

Early Postpartum Weight Retention in Women with Gestational Diabetes Mellitus in China: Current Status and Influencing Factors

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Purpose: To investigate postpartum weight retention (PPWR) in women with gestational diabetes mellitus (GDM) during the early postpartum period and to identify its key determinants.

Patients and Methods: This study enrolled 342 women with GDM who delivered at Fujian Maternity and Child Health Hospital between January 2024 and June 2025. Data on sociodemographic characteristics, pre-pregnancy body mass index (BMI), gestational weight gain (GWG), and postpartum weight were collected using questionnaires and telephone follow-ups at 42 days and 3 months postpartum. Generalized Estimating Equation (GEE) models were applied to examine factors influencing PPWR.

Results: Mean PPWR at 42 days and 3 months postpartum was 5.09 ± 4.55 kg and 4.12 ± 4.17 kg, respectively. GEE analysis showed that postpartum time, monthly household income per capita, pre-pregnancy BMI, GWG, and parity significantly influenced PPWR (all $P < 0.05$). PPWR at 3 months postpartum was significantly lower than at 42 days ($\beta = -0.970$, $P < 0.001$). Higher household income (>5000 CNY/month) was associated with lower PPWR. Compared with women with normal pre-pregnancy BMI, overweight and obese women had lower PPWR, whereas underweight women had higher PPWR. Excessive GWG was a risk factor for PPWR ($\beta = 3.312$, $P < 0.001$), and multiparous women had lower PPWR than primiparous women ($\beta = -1.057$, $P = 0.009$). No significant associations were observed between PPWR and age, education level, mode of delivery, infant feeding method, or sleep quality (all $P > 0.05$).

Conclusion: Women with GDM experience significant PPWR in the early postpartum period, although weight retention decreases over time. GWG, pre-pregnancy BMI, household economic status, and parity are major determinants of early PPWR. Targeted weight management interventions should prioritize women with low income, pre-pregnancy underweight, and primiparity, with interventions initiated during pregnancy to reduce long-term metabolic risk.

Keywords: gestational diabetes mellitus, postpartum weight retention, influencing factors, weight management

Introduction

Gestational diabetes mellitus (GDM) is defined as glucose intolerance that is first recognized or develops during pregnancy. It's reported global prevalence ranges from approximately 1% to 30%.¹ In China, the prevalence of GDM has been reported to reach as high as 18.4%.² Beyond its immediate obstetric implications, GDM confers a pronounced long-term metabolic burden. Women with a history of GDM have a significantly higher risk of developing type 2 diabetes after delivery, with cumulative incidence estimates of up to 70% over the life course.³ Postpartum weight retention (PPWR) refers to the difference between body weight measured at a defined postpartum time point (eg, 6 weeks or 3 months after delivery) and pre-pregnancy weight.⁴ PPWR is regarded as a key marker of postpartum metabolic

recovery. A PPWR of ≥ 5 kg is classified as high postpartum weight retention (HPPWR).⁵ Among women with GDM, the reported prevalence of HPPWR ranges from 35.8% to 46.7%.^{6,7} Both PPWR and GDM are established predictors of subsequent obesity and cardiovascular disease.^{8,9} Notably, within the GDM population, PPWR is an independent risk factor for postpartum diabetes.⁶ Therefore, effective management of postpartum weight retention is of substantial clinical relevance for mitigating long-term metabolic risk in both mothers and their offspring.

Accumulating evidence suggests that gestational weight gain (GWG) is a major determinant of PPWR and is positively correlated with the magnitude of weight retained after childbirth.^{10,11} However, the influence of other factors is not well characterized. Previous studies have reported inconsistent findings regarding the roles of education level, socioeconomic status, parity, mode of delivery, and infant feeding practices in shaping postpartum weight trajectories.¹² Furthermore, the determinants of PPWR may vary across different postpartum periods.^{13,14} The early postpartum period, particularly 6–8 weeks postpartum, is considered a sensitive or critical window for weight intervention in women with GDM,¹ and early PPWR has been shown to independently predict weight retention at later postpartum stages.¹⁵ Despite this, existing research on PPWR in women with GDM has predominantly focused on outcomes assessed at 6 months and 1 year postpartum, with relatively less attention paid to the early postpartum period within the first 3 months after delivery. This gap restricts the ability to identify early modifiable risk factors and to implement timely, targeted interventions.

Therefore, the present study selected 42 days and 3 months postpartum as key observation points to systematically explore the determinants of early PPWR in women with GDM. The findings may inform the development of more effective postpartum weight management strategies for women with GDM.

Materials and Methods

Study Population

This study was conducted as part of the “Maternal and Infant Health Cohort on the Impact of Gestational Weight Gain on Breastfeeding” at Fujian Maternity and Child Health Hospital. A convenience sampling approach was used to select women diagnosed with GDM who delivered at the hospital between January 1, 2024, and June 30, 2025, and met the predefined selection criteria.

The inclusion criteria were as follows: (1) age ≥ 18 years; (2) natural conception with a singleton pregnancy; (3) gestational age at delivery 37–41⁺⁶ weeks; (4) ability to read and write with normal cognitive function; (5) diagnosis of GDM according to the American Diabetes Association (ADA) criteria;¹⁶ and (6) voluntary participation with provision of written informed consent. The exclusion criteria were as follows: (1) severe intrapartum complications, such as uterine rupture or amniotic fluid embolism; (2) neonates with malformations or congenital diseases; (3) women with intellectual disability or mental disorders; (4) first prenatal examination conducted after 12 weeks of gestation, resulting in incomplete acquisition of key baseline data, including GWG and blood glucose monitoring information. This study was approved by the Medical Ethics Committee of Fujian Maternity and Child Health Hospital (approval number: 2020KY095). All participants provided written informed consent before enrollment.

Variables

The questionnaire entitled “Questionnaire on Early Postpartum Weight and Related Factors in Women with GDM” was self-developed to assess factors influencing early postpartum weight retention among women with GDM. Item development was informed by the Chinese Guidelines for the *Joint Management of Mothers and Infants with Gestational Diabetes Mellitus* (2024 Edition)¹⁶ and by published literature on patient-reported outcomes related to early PPWR in women with GDM. Prior to formal data collection, the questionnaire was evaluated by an expert panel comprising three obstetrics and gynecology clinicians and two researchers with expertise in clinical questionnaire design. The panel assessed item clarity, content relevance, and face validity. No substantive revisions were required following this review, indicating that the questionnaire was appropriate for the target population and study objectives. The questionnaire comprised 3 modules. The first module collected general demographic and anthropometric information, including age, height, pre-pregnancy weight, pre-delivery weight, educational level, and per capita monthly household income. The second module captured delivery-related information, including parity, date of delivery, and mode of delivery. The third module assessed postpartum-related factors, including

postpartum body weight, infant feeding mode, sleep quality, and other related variables. Data were collected using a combination of face-to-face interviews and telephone follow-up. Trained investigators obtained baseline data prior to hospital discharge. Follow-up assessments were conducted by telephone at 42 days and 3 months postpartum.

Judgment Criteria and Operational Definitions

Pre-Pregnancy Body Mass Index (BMI)

Pre-pregnancy BMI was calculated as pre-pregnancy weight (kg) divided by height squared (m^2). To minimize recall bias, pre-pregnancy weight was obtained from the weight registered in the hospital medical record system at the first prenatal examination conducted during the first trimester (≤ 12 weeks).¹² Studies have demonstrated a close relationship between weight measured at the first prenatal visit in the first trimester and the pre-pregnancy weight.¹⁷ According to the criteria recommended by the Working Group on Obesity in China,¹⁸ pre-pregnancy BMI was categorized as low weight (BMI < 18.5 kg/ m^2), normal weight (18.5–23.9 kg/ m^2), overweight (24.0–27.9 kg/ m^2), and obese (≥ 28.0 kg/ m^2).

Measurement and Classification of GWG

GWG was calculated as the difference between pre-delivery weight (kg) and pre-pregnancy weight (kg). Pre-delivery weight was defined as the measured body weight recorded at hospital admission for delivery, typically within 2–3 days before delivery. According to the “Recommended Standards for Weight Gain of Pregnant Women” issued by the National Health Commission, the recommended total GWG ranges were stratified by pre-pregnancy BMI category: 11.0–16.0 kg for underweight women, 8.0–14.0 kg for normal-weight women, 7.0–11.0 kg for overweight women, and 5.0–9.0 kg for obese women. GWG below the recommended range was classified as insufficient, GWG within the recommended range as appropriate, and GWG above the recommended range as excessive.

Definition of PPWR

PPWR was defined as the difference between body weight measured at a specified postpartum time point and pre-pregnancy weight. Postpartum weight recovery was defined as PPWR ≤ 0 kg within one year after delivery, indicating a return to or reduction below pre-pregnancy weight. HPPWR was defined as PPWR ≥ 5 kg.

Classification of Infant Feeding Mode

Infant feeding mode was classified according to the standards of the United Nations Children’s Fund.¹⁹ Exclusive breastfeeding included both exclusive breast milk feeding and almost exclusive breastfeeding (in addition to breast milk, supplementation with water/juice no more than 1–2 times a day and limited to 1–2 sips per occasion). Mixed feeding referred to the provision of formula milk, other milk, or solid/semi-solid foods in addition to breast milk. Artificial feeding was defined as a complete absence of breast milk intake, with infants fed exclusively with formula milk.

Statistical Analysis

The sample size for this study was calculated based on a widely accepted methodological consensus for cross-sectional nursing research in China.²⁰ This consensus recommends that the final sample size be 5–10 times the number of variables included in the analysis. This approach is consistent with established methodological guidelines and provides adequate statistical power for observational studies in nursing. Accounting for a non-response rate of 20%, the minimum sample size required for this study was 94 participants. Power analysis was conducted using PASS 15.0 software with the Repeated Measures Analysis module. The mean and standard deviation of postpartum weight retention at two time points were used for the calculation. The intraclass correlation coefficient (ICC) was set at 0.1, and the significance level (α) was set at 0.05. The resulting statistical power was 0.856, corresponding to a type II error rate (β) of 0.144.

IBM SPSS 24.0 statistical software was used for data analysis. Continuous variables with a normal distribution were presented as mean \pm standard deviation, and those with a non-normal distribution were presented as median (Q1, Q3). Categorical variables were summarized as frequency (percentage). For comparisons between groups, continuous variables with a normal distribution and meeting the assumption of homogeneity of variance were analyzed using the *t*-test. Continuous variables with non-normal distributions were compared using the Mann–Whitney U rank sum test. Categorical variables were compared using the chi-square test or Fisher’s exact test, as appropriate. Missing data were

handled using multiple imputation. Generalized estimating equation (GEE) models were applied to identify factors associated with postpartum weight retention. In the GEE analysis, the linearization method was adopted. An unstructured working correlation matrix was specified, and post-hoc comparisons were conducted using the least significant difference method. P-values <0.05 were considered indicative of statistical significance.

Results

General Characteristics of the Study Population

A total of 394 women with GDM were initially enrolled in the study. Of these, 52 were lost to follow-up at 3 months postpartum, resulting in 342 women included in the final analysis. Comparisons of baseline characteristics between the included group (n = 342) and the lost-to-follow-up group (n = 52) revealed a significant difference in the distribution of monthly household income per capita ($P < 0.05$). Specifically, women with a monthly household income per capita of 5001–10000 CNY were overrepresented in the lost-to-follow-up group, whereas the proportions in the other income brackets were lower compared with those in the included group. No significant differences were observed with respect to other baseline variables (Table 1).

Table 1 Comparison of General Characteristics Between the Included and Lost-to-Follow-up Groups

Variables	Inclusion Group n = 342	Lost-to-Follow-Up Group n = 52	t/ χ^2	P
Age	32.53±4.12	32.85±0.96	-1.222 ^a	0.223
Gestational age (weeks)	39.00±1.20	39.19±1.24	-1.073 ^a	0.284
Parity			0.398 ^b	0.820
1 time	180 (52.6)	25 (48.1)		
2 times	128 (37.4)	21 (40.4)		
≥3 times	34 (9.9)	6 (11.5)		
Education level			1.483 ^c	0.831
Junior high school and below	32 (9.4)	3 (5.8)		
Senior middle school	45 (13.2)	9 (17.3)		
Junior college	88 (25.7)	14 (26.9)		
Undergraduate course	155 (45.3)	24 (46.2)		
Graduate and above	22 (6.4)	2 (3.8)		
Monthly household income per capita (Yuan)			10.291 ^c	0.013
≤2000	9 (2.6)	0 (0.0)		
2001–5000	34 (9.9)	0 (0.0)		
5001–10,000	168 (49.1)	35 (67.3)		
>10,000	131 (38.3)	17 (32.7)		
Pregestation BMI			0.348 ^b	0.555
Underweight	31 (9.1)	6 (11.5)		
Normal	200 (58.5)	36 (69.2)		
Overweight	84 (24.6)	5 (9.6)		
Obese	27 (7.9)	5 (9.6)		
Weight gain during pregnancy			2.768 ^b	0.251
Poor	173 (50.6)	27 (51.9)		
Normal	131 (38.3)	23 (44.2)		
Excessive	38 (11.1)	2 (3.8)		
Mode of delivery			0.348 ^b	0.555
Normal vaginal delivery	199 (58.2)	28 (53.8)		
C-section	143 (41.8)	24 (46.2)		
Family history of diabetes			0.005	0.946
No	255 (74.6)	39 (75.0)		
Yes	87 (25.4)	13 (25.0)		

Notes: Data presented as n (%) or mean ± standard deviation. ^at-test; ^bchi-square test; ^cFisher's exact test.

The mean age of the study population was 32.53 ± 4.11 years (range, 21–45). Out of the 342 participants, 95 (27.8%) were aged ≥ 35 years. The most common monthly household income per capita was 5001–10000 CNY (172 cases, 50.3%). Primiparous women accounted for 180 cases (52.6%). Pre-pregnancy overweight or obesity was observed in 111 participants (32.3%), and excessive GWG was identified in 38 participants (11.1%). The exclusive breastfeeding rates at 42 days and 3 months postpartum were 29.2% and 28.9%, respectively, while the overall breastfeeding rates were 94.4% and 91.2%, respectively. The baseline characteristics of the study population are summarized in Table 2.

Table 2 Baseline Characteristics of the Study Population (N = 342)

Variable	Frequency (N)	Percentage (%)
Age		
<35 years	247	72.2
≥ 35 years	95	27.8
Education level		
Junior high school and below	32	9.4
Senior middle school	45	13.2
Junior college	88	25.7
Undergraduate course	155	45.3
Graduate and above	22	6.4
Monthly household income per person (yuan)		
≤ 2000	9	2.6
2001–5000	34	9.9
5001–10,000	168	49.2
>10,000	131	38.3
Pregestation BMI		
Underweight	31	9.1
Normal	200	58.5
Overweight	84	24.6
Obese	27	7.9
Weight gain during pregnancy		
Poor	173	50.6
Normal	131	38.3
Excessive	38	11.1
Parity		
1 time	180	52.6
2 times	128	37.4
≥ 3 times	34	9.9
Mode of delivery		
Normal vaginal delivery	199	58.2
C-section	143	41.8
Family history of diabetes		
No	255	74.6
Yes	87	25.4
Infant feeding at 42 days after delivery		
Exclusive breastfeeding	100	29.2
Mixed feeding	223	65.2
Artificial feeding	19	5.6
Feeding status at 90 days postpartum		
Exclusive breastfeeding	99	28.9
Mixed feeding	213	62.3
Artificial feeding	30	8.8

(Continued)

Table 2 (Continued).

Variable	Frequency (N)	Percentage (%)
Sleep quality 42 days postpartum		
Fine	12	3.6
Good	221	64.6
Same as before	100	29.2
Different	9	2.6
Sleep quality 90 days postpartum		
Fine	5	1.5
Good	255	74.5
Same as before	77	22.5
Different	5	1.5

Status of PPWR

PPWR among women with GDM showed a gradual decline over time. The mean PPWR was 5.09 ± 4.55 kg at 42 days postpartum and declined to 4.12 ± 4.17 kg at 3 months postpartum. The proportion of women who had returned to their pre-pregnancy weight increased from 12.0% at 42 days postpartum to 17.3% at 3 months postpartum. Correspondingly, the prevalence of HPPWR decreased from 50.3% at 42 days to 43.9% at 3 months postpartum. Weight retention status is summarized in [Table 3](#).

Factors Influencing PPWR

Generalized estimating equation (GEE) analysis identified postpartum time, monthly household income per capita, pre-pregnancy BMI, GWG, and parity as significant factors influencing PPWR ($P < 0.05$). Overall, PPWR decreased over time, with weight retention at 3 months postpartum significantly lower than that at 42 days postpartum ($\beta = -0.970$, 95% CI: -1.206 to -0.735 , $P < 0.001$). Compared to women with a monthly household income per capita of ≤ 2000 CNY, those with incomes of 5001–10000 CNY and > 10000 CNY exhibited significantly lower PPWR ($\beta = -3.054$, 95% CI: -4.925 to -1.184 , $P = 0.001$; $\beta = -2.364$, 95% CI: -4.393 to -0.335 , $P = 0.022$, respectively). With respect to pre-pregnancy BMI, overweight and obese women retained significantly less postpartum weight than women with normal BMI ($\beta = -2.274$, 95% CI: -3.076 to -1.471 , $P < 0.001$; $\beta = -4.298$, 95% CI: -5.353 to -3.242 , $P < 0.001$), whereas underweight women exhibited greater PPWR ($\beta = 2.450$, 95% CI: 0.919 to 3.981 , $P = 0.002$).

Gestational weight gain was also significantly associated with PPWR. Compared with women who achieved appropriate GWG, those with excessive GWG had greater weight retention ($\beta = 3.312$, 95% CI: 2.401 to 4.222 , $P < 0.001$), while women with inadequate GWG retained less weight postpartum ($\beta = -1.449$, 95% CI: -2.498 to -0.400 , $P = 0.007$). In addition, multiparous women had significantly lower PPWR compared with primiparous women ($\beta = -1.057$, 95% CI: -1.855 to -0.258 , $P = 0.009$). Age, education level, mode of delivery, infant feeding method, and sleep quality showed no significant association with PPWR ($P > 0.05$). The results of GEE analysis are presented in [Table 4](#).

Table 3 Postpartum Retention of Maternal Weight in Women with GDM (N = 342)

Group	PPWR \leq 0kg/(Case)	0kg<PPWR<5kg/(Case)	PPWR \geq 5kg/(Case)
42 days postpartum	41 (12.0)	129 (37.7)	172 (50.3)
3 months postpartum	59 (17.3)	133 (38.9)	150 (43.9)

Note: Data presented as frequency (percentage).

Table 4 Factors Associated with PPWR Based on Generalized Estimating Equation Analysis

Parameter	β	SE	wald χ^2	P	95% Confidence Interval	
					Lower Limit	Upper Limit
Nodal increment	8.776	1.715	26.173	<0.001	5.414	12.138
Postpartum time/day						
90	-0.970	0.120	65.075	<0.001	-1.206	-0.735
42						
Age						
≥35 years	0.048	0.415	0.013	0.908	-0.766	0.862
<35						
Education level						
Graduate and above	-0.172	1.065	0.026	0.872	-2.259	1.916
Undergraduate course	0.824	0.740	1.240	0.266	-0.626	2.274
Junior college	1.128	0.753	2.244	0.134	-0.348	2.604
Senior middle school	0.329	0.848	0.151	0.698	-1.333	1.991
Junior high school and below						
Monthly household income per capita						
>10000 Yuan	-2.364	1.035	5.215	0.022	-4.393	-0.335
5001-10000 Yuan	-3.054	0.954	10.244	0.001	-4.925	-1.184
2001-5000 Yuan	-1.683	1.030	2.668	0.102	-3.702	0.337
≤2000 Yuan						
Pregestation BMI						
Obese	-4.298	0.539	63.691	<0.001	-5.353	-3.242
Overweight	-2.274	0.410	30.805	<0.001	-3.076	-1.471
Underweight	2.450	0.781	9.841	0.002	0.919	3.981
Normal						
Weight gain during pregnancy						
Excessive	3.312	0.465	50.829	<0.001	2.401	4.222
Poor	-1.449	0.535	7.336	0.007	-2.498	-0.400
Normal						
Mode of delivery						
C-section	0.622	0.389	2.552	0.110	-0.141	1.384
Normal vaginal delivery						
Infant feeding status						
Artificial feeding	0.051	0.515	0.010	0.922	-0.959	1.061
Mixed feeding	0.110	0.409	0.072	0.789	-0.692	0.912
Exclusive breastfeeding						
Quality of postpartal sleep						
Different	-0.522	1.939	0.072	0.788	-4.323	3.279
Same as before	-1.899	1.459	1.694	0.193	-4.758	0.961
Good	-1.292	1.308	0.976	0.323	-3.856	1.272
Fine						
Parity						
Multipara	-1.057	0.407	6.730	0.009	-1.855	-0.258
l-para						

Discussion

Compared with healthy postpartum women, women with GDM experience greater difficulty in postpartum weight recovery, largely due to pre-existing abnormalities in glucose metabolism and pregnancy-related insulin resistance. The mean PPWR at 42 days postpartum of 5.09 ± 4.55 kg observed in this study is lower than the 10.38 ± 4.40 kg reported for non-GDM women by Shufang et al²¹ and is similar to the 4.53 kg reported for the general postpartum population by Yuting et al.²² However, the incidence of HPPWR at 42 days postpartum in our study (50.4%) far

exceeded the 20.24% reported by Shufang et al.²¹ This indicates that over half of the women with GDM failed to achieve effective weight loss during the puerperium, exposing them to a high risk of long-term metabolic complications. The mean PPWR at 3 months postpartum in this study (4.12 ± 4.17 kg) was lower than that reported in several domestic and overseas studies.^{12,13} Nevertheless, the HPPWR rate at this time point was 43.75%, closely approximating the 50% incidence at 2 months postpartum reported by Radwan et al.²² According to the Institute of Medicine (IOM) recommendations, approximately half of postpartum women should return to their pre-pregnancy weight within 6 weeks after delivery.²² Our findings suggest that the majority of women with GDM lack effective weight management awareness. Another study recommended returning to pre-pregnancy weight within 2 months postpartum to prevent long-term PPWR.²³

GWG as the Primary Determinant

Among examined factors, GWG emerged as the most important determinant of PPWR, consistent with prior research.^{11,13,24–26} Using the standards issued by the National Health Commission in 2022, which are considered more suitable for the Chinese GDM population,²⁷ the mean GWG in this cohort was 10.56 ± 5.21 kg. The proportion with excessive GWG was only 11.1%, significantly lower than the approximately 47% reported globally in the general postpartum population,²⁸ reflecting the effectiveness of strict medical management during pregnancy. However, the proportion with inadequate GWG was as high as 50.6%, suggesting a need to better balance glycemic control with adequate nutrition. Previous studies have demonstrated a dose–response relationship between GWG and PPWR. Each additional kilogram of GWG is associated with 0.62 kg of retained weight at 6–9 months postpartum and 0.48 kg at 1–3 years postpartum. Women exceeding the IOM-recommended GWG ranges retain, on average, 2–3 kg more weight from six months to four years postpartum, with a more than threefold increase in HPPWR risk.²⁸ Our findings confirm that excessive GWG significantly increases weight retention at both 42 days and 3 months postpartum. Excessive GWG is largely stored as maternal adipose tissue, directly increasing the difficulty of postpartum weight loss. In women with GDM, this process is further aggravated by insulin resistance,²⁷ which promotes fat storage and inhibits lipid mobilization.^{1,29} Therefore, strict control of GWG is crucial for women with GDM,^{1,27,29} with stricter GWG standards recommended compared to the general pregnant population.^{27,29} Controlling GWG within the recommended ranges is the most cost-effective strategy for preventing PPWR.³⁰ Despite the low prevalence of excessive GWG in our cohort, HPPWR rates remained high at both postpartum time points. This may reflect a transition from strict dietary control during pregnancy to insufficient postpartum support, relaxation of dietary restraint, and increased caloric intake after delivery, possibly reinforced by traditional postpartum practices.

Influence of Pre-Pregnancy BMI

The association between pre-pregnancy BMI and PPWR remains controversial. In this study, lower pre-pregnancy BMI was associated with greater PPWR, consistent with some studies.^{11,12,31} The potential mechanisms are as follows: First, women with pre-pregnancy underweight (BMI < 18.5 kg/m²) may more actively adhere to weight gain recommendations during pregnancy.¹⁰ Specifically, women with lower pre-pregnancy body weight are assigned higher recommended weekly weight gain targets during the second and third trimesters, which may lead to relatively greater GWG and, in turn, increase the risk of PPWR. Second, underweight pregnant women with insufficient GWG have a significantly increased risk of preterm birth (OR = 1.61),³² a condition often associated with placental insufficiency and inadequate maternal nutritional reserves. To reduce the risks of preterm birth (OR = 0.55) and low birth weight infants (OR = 0.75), clinical professionals commonly encourage underweight pregnant women to achieve or even modestly exceed the recommended GWG range to approach a healthier weight status.³³ This clinically oriented weight management strategy may promote greater maternal fat accumulation during pregnancy among women with low pre-pregnancy BMI, further exacerbating PPWR. Third, previous studies¹⁰ have indicated that women with pre-pregnancy underweight are more likely to retain weight postpartum, whereas women with obesity tend to retain less weight. Thus, similar to obesity, pre-pregnancy underweight may also exert adverse health effects. For underweight women, retaining a relatively higher postpartum weight may be perceived as beneficial, as it facilitates progression toward the normal, healthy weight range. Importantly, prior evidence indicates that GWG, rather than pre-pregnancy BMI itself, is the principal determinant of both short-term and long-term PPWR.¹¹ GWG may therefore mediate the observed association between low pre-

pregnancy BMI and increased weight retention. These findings reinforce that, regardless of pre-pregnancy BMI, controlling GWG within recommended ranges remains the most effective approach for preventing PPWR. Future research should further explore interactions between pre-pregnancy BMI and GWG to inform personalized weight management strategies.

Socioeconomic Status and Parity

Socioeconomic status, represented by monthly household income per capita, was a significant factor influencing PPWR in this study, with lower income associated with greater weight retention, consistent with previous findings.³⁴ Low-income women may have limited access to healthy foods and rely more on inexpensive, energy-dense diets. This leads to fat accumulation during pregnancy, disrupts intestinal flora balance, and induces metabolic disorders, which are difficult to reverse after childbirth, increasing the risk of excessive GWG.³⁵ In addition, work demands, childcare responsibilities, and limited access to exercise facilities may further constrain postpartum weight management. Conversely, high-income individuals often have greater access to nutritional counseling, exercise facilities, and structured interventions such as mobile health applications and meal replacement programs, which have been shown to reduce PPWR risk.^{36,37} Additionally, in the context of low-income Hispanic women, who experience both a high prevalence of obesity and exposure to multiple environmental and social stressors, studies have suggested that these daily stress exposures may lead to excessive GWG and PPWR through pathways involving increased perceived stress, disruption of cortisol circadian rhythms, and the adoption of unhealthy dietary behaviors and low levels of physical activity.³⁸ Economic disparities may, therefore, exacerbate differences in postpartum weight recovery through the multidimensional interaction of dietary behaviors, physical activity, access to health resources, and psychological factors. Although loss to follow-up in this study was concentrated in the 5000–10000 CNY income group and may have introduced some bias, the overall findings support a meaningful association between socioeconomic status and PPWR, highlighting health equity considerations.

Parity also influenced PPWR, with primiparous women experiencing greater weight retention than multiparous women, consistent with prior studies.^{31,34} A study found a negative correlation between parity and GWG, possibly because multiparous women benefit from greater experience, health knowledge, and weight management awareness.³⁵ Primiparous women may be more susceptible to traditional postpartum practices emphasizing excessive nutrition and to non-professional dietary advice from family members, particularly in multi-generational households,^{13,39} hindering effective postpartum weight recovery.

Breastfeeding, Sleep, and Other Factors

The effects of breastfeeding on PPWR remain inconsistent across studies. Lactation increases maternal energy expenditure and may facilitate fat mobilization,⁴⁰ yet some studies report greater weight retention among breastfeeding women, potentially due to increased caloric intake.^{11–13} Although some studies identified exclusive breastfeeding as protective against HPPWR,^{7,41} our study did not observe a significant association between breastfeeding mode and PPWR. This may be due to the small number of exclusively formula-feeding women, the short follow-up period of 3 months, and the likelihood that the benefits of breastfeeding on weight retention become more apparent with longer duration. Haer et al⁴² reported no effect of breastfeeding on weight retention at 3 months postpartum but observed lower weight retention among women who breastfed for at least 6 months.

Similarly, although sleep deprivation and poor sleep quality have been linked to insulin resistance and obesity risk,^{7,43} our study did not identify a significant association between sleep quality and PPWR. This may reflect reliance on subjective sleep assessments rather than objective measures. Previous research indicates that sleep duration of ≤ 5 hours at 6 months postpartum is strongly associated with PPWR of at least 5 kg at 1 year postpartum,⁴⁴ suggesting the need for longer follow-up and objective sleep measurements. Additionally, this study found no association between age, mode of delivery, and PPWR, consistent with previous research.^{6,12,13}

Strengths and Limitations

This study has several strengths. It focuses specifically on early postpartum weight gain in women with GDM, a metabolically vulnerable population, and identifies a pattern of relatively modest average PPWR accompanied by a high prevalence of HPPWR. It is also the first to apply the 2022 National Health Commission GWG standards to

women with GDM, supporting their clinical relevance. Additionally, the inclusion of monthly household income per capita highlights socioeconomic barriers to postpartum weight recovery from a health equity perspective.

However, some limitations should be acknowledged. First, the sample size was limited, and loss to follow-up was non-random, with attrition mainly concentrated among participants with a monthly household income of 5000–10,000 RMB. This selective loss to follow-up may have introduced selection bias, potentially leading to underestimation or overestimation of the associations between socioeconomic factors and PPWR. It also limits the generalizability of the findings across different income groups, particularly with respect to socioeconomic influences. Second, several variables, including sleep quality and dietary behaviors, were assessed using self-reported measures and lacked objective assessment. In particular, reliance on subjective sleep quality evaluation represents a major limitation and may have reduced the precision of the findings related to sleep and PPWR. Third, this was a single-center study with a relatively small sample size, and several potentially important influencing factors, such as dietary patterns and physical activity, were not included. Although this study focused on demographic, obstetric, and basic behavioral factors (eg, feeding practices and sleep status) on PPWR, multiple potential confounders factors were not systematically measured. These included postpartum dietary energy and nutrient intake, frequency and duration of moderate-to-vigorous physical activity, parenting stress levels, and specific postpartum weight management behaviors, such as the use of mobile applications for weight management and consultation with healthcare professionals. These unmeasured factors may be correlated with variables included in the analysis, such as household income and parity, and may independently influence PPWR. Finally, follow-up was limited to 3 months postpartum, preventing assessment of long-term PPWR trajectories and delayed effects of breastfeeding and lifestyle modification.

Conclusion

This study indicates that monthly household income per capita, pre-pregnancy BMI, GWG, and parity are significant determinants of early postpartum weight retention in women with GDM. Clinical management should emphasize appropriate GWG control during pregnancy and strengthened postpartum weight management, particularly for women with low income, pre-pregnancy underweight, and primiparity. Providing systematic prenatal and postpartum guidance to promote evidence-based nutrition and lifestyle behaviors is essential for reducing PPWR and mitigating long-term metabolic risks associated with GDM. Future studies should expand sample size, adopt multicenter designs, extend follow-up duration, and incorporate objective measures of diet, physical activity, and sleep to further clarify mechanisms of PPWR and guide targeted interventions.

Ethics Approval

Approval was obtained from the Ethics Committee of Fujian Maternity and Child Health Hospital. All procedures were conducted in accordance with the principles of the Declaration of Helsinki.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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