables) or one-way ANOVA (for independent continuous variables). Associations between pre-pregnancy BMI, GWG and 12-month PPWR were examined using simple and multiple regression models. Covariates included in the models were selected with reference to the literature as plausible confounding factors: maternal age, education, employment status, parity, gestational diabetes mellitus, gestational age, mode of delivery, total energy intake and total physical activity level during pregnancy. The effect modification by pre-pregnancy BMI on the association between GWG and PPWR and vice versa (i.e., the interaction between pre-pregnancy BMI and GWG on PPWR) was assessed using a likelihood ratio test. We further carried out regression analyses by stratifying participants according to both pre-pregnancy BMI and GWG. A sensitivity analysis was further conducted after removing 62 (3.7%) participants who gave birth to low birthweight infants (<2500 g). All statistical analyses were performed using the STATA software version 15.1 [27].

Ethical statement

This study was approved by the Human Research Ethics Committee of Curtin University (approval no. HR32/2015) and the Human Research Ethics Committee of Hai Phong University of Medicine and Pharmacy (approval no. 05/HPUMPRB/2015). Participation was entirely voluntary and all participants signed the written informed consent form before their baseline interview.

Results

In the study population, 90% of participants were aged 34 years or younger, with mean age 27.46 ± 5.23 years at the

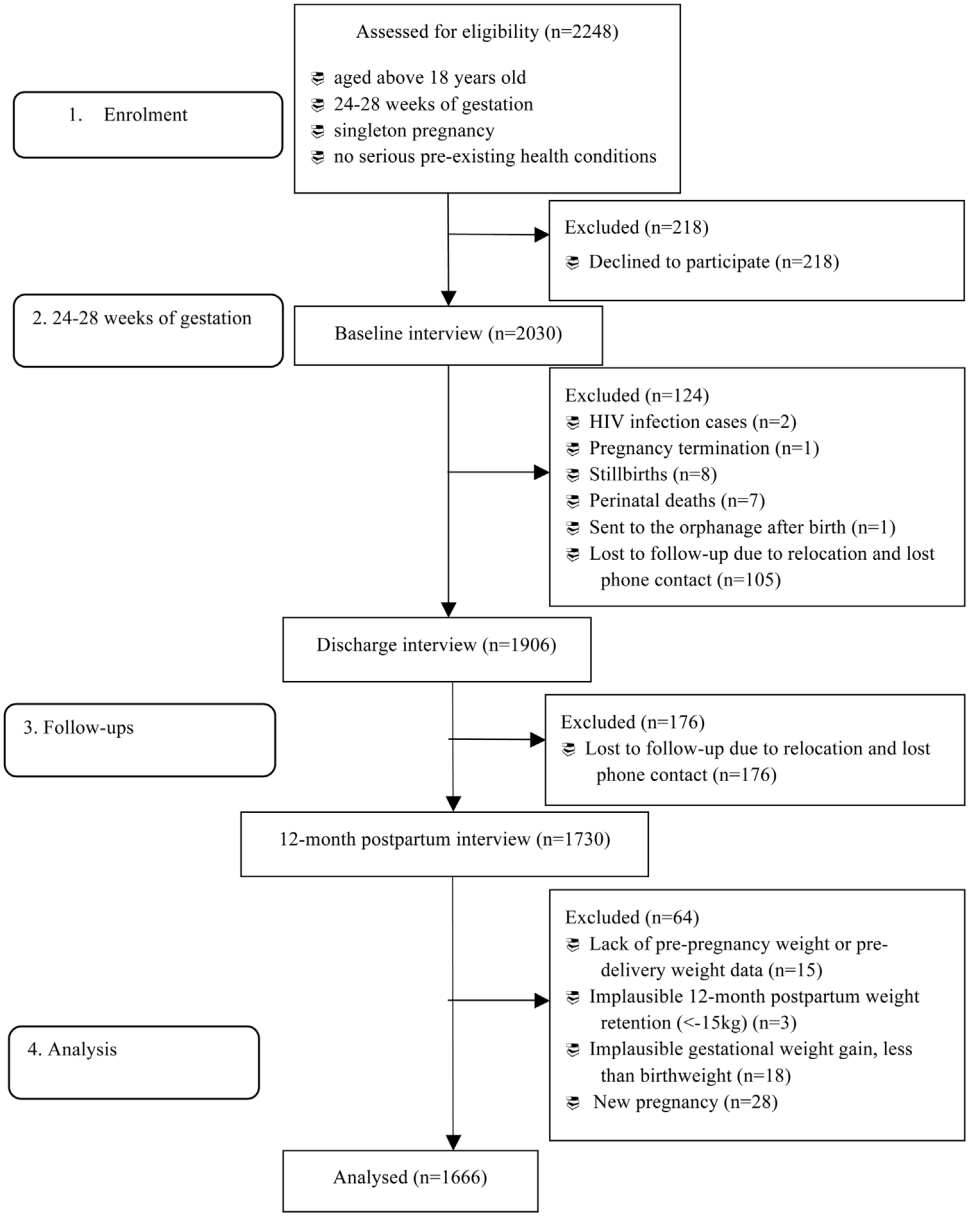

Fig. 1. Flow chart of participants.

baseline interview. About two-third of the participants attained high school education or above, and were employed (68.91%) and multiparous (61.10%). During pregnancy, the mean (±SD) total energy intake and total physical activity were 2123.31 (±742.03) Kcal/day and 124.77 (±57.24) MET-hour/week, respectively.

Before pregnancy, the mean (±SD) weight of the cohort was 48.41 (±6.26) kg. The prevalence of underweight and overweight/obese were 26.10% and 3.66%, respectively. During pregnancy, women gained 12.86 ± 3.9 9kg on average. Over one-third of them (n = 622, 37.33%) gained gestational weight inadequately, while 16.15% (n = 269) gained gestational weight excessively. At 12-month postpartum, participants weighed 51.04 ± 6.89 kg and retained 2.63 ± 3.80 kg on average. About a quarter of them (n = 433, 25.99%) retained 5 kg or more. As shown in Fig. 2, overweight women or those with obesity before pregnancy had the greatest proportion of excessive GWG (50.82%), whereas the lowest rate of excessive GWG (11.06%) was observed in pre-pregnancy underweight women. The bivariate analyses showed there was a statistical significant association between pre-pregnancy BMI and GWG (Tables 1 and 2). Furthermore, both pre-pregnancy BMI and GWG were found to be associated with maternal characteristics, including age, education, parity, mode of delivery and total energy intake during pregnancy (Tables 1 and 2). Individually pre-pregnancy BMI was associated with gestational diabetes mellitus (Table 1).

Table 3 presents the results of regression analyses, which suggest that both pre-pregnancy BMI and GWG were significantly associated with PPWR ($P < 0.001$) after accounting for the effects of covariates. The mean weight retention in underweight women before pregnancy (3.71 kg, 95% confidence interval (CI) 3.37–4.05) was significantly higher than that in those with normal pre-pregnancy weight (2.34 kg, 95% CI 2.13–2.54). In contrast, overweight women or those with obesity retained 1.8 3kg less weight on average than their normal pre-pregnancy weight counterparts. Moreover, we found positive association between GWG and PPWR. Women with excessive GWG retained significantly more weight (5.07 kg, 95% CI 4.63–5.50) on average at 12-month

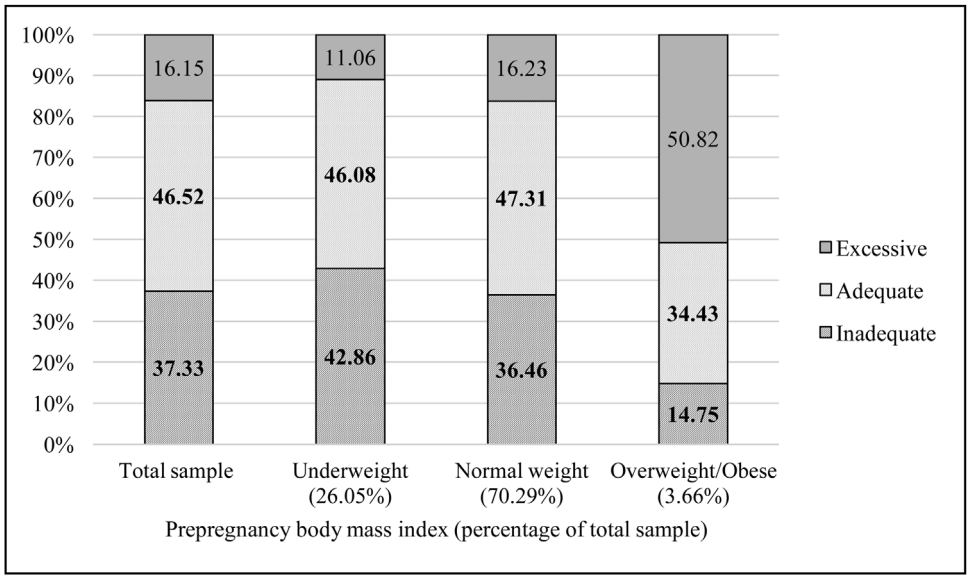

Fig. 2. Percentage of Vietnamese women (2015–2017, n = 1666) by pre-pregnancy BMI and gestational weight gain.

Table 1
Difference in proportions of pre-pregnancy BMI categories by sample characteristics (2015–2017, n = 1666).

Characteristics	Pre-pregnancy BMI[b]			P[a]
	Underweight n (%)	Normal n (%)	Overweight and obese n (%)	
Maternal age (years)				<0.001
<25	236 (54.38)	443 (37.83)	19 (31.15)	
25–34	175 (40.32)	590 (50.38)	29 (47.54)	
≥35	23 (5.30)	138 (11.78)	13 (21.31)	
Education				0.007
Secondary or lower	121 (27.88)	398 (33.99)	29 (47.54)	
High school	123 (28.34)	292 (24.94)	17 (27.87)	
College or above	190 (43.78)	481 (41.08)	15 (24.59)	
Employment status				0.762
Working	293 (67.51)	813 (69.43)	42 (68.85)	
Not working	141 (32.49)	358 (30.57)	19 (31.15)	
Parity				<0.001
First pregnancy	205 (47.24)	426 (36.38)	17 (27.87)	
Multiparous	229 (52.76)	745 (63.62)	44 (72.13)	
Gestational diabetes mellitus[c]				0.002
Yes	79 (18.29)	259 (22.17)	23 (37.70)	
No	353 (81.71)	909 (77.83)	38 (62.30)	
Mode of delivery				<0.001
Vaginal	312 (71.89)	691 (59.01)	23 (37.70)	
Caesarean	122 (28.11)	480 (40.99)	38 (62.30)	
Gestational age (weeks)				0.249
<37	16 (3.69)	48 (4.10)	5 (8.20)	
≥37	418 (96.31)	1123 (95.90)	56 (91.80)	
Gestational weight gain[e]				<0.001
Inadequate	186 (42.86)	427 (36.46)	9 (14.75)	
Adequate	200 (46.08)	554 (47.31)	21 (34.43)	
Excessive	48 (11.06)	190 (16.23)	31 (50.82)	
Total physical activities during pregnancy (MET-h/week)[d]	124.20 ± 55.89	124.53 ± 57.76	133.47 ± 57.12	0.502
Total energy intake during pregnancy (Kcal/day)[d]	2239.08 ± 717.99	2095.71 ± 746.45	1829.34 ± 703.10	<0.001

[a] Based on Chi-square or Fisher's exact test or ANOVA.
[b] The cut-off for overweight is 25 kg/m^2, recommended by World Health Organization.
[c] Missing data present.
[d] Continuous variables were presented as mean ± standard deviation.
[e] Categorised according to 2009 IOM recommendations.

postpartum, whereas women with inadequate GWG retained less weight (1.21 kg, 95% CI 0.93–1.49), when compared to mothers with adequate GWG (2.92 kg, 95% CI 2.67–3.17). There was no apparent interaction between GWG and pre-pregnancy BMI in relation to PPWR (P = 0.724). The adjusted estimated mean weight retention at 12-month postpartum stratified by GWG and pre-pregnancy BMI were presented in Table 4. After excluding low birthweight deliveries (n = 62), the associations of pre-pregnancy BMI and gestational weight gain with 12-month PPWR remained similar to those in the original full sample.

Discussion

The present study provides the first report on the relationship between pre-pregnancy BMI, GWG and PPWR in Vietnamese women. Consistent with our results, a review including most

Table 2
Difference in proportions of gestational weight gain categories by sample characteristics (2015-2017, n = 1666).

Characteristics	Gestational weight gain[e]			P[a]
	Inadequate n (%)	Adequate n (%)	Excessive n (%)	
Maternal age (years)				<0.001
<25	229 (36.82)	331 (42.71)	138 (51.30)	
25-34	315 (50.64)	371 (47.87)	108 (40.15)	
≥35	78 (12.54)	73 (9.42)	23 (8.55)	
Education				0.041
Secondary or lower	232 (37.30)	234 (30.19)	82 (30.48)	
High school	159 (25.56)	205 (26.45)	68 (25.28)	
College or above	231 (37.14)	336 (43.35)	119 (44.24)	
Employment status				0.706
Working	421 (67.68)	540 (69.68)	187 (69.52)	
Not working	201 (32.32)	235 (30.32)	82 (30.48)	
Pre-pregnancy BMI (kg/m^2)[b]				<0.001
Underweight (<18.5)	186 (29.90)	200 (25.81)	48 (17.84)	
Normal (18.5–<24.9)	427 (68.65)	554 (71.48)	190 (70.63)	
Overweight and obese (≥25)	9 (1.45)	21 (2.71)	31 (11.52)	
Parity				<0.001
First pregnancy	212 (34.08)	301 (38.84)	135 (50.19)	
Multiparous	410 (65.92)	474 (61.16)	134 (49.81)	
Gestational diabetes mellitus[c]				0.979
Yes	135 (21.77)	169 (21.86)	57 (21.27)	
No	485 (78.23)	604 (78.14)	211 (78.73)	
Mode of delivery				<0.001
Vaginal	424 (68.17)	463 (59.74)	139 (51.67)	
Caesarean	198 (31.83)	312 (40.26)	130 (48.33)	
Gestational age (weeks)				0.708
<37	29 (4.66)	30 (3.87)	10 (3.72)	
≥37	593 (95.34)	745 (96.13)	259 (96.28)	
Total physical activities during pregnancy (MET-h/week)[d]	124.10 ± 59.56	126.58 ± 56.64	121.10 ± 53.38	0.727
Total energy intake during pregnancy (Kcal/day)[d]	2071.86 ± 744.96	2146.14 ± 720.63	2176.50 ± 790.29	<0.001

[a] Based on Chi-square or Fisher's exact test or ANOVA.
[b] The cut-off for overweight is 25 kg/m^2, recommended by World Health Organization.
[c] Missing data present.
[d] Continuous variables were presented as mean ± standard deviation.
[e] Categorised according to 2009 IOM recommendations.

Table 3
Associations between pre-pregnancy BMI, gestational weight gain, and 12-month postpartum weight retention in Vietnamese women (2015-2017, n = 1666).

	n	%	Estimated regression coefficient				12-month postpartum weight retention (kg)			
			Crude		Adjusted		Crude		Adjusted	
			Coefficient	P	Coefficient	P	Mean	95% CI	Mean	95% CI
Pre-pregnancy BMI[a]				<0.001		<0.001				
Underweight	434	26.05	1.09	<0.001	1.37	<0.001	3.46	(3.11, 3.81)	3.71	(3.37, 4.05)
Normal	1171	70.29	Reference		Reference		2.37	(2.16, 2.59)	2.34	(2.13, 2.54)
Overweight/obese	61	3.66	−0.74	0.134	−1.83	<0.001	1.63	(0.69, 2.58)	0.51	(−0.40, 1.43)
Gestational weight gain[b]				<0.001		<0.001				
Inadequate	622	37.33	−1.61	<0.001	−1.71	<0.001	1.32	(1.04, 1.60)	1.21	(0.93, 1.49)
Adequate	775	46.52	Reference		Reference		2.93	(2.67, 3.18)	2.92	(2.67, 3.17)
Excessive	269	16.15	1.87	<0.001	2.15	<0.001	4.79	(4.36, 5.22)	5.07	(4.63, 5.50)

[a] Regression model was adjusted for maternal age, education, employment, gestational age, mode of delivery, parity, gestational diabetes mellitus, total energy intake during pregnancy, total physical activity during pregnancy and GWG.
[b] Regression model was adjusted for maternal age, education, employment, gestational age, mode of delivery, parity, gestational diabetes mellitus, total energy intake during pregnancy, total physical activity during pregnancy and pre-pregnancy BMI.

Table 4
Adjusted mean values[a] and 95% CIs of 12-month postpartum weight retention (kg) in Vietnamese women by gestational weight gain and pre-pregnancy BMI (2015–2017, n = 1666).

		Pre-pregnancy BMI		
		Underweight	Normal	Overweight/obese
Gestational weight gain	Inadequate	1.24 (0.96, 1.53)	1.28 (0.99, 1.57)	1.25 (0.96, 1.53)
	Adequate	2.91 (2.66, 3.16)	2.91 (2.66, 3.17)	2.89 (2.63, 3.14)
	Excessive	4.91 (4.48, 5.35)	4.80 (4.37, 5.24)	4.97 (4.53, 5.41)

[a] Regression model was adjusted for maternal age, education, employment, gestational age, mode of delivery, parity, gestational diabetes mellitus, total energy intake during pregnancy, total physical activity during pregnancy, and GWG by stratifying participants according to pre-pregnancy BMI.

studies from Asia showed an inverse association between pre-pregnancy BMI and PPWR [11]. Likewise, a recent USA study reported women with pre-pregnancy underweight status had increased odds of retaining moderate weight (1–10 lb) at 12 months postpartum (odds ratio 2.0, 95% CI 1.6–2.7) after adjusting for GWG and total physical activity [16]. However, a lack of association was found in a Chinese study and another study conducted in Australia [14,15], probably due to their smaller sample sizes. Our study showed the mean PPWR of underweight pregnant women was significantly higher than that of their normal or overweight counterparts. This finding suggests underweight pregnant women might be more lenient and persuaded to 'eat-for-two' in the Asian culture [28]. Retaining some postpartum weights among underweight women may have advantage in subsequent pregnancy outcomes, including the decreased risk of having intrauterine growth restriction and hypoglycaemia [29].

Our finding on a positive association between GWG and PPWR also concurs with previous studies in other Asian populations [19]. A meta-analysis confirmed that women with inadequate GWG retained 2.23 kg less weight than women with adequate GWG 1–9 years postpartum [8]. Similarly, our participants with inadequate GWG had 1.71 kg on average less weight retention than those with adequate GWG at 12 months postpartum. Moreover, a Canadian study showed that women who gained gestational weight excessively retained a mean postpartum weight of 5.0 kg (95% CI 4.9–5.2) [30] as did our study. Despite this, Canadian women with inadequate GWG retained less weight postpartum (0.4 kg) than our study participants (1.2 kg)[30]. Reasons for the difference are unclear, but may be attributed to restrictions on postpartum physical activity among Vietnamese mothers [31]. Alternatively, Vietnamese women with inadequate GWG may strive to consume a high-energy diet coupled with long sitting duration while engaging less in physical activity during the postpartum period, when they are typically on their 6-month maternity leave. While several studies have reported the impact of excessive GWG on delivery outcomes in Vietnam [11,32], it has been less recognised that retaining postpartum weight may be linked to subsequent obesity and associated comorbidities. Women with excessive GWG have been reported an increased risk of diabetes mellitus later through the mediation of PPWR and obesity [6]. In addition, a recent review found children whose mothers had been diagnosed with gestational diabetes mellitus (GDM) have an increased risk of type 2 diabetes and obesity [33]. Our finding on excessive PPWR among women with excessive GWG is consistent with the increasing trends towards overweight, as well as GDM and diabetes mellitus in Vietnam that have been noted in recent decades [34–36]. This implies the importance of including maternal weight management during childbearing period as a public health effort of preventing diabetes mellitus in Vietnam.

There are several strengths of our study, including the prospective cohort design with a large sample size and 12 months of follow-up. Our regression analyses have accounted for the effects of confounding factors including demographics, obstetrics and birth-related factors, as well as energy intake and energy expenditure (physical activity) during pregnancy which are prevalent in our study population. Furthermore, we have included sensitivity analysis to confirm the apparent associations in the presence of low birthweight infants. However, a major limitation concerns the self-reported pre-pregnancy weight, even though the maternal weight at 12 months was measured by our trained interviewers, which might lead to inaccuracy in the main study variables. A second limitation is the possibility of selection bias after excluding n = 364 women due to their missing or implausible weight values and lost to follow-up. These women had slightly lower education levels than our final participants, but were only 16% of the original sample. Nevertheless, our findings may be representative of the underlying population in Vietnam. Another limitation of our study is that we did not have data on other postpartum lifestyle factors that may influence maternal weight after delivery. On the other hand, further research studies are needed in Vietnam on the long term effects of weight gain in pregnancy and weight loss after pregnancy at different levels of pre-pregnancy BMI. This research should include long-term outcomes in terms of diabetes and other maternal and offspring complications, including maternal microbiome and subsequent offspring adiposity [37].

In summary, we found both pre-pregnancy BMI and GWG were significantly associated with PPWR in this large prospective cohort study of Vietnamese women. Being underweight before pregnancy and those who gained excessive weight during pregnancy experienced the largest weight retention one year after giving birth. Therefore, the pre-pregnancy BMI should be reviewed and examined by health professionals at the first antenatal visit. Interventions to prevent postpartum maternal obesity should also monitor and control the weight gain of women throughout pregnancy and after delivery.

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Conflict of interests

There is no conflict of interest for all authors.

Ethical statement

This study was approved by the Human Research Ethics Committee of Curtin University (approval no. HR32/2015) and the Human Research Ethics Committee of Hai Phong University of Medicine and Pharmacy (approval no. 05/HPUMPRB/2015). Participation was entirely voluntary and all participants signed the written informed consent form before their baseline interview.

CRediT authorship contribution statement

Anh Vo Van Ha: Methodology, Validation, Formal analysis, Investigation, Writing - original draft. **Yun Zhao:** Methodology, Validation, Formal analysis, Writing - review & editing, Supervision. **Ngoc Minh Pham:** Formal analysis, Writing - review & editing, Supervision. **Cong Luat Nguyen:** Validation, Investigation, Resources. **Phung Thi Hoang Nguyen:** Validation, Investigation, Data curation. **Tan Khac Chu:** Investigation, Data curation. **Hong Kim Tang:** Writing - review & editing. **Colin W. Binns:** Writing - review & editing, Supervision. **Andy H. Lee:** Writing - review & editing, Supervision, Project administration.

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