Traditional Cantonese puerperal practices and postpartum cardiometabolism in gestational diabetes

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ABSTRACT

Background and Objectives: With gestational diabetes (GDM), women have a higher risk for future type 2 diabetes, and risk factors for diabetes for it are amplified. Whether this phenomenon is affected by traditional puerperal or postpartum practices among Chinese women who develop gestational diabetes is unclear. This has been explored in a Cantonese cultural setting to enable relevant risk management. **Methods and Study Design:** Some 138 women were followed before, during and after pregnancy in accordance with Cantonese Puerperal Practices (CPP), and occurrence of GDM and exclusive breast-feeding. Body compositional and cardiometabolic information were collected. These included glucose tolerance and insulin resistance. **Results:** During a median postpartum follow-up of 60.4 days, women with a typical CPP had a greater body weight and weight retention. With artificial feeding, women with a typical CPP had greater OGTT glycemic responses and more insulin resistance. With exclusive breast-feeding, however, no differences in postpartum cardiometabolic measurements were observed, except for a higher early-phase insulin response. **Conclusions:** Traditional CPP is associated with early postpartum cardiometabolic impairment in gestational diabetes, but this is avoided with breast-feeding.

Key Words: gestational diabetes mellitus, puerperal practice, weight retention, insulin resistance, postpartum metabolism

INTRODUCTION

Health beliefs and practices surrounding the postpartum period are culturally patterned, and marked distinctions exist worldwide. For example, in Turkey, 'Bulamac' dishes of gruel and tight abdominal wrapping are common; hot water baths may be recommended in non-western regions, now abandoned by western health care providers.[1,2] In China, adherence to traditional puerperal practices for the first month after delivery is usual.[3,4] The cultural concept of 'Yin and Yang balance' strongly influences the first month practice. Thus, some otherwise acceptable healthy behaviors like fruit consumption and physical activity are considered to compromise 'balance'.[5] Instead, high-fat and energy dense food consumption with sedentariness are often thought to restore balance.[6] In Table 1, we summarize some geo-specific puerperal dietary characteristics in China.

Cantonese Puerperal Practices (CPP) is indicative of puerperal practice in China.[7,8] CPP food customs include 1) Sweet vinegar ginger pork feet with eggs, a classic delicacy where pork feet are boiled with ginger vinegar and eggs for around 3 to 4 hours; 2) Old fire soup, or

'lou fo tong', a clear broth prepared by simmering meat and other ingredients over low heat for several hours; 3) Yellow glutinous rice wine chicken, a whole chicken cooked with, old ginger, and yellow rice wine; along with a minimum of physical activity. CPP originated in Guangdong Province, mainland China and is also common in Hong Kong, Macau, and some areas of Southeast Asia such as Singapore and Malaysia.8 With limited cultural insight, the potential consequence on postpartum health may be neglected in China and elsewhere.

The worldwide prevalence of type 2 diabetes (T2DM) is increasing and the burden on the healthcare system is rising.[9] Along with the risk factors like the obesity pandemic, the incidence of gestational diabetes (GDM) is also growing, estimating from 6.8% in 2008 up to 14.8% in 2019 in Mainland China.[10,11] The incidence rate of T2DM after GDM was evaluated to be 26.2 per 1000 person-years overall, which is approximately 10-fold higher than women without a history of GDM.[12,13] With the understanding of the pathophysiological characteristics in GDM women, we presumed that metabolic stress caused by some potentially modifiable factors, such as eating patterns and physical activity may have an amplified effect on GDM women.[14] However, due to the specificity, previous results may not be applicable for Chinese women.

Here, to provide better healthcare recommendations for Chinese women, we conducted this study by the representative CPP. A questionnaire of puerperal behaviors including the food choices, consumption frequency, and exercise intensity of CPP segments was performed in our ongoing GDM women cohort. The postpartum metabolic parameters were measured and compared between those with or without typical CPP. Data from the current study may support future healthcare recommendations for postpartum GDM women.

MATERIALS AND METHODS

Study design and participants

Participants were recruited from an ongoing prospective GDM women cohort between December 2017 and August 2020 in the outpatient clinic of The First Affiliated Hospital of Sun Yat-sen University. The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the ethics committee of The First Affiliated Hospital of Sun Yat-sen University (ethical approval number: [2017] 124).

The participants were eligible if they were 1) aged between 18 to 45 years old; 2) meeting the diagnostic criteria for GDM; 3) meeting the definition for typical CPP or non-CPP; 4) delivering a singleton; 5) live birth ≥35 weeks of gestation; 6) without pregnancy complications; 7) providing the written informed consent. The exclusion criteria included

women with 1) previous metabolic disorders (defined as self-reported diabetes, impaired glucose tolerance, dyslipidemia, hyperuricemia); 2) hereditary disease; 3) psychological problem; 4) viral hepatitis; 5) inflammatory bowel disease; 6) neuromuscular disorders; 7) could not control blood sugar and need insulin treatment and 8) with special dietary behaviors, such as vegetarianism, Muslim eating pattern, restricted carbohydrate diet et al.

Exposure factors of typical- or non-CPP

In consideration of the glucose dysregulation during pregnancy, we advise the participants to avoid the Chinese traditional puerperal practices during the last visit. Though abandoned to some extent, numerous participants still adhered to it. Hence, at the first visit after delivery, we investigated the exposure factors.

The puerperal practices regarding the CPP segments was recalled at the visit after delivery. Eating habit was categorized into 3 levels according to the consumption frequency (very frequently, occasionally, very rarely corresponding to options A, B, and C). In this study, we defined the planned physical activity as approximately 30 minutes of continuous moderate aerobic exercise every day, as recommended by ACOG for the postpartum period, including brisk walking, fit aerobics, Yoga et al, corresponding to option C.[15] Less frequent sessions of aerobic exercise correspond to option B. Hardly exercise corresponds to option A (Table 2).

Based on the choices, typical CPP was defined as women who chose at least three options A. Non-CPP was defined as women who got at least three options C and without options A.

Besides, women were re-confirmed that these were additional foods consumed postpartum and other diets stayed relatively balanced. The actual amount of food intake was estimated by our researchers according to the patients' descriptions using their hands and fists. We estimated the calories of the main ingredients online (https://www.calories.info). Once consumption of sweet vinegar ginger pork feet with eggs usually included 3 to 5 bite-sized pork feet (around 3-4 ounces, estimated calories were 197-275 kcal), 5 to 10 thick-cut pieces of ginger and remained vinegar in the bowl with the size of the palm of a hand. For old fire soup, a small bowl of soup accompanied with lunch and (or) dinner (for soup mixed with meat and vegetables, the calories were estimated to be 100 kcal/bowl). As to yellow glutinous rice wine chicken, once consumption commonly included a whole chicken (around 1400 kcal).

Data collection

Firstly, baseline characteristics were collected. Name, age, date of delivery, family history of diabetes mellitus (DM) in first degree relatives, types of delivery, neonatal weight, ways of

baby-feeding, pre-pregnancy weight and height were collected from self-report; smoking, alcohol consumption, heart rate, blood pressure, gestational age, blood glucose responses to 75g 2-h OGTT and lipid profiles during pregnancy were collected from medical records.

Secondly, outcome data including postpartum blood pressure, postpartum weight and height, postpartum waist and hip circumference were measured by trained medical workers. Then, fasting blood samples were collected to determine postpartum lipid profiles, fasting blood glucose and insulin. After that, 75g 2-h OGTT was performed, and 30min and 2h- post-load blood glucose and insulin were determined. The data collection were performed at 40-100 days postpartum. All physical examinations and blood biochemistry were carried out by recommended standard procedures as previously reported.[16]

Definitions

Feeding approaches were categorized to 1) exclusive breast-feeding or 2) artificial feeding mode, which was lasting by the time of the visit. Exclusive breast-feeding was defined as the infant receiving only breast milk. Artificial feeding mode was defined as feeding the baby with infant formula, or together with breast milk.

Calculations

Postpartum weight retention (PPWR) was calculated by subtracting the pre-pregnancy weight from weight at the visit of 40-100 days postpartum.[17] The total (120min), early-phase (first 30min of the OGTT), and late-phase (last 90min of the OGTT) area under the curve values (AUC) for the glucose or insulin were calculated using trapezoidal reconstruction.

Insulin resistance was evaluated with 1) homeostasis model assessment of insulin resistance (HOMA-IR = (insulin[mU/L]×glucose[mmol/L])/22.5); 2) the ratio of TG to HDL-C (TG/HDL-C); 3) insulin sensitivity index (ISI(0,120) = 10,000/√{[fasting glucose (mg/dL)×fasting insulin (μU/mL)]×[mean glucose×mean insulin]}); and 4) quantitative insulin sensitivity check index (QUICKI =1/[log fasting insulin (mU/L)+log fasting glucose (mg/dL)].[18]

Diagnosis criteria

The diagnostic criteria for GDM was made according to the International Association of Diabetes and Pregnancy Study Groups (IADPSG).[19] After delivery, women returned for a 75g 2-h OGTT, on which current glucose tolerance status was defined according to the WHO1999 criteria.[20]

Data processing and statistical analysis

Data were expressed as frequency and proportion for categorical variables, mean ± standard deviation or median (IQR) for continuous variables. The differences between groups were analyzed using the chi-squared test for categorical variables, the t-test for normally distributed continuous variables, and the Kruskal-Wallis test for skewed continuous variables. Comparisons of PPWR was performed by ANCOVA, controlling for age, family history of DM, delivery mode, and infant-feeding mode. Comparisons of insulin resistance indexes were performed by ANCOVA, controlling for age, family history of DM, delivery mode, infant-feeding mode and percent change of BMI. Comparisons of AUC for OGTT were performed by ANCOVA, controlling for age, family history of DM, delivery mode, infant-feeding mode, percent changes of BMI and relative baseline values.

RESULTS

During the inclusion period, 254 women with GDM were identified and enrolled in this study. 50 women were excluded according to the exclusion criteria besides the CPP conformity. Participants without adequate follow-up data were excluded (n=28). To make the results more representative, women with atypical CPP (depending on the options of the questionnaire) were also excluded (n=38). A total of 138 women were eventually analyzed in the present study: 1) 78 women in the typical CPP group, and 2) 60 women in the non-CPP group (Figure 1).

Baseline characteristics of participants

The two groups of women showed similar baseline characteristics as shown in Table 3, except that women with non-CPP had a significantly higher rate for exclusive breast-feeding mode (61.67% vs 38.46%, respectively, $p<0.05$). No participant reported smoking and alcohol consumption during pregnancy and after delivery.

Postpartum anthropometry and metabolic characteristics among total participants

During a median follow-up of 60.4 days postpartum, women with the typical CPP showed significantly higher postpartum body weight and PPWR. Women with typical CPP showed worse insulin sensitivity (TG/HDL-C, QUICKI and HOMA-IR), but with borderline significant *p*-values (Table 4).

Feeding mode-specific postpartum anthropometry and metabolic characteristics in different puerperal practices groups

For further controlling the feeding mode factors, we subsequently proceeded with stratified analysis. Overall, the baseline characteristics were comparable (Table 5). The pre-pregnancy body weight seems to be higher in women with typical CPP in the artificial feeding subgroup, but the p-value was above 0.05. As such, we control the potential confounders using the percent change of BMI in our analysis.

With artificial feeding mode, we found that the total-, early-phase- and late-phase- AUC values for the glucose were significantly increased in typical CPP women (Figure 2 P-R). Though fasting and 2-h post load insulin increased in the typical CPP group, adjusted AUC values were non-significant (Figure 2 S-U). In the exclusive breast-feeding subgroup, early-phase insulin response was increased with no differences observed in post-load glucose and glucose AUC values between the two puerperal practices groups. Moreover, data analysis showed that women with typical CPP had significantly higher insulin resistance in the artificial feeding mode subgroup, whereas no significant differences were observed in the exclusive breast-feeding subgroup (Figure 2 V-Y).

DISCUSSION

The present study compared several postpartum metabolic measurements among GDM women with or without typical CPP. The main finding of this study is that during a median follow-up of 60.4 days postpartum, women with typical CPP were found to have a greater postpartum body weight and PPWR. With artificial feeding, women with a typical CPP had greater OGTT glycemic responses and more insulin resistance. With exclusive breast-feeding, however, no differences in postpartum cardiometabolic measurements were observed, except for a higher early-phase insulin response.

Tracing back to thousands of years ago, women in China have been adhering to the traditional postpartum practices called ‘zuo yue zi’, or terminologically ‘doing the month’, which included a series of limitations for activity, clothing, and food consumption.[21] Nowadays, with the development of the economy and expansion of confinement service centers, this postpartum practice is bringing into more high-calorie eating habits along with the traditional sedentary styles.[3] Numerous researches have revealed the possible association with adverse postpartum health events, like micronutrients deficiency and bleeding gums.[3,4] However, few studies were conducted to reveal the potential effect on maternal metabolism.

CPP is a representative Chinese-specific puerperal practices, with the common characteristics of high-calorie food consumption (except for the Cantonese cuisine taste) and sedentary style. It is widely prevalent in Cantonese-speaking areas both in southeast China and Southeast Asia. According to previous data, the prevalence of postpartum anemia was higher in Guangzhou than other areas in north and east China, and the potential reason may be related to the geographic-specific postpartum practice.[22] Hence, we assumed the CPP may also affect postpartum cardiometabolic factors. The current study participants were sampled out in Guangzhou, which was predominately made of native residents and inhabitants born in other cities out of Guangzhou. Though abandoned to a certain extent, the puerperal practice ranges from eating a whole chicken every day to a normal habit as the general population. This feature provided a chance for us to investigate the influence among the same settings of participants.

Our data revealed that adopting the typical CPP after delivery led to higher early-postpartum body weight and PPWR. PPWR have been proved to increase adverse outcome in a second pregnancy, as well as future obesity and T2DM.[23] In our participants the typical CPP increased the weight retaining around 4kg, remaining at a relatively high level during the early postpartum period.[24] Concerning the long-term maternal health, we assumed that women with typical CPP should speed up weight loss during the later postpartum period through a combination of intensive dietary intervention together with exercise as previously recommended.[25,26]

Pregnancy is characterized by a 50% increase in insulin resistance, which is essential for the accommodation to the nutritional requirements of growing fetus.[27] Being out of balance between β-cell function and insulin resistance lays the foundation for both the GDM and postpartum T2DM occurrence.[28] Women with GDM have a considerably higher risk of future T2DM, for a faster deterioration in insulin sensitivity and β-cell compensation than their counterparts without GDM.[29,30] For Chinese women with prior GDM, postpartum β-cell dysfunction and insulin resistance have been proved to contribute to postpartum hyperglycemia;[31] and our group previously reported that intrinsic β-cell dysfunction may be the predominant contributor to the early postpartum abnormal glucose regulation in Chinese women with previous GDM.[32] In the current study, we found that although women adhered to typical CPP just for one month after delivery, it resulted in higher insulin resistance. After controlling for feeding mode by stratified analysis, significant differences were displayed in the artificial feeding subgroup. To sum up, we assumed that typical CPP may deteriorate later

maternal glucose metabolism by disturbing insulin action, especially in artificial feeding mode women.

Infant feeding modes were not parallel in baseline characteristics. Previous studies reported that dietary factors may not only affect the nutrients composition, but also the secretion of breast milk.[6,33] A regular intake of ginger vinegar was defined as a risk factor for insufficient milk secretion.[6] As for our study participants, it may lay the objective reason for a higher artificial feeding rate in typical CPP group. Then, we performed stratified analysis for more unified comparisons, though the interaction effect analysis were not all significant for different outcome measurements (data not shown). Our current data showed that though all post-load insulin increased (with a borderline *p*-value in OGTT-30min insulin) in women with typical CPP in the artificial feeding subgroup. However, the early-phase glucose was significantly higher. This diversity attempted us to test the glycemic and insulin responses to OGTT by calculating the adjusted AUC level. We found that in the artificial feeding subgroup, insulin responses were similar between groups, with increased glycemic responses. While in the exclusive breast-feeding subgroup, significantly increased early-phase insulin response was observed in the typical CPP group, without changes in glycemic responses.

Previous studies suggested that breast-feeding may associate with favorable changes in glycemic and lipid homeostasis, and insulin resistance, which was possibly related to higher serum prolactin and the suppression of leptin by prolactin.[34-36] Though we didn't make a further comparison, however, our data showed that breast-feeding subgroup women displayed a higher insulin resistance. The reason may relate to different postpartum follow-up periods, as prolactin concentration dynamically change after delivery.[37]

Prolactin serves as an important factor in pregnancy insulin resistance and causes of GDM.[38] After delivery, serum prolactin increment in response to lactation can be as much as 50 times the basal concentration and significantly higher than in non-lactation women.[37] The association between high serum prolactin and insulin resistance has been observed in multiple evidence.[39-41] But in postmenopausal women, a high circulating prolactin was found to be associated with improved glucose homeostasis.[42] Previous studies have found a positive association between serum prolactin with HDL-C in women with polycystic ovary syndrome.[41,43] But, the impact in breast-feeding women was unclear.

From our study results, we assumed that the early postpartum insulin resistance was affected by the potential function of prolactin, especially in breast-feeding subgroup women. In the artificial feeding women, the influence of prolactin was weakened. Hence, insulin resistance may be more affected by puerperal practices. As we observed in this subgroup,

insulin resistance consistently increased in the typical CPP group, as well as a greater TG values. But for the long-term concern, breast-feeding may still be beneficial as previously reported.[44] And the mechanism may be possible through improving glucose tolerance over time by increasing early-phase insulin responses. Until now, few studies have revealed the postpartum prolactin's influence on insulin resistance and lipid profile changes in women with previous GDM. To provide better healthcare suggestions, it needs to be further studied.

Our study adopted several indexes to assess insulin resistance, that the applicability needed to be discussed. In general, our participants were qualified for the insulin resistance indexes used.[18] BMI and age have been proved to be confounding factors for these indexes, which were controlled in our study.[45] Besides, we further control the factors like family DM history and delivery mode. The well consistency among these indexes corporately confirmed the metabolic characteristics of our study participants.

Some established postpartum predictor factors for the early onset of diabetes such as glucose and serum lipid profiles did not differ between practice groups in our study.[46] However, we assumed that these metabolic parameters may not exhibit systematic change across a very wide range of falling β-cell function and increasing insulin resistance, and they could not provide a strong clinical signal for declining metabolic function until relatively late in the progression toward diabetes.

There were several strengthens in our study. Firstly, we evaluated the impact of traditional puerperal practices on postpartum maternal metabolism among GDM women, which hasn't been reported before. Secondly, during the postpartum visit, OGTT insulin was measured to elucidate the nature of the glucose response. Lastly, we used several indexes as interpretative cross-checks.

There were limitations. Firstly, sample size was small and follow-up duration short. Secondly, plasma insulin during pregnancy is affected by placental factors.[47] We do not have an independent index for pregnancy-induced plasma insulin which takes into account baseline insulin resistance. However a relatively stable index of TG/HDL-C was adopted. Lastly, a probable negative effect of the typical CPP needs further investigation with a study design which explores mechanisms.

It is concluded that traditional Cantonese puerperal practices in the first month after delivery may have adverse metabolic effects. This presents cultural challenges and judicious review in community context, particularly in women with GDM. History cautions in respect of unintended consequences of novel healthcare policy, which can be avoided by participatory engagement of the individuals and communities at risk in whatever educational or systemic

measures are envisaged. These can enhance evidence-based approaches to breast and infant feeding among Chinese women.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors have no conflicts of interest to declare.

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Table 1. Summary of geographic-specific puerperal dietary characteristics in China

Area	Study	Participants number	Participants description	Dietary assessment	Results	Author, reference
Shanghai	Prospective cohort study	122	Community (n=92) Maternal Care Center (n=30)	Dietary records by diet diary and photographic record	Low consumption of fruit, vegetable, bean, tuber, and milk.	Hu, et al.,[3]
Hubei	Retrospective survey	1975	Urban area (n=638) Suburban area (n=627) Rural area (n=710)	FFQ	Plentiful consumption of eggs, fish, poultry and meats; Inadequate consumption of fruit, vegetable and milk.	Mao, et al.,[4]
Guangzhou	Retrospective survey	1977	Urban area (n=1002) Suburban area (n=975)	FFQ	Over-consumption of fish, poultry, eggs and red meat; Inadequate consumption of vegetables, soybeans and soybean products, dairy and fruits.	Qin, et al.,[6]
Beijing	Prospective cohort study	52	Recruited from maternal and child hospitals	FFQ	Excessive fat intake.	Wu, et al.,[33]
Hong Kong	Prospective cohort study	51	Recruited from the postnatal ward of the Obstetrics and Gynaecology Department in the Prince of Wales Hospital	FFQ	Commonly consumption of ginger, pig's trotter and ginger vinegar soup.	Chan, et al.,[8]

Table 2. Questionnaire about Cantonese puerperal practices

Puerperal Practices	Options		
	A	B	C
Consumption of old fire soup	≥1 time per day (very frequently)	<1 time per day (occasionally)	<1 time per week (very rarely)
Consumption of sweet vinegar ginger pork feet with eggs	≥3 times per week (very frequently)	<2 times per week (occasionally)	<1 time per month (very rarely)
Consumption of yellow glutinous rice wine chicken	≥1 time per day (very frequently)	<1 time per day (occasionally)	<1 time per month (very rarely)
Exercise	None at all	Less frequent sessions of aerobic exercise or others	15-30 minutes regular moderate aerobic exercise everyday

Table 3. Baseline characteristics of study participants

	Typical CPP (n=78)	Non-CPP (n=60)	*p*-value
Pre-pregnancy characteristics			
Age (years old)	32.47±4.47	33.27±4.45	0.294
Weight (kg)	56.69±9.22	55.40±8.71	0.879
Height (cm)	159.40±4.77	160.24±3.46	0.625
BMI (kg/m^2)	21.72±3.29	21.51±2.63	0.682
With family history of DM, n (%)	22 (28.21%)	19 (31.67%)	0.977
Pregnancy characteristics			
Systolic pressure (mm Hg)	112.73±8.62	109.89±9.46	0.068
Diastolic pressure (mm Hg)	69.87±6.83	71.09±4.86	0.243
Heart rate (bpm)	81.14±10.24	83.75±8.43	0.115
OGTT-0min BG (mmol/L)	4.65±0.47	4.67±0.39	0.784
OGTT-60min BG (mmol/L)	11.19±0.79	11.17±1.15	0.912
OGTT-120min BG (mmol/L)	8.85±1.07	8.80±1.24	0.812
Total Cholesterol (mmol/L)	6.45±1.07	6.30±0.96	0.397
HDL-C (mmol/L)	2.03±0.40	1.89±0.33	0.055
TG (mmol/L)	2.63±1.17	2.63±0.89	0.994
LDL-C (mmol/L)	3.55±0.67	3.35±0.62	0.075
TG/HDL-C	1.38±0.80	1.41±0.55	0.753†
Postpartum characteristics			
Natural birth, n (%)	47 (60.26%)	36 (60.0%)	0.996
Neonatal weight (kg)	4.73±0.71	4.56±0.60	0.146
Exclusive breastfeeding, n (%)	30 (38.46%)	37 (61.67%)	0.026*

DM: diabetes mellitus; BG: blood glucose; TG: triglyceride
†*p*-value controlling for age, family history of DM and pre-pregnancy BMI.
**p*<0.05 compared with the typical CPP group.

Table 4. Postpartum anthropometry, BP and metabolic indicators

	Typical CPP (n=78)	Non-CPP (n=60)	*p*-value
Weight (kg)	60.52±8.89	56.13±7.33	0.019*
Postpartum weight retention (kg)	4.04±4.64	2.74±3.76	0.046*
BMI (kg/m^2)	23.21±3.12	22.72±0.34	0.136
Waist circumference (cm)	79.91±7.58	77.94±6.11	0.201
Hip circumference (cm)	96.56±6.62	95.02±5.40	0.204
Waist-hip ratio	0.83±0.05	0.82±0.05	0.649
Systolic pressure (mm Hg)	110.39±6.32	109.95±8.46	0.727
Diastolic pressure (mm Hg)	70.42±6.35	69.14±4.41	0.184
Heart rate (bpm)	85.56±8.93	83.68±10.40	0.256
OGTT-0min BG (mmol/L)	4.91±0.55	5.01±0.67	0.361
OGTT-30min BG (mmol/L)	9.98±2.49	9.26±2.27	0.081
OGTT-120min BG (mmol/L)	6.96±1.75	7.28±1.91	0.309
OGTT-0min Insulin (uU/mL)	6.52±2.60	6.05±2.93	0.348
OGTT-30min Insulin (uU/mL)	65.16±35.65	49.20±17.05	0.003*
OGTT-120min Insulin (uU/mL)	32.93 (20.28-46.09)	34.38 (23.64-50.42)	0.140
Total Cholesterol (mmol/L)	5.76±1.12	5.71±1.11	0.790
HDL-C (mmol/L)	1.67±0.37	1.71±0.34	0.511
TG (mmol/L)	1.25±0.65	1.12±0.68	0.268
LDL-C (mmol/L)	3.45±0.77	3.41±0.82	0.825
Total glucose AUC (mmol.min^{-1}.L^{-1})	16.08±3.09	15.25±2.66	0.075
Early-phase glucose AUC (mmol.min^{-1}.L^{-1})	7.45±1.35	7.13±1.25	0.114
Late-phase glucose AUC (mmol.min^{-1}.L^{-1})	8.63±1.84	8.11±1.53	0.072
Total insulin AUC (μU.min^{-1}.mL^{-1})	78.28 (57.71-1116.65)	71.24 (53.53-82.90)	0.404
Early-phase insulin AUC (μU.min^{-1}.mL^{-1})	32.01 (21.69-51.08)	28.89 (20.15-33.56)	0.067
Late-phase insulin AUC (μU.min^{-1}.mL^{-1})	48.14 (34.63-65.67)	43.39 (34.32-50.66)	0.953
Postpartum TG/HDL-C	0.82±0.56	0.69±0.50	0.064
ISI index (arbitrary unit)	5.5 (3.4-6.6)	5.1 (3.4-7.1)	0.724
QUICKI index (arbitrary unit)	0.36±0.03	0.37±0.03	0.052
HOMA-IR (arbitrary unit)	1.37±0.67	1.25±0.77	0.067

BG: blood glucose; TG: triglyceride; AUC: area under the curve values.
**p*<0.05 compared with the typical CPP group.

Table 5. Baseline characteristics by feeding mode

	Breast-feeding (n=67)			Artificial feeding (n=71)		
	Typical CPP (n=30)	Non-CPP (n=37)	*p*-value	Typical CPP (n=48)	Non-CPP (n=23)	*p*-value
Pre-pregnancy characteristics						
Age (years old)	32.11±4.24	33.31±4.40	0.265	32.69±4.64	33.22±4.63	0.654
Weight (kg)	55.13±9.80	54.53±6.98	0.769	56.30±9.16	52.64±8.52	0.110
Height (cm)	160.53±3.91	158.68±4.92	0.097	159.84±4.88	158.32±5.87	0.259
BMI (kg/m^2)	21.35±3.45	21.78±2.65	0.569	22.00±3.13	20.93±2.73	0.173
With family history of DM, n (%)	12 (40%)	16 (43.2%)	0.802	10 (20.8%)	3 (13.0%)	0.526
Pregnancy characteristics						
Systolic pressure (mm Hg)	111.32±8.60	109.60±9.42	0.443	113.42±7.99	109.97±9.52	0.114
Diastolic pressure (mm Hg)	69.06±4.09	70.06±6.48	0.485	70.59±3.87	71.72±5.48	0.320
Heart rate (bpm)	80.47±9.47	83.43±9.04	0.196	81.56±10.78	84.27±7.45	0.290
OGTT-0min BG (mmol/L)	4.63±0.48	4.73±0.37	0.352	4.65±0.47	4.56±0.40	0.443
OGTT-60min BG (mmol/L)	11.27±1.01	11.29±1.30	0.957	11.14±0.63	10.98±0.85	0.399
OGTT-120min BG (mmol/L)	9.00±1.19	8.83±1.46	0.629	8.76±1.00	8.76±0.82	0.991
Total Cholesterol (mmol/L)	6.56±1.02	6.15±1.00	0.122	6.40±1.10	5.87±0.91	0.050
HDL-C (mmol/L)	2.04±0.37	1.89±0.37	0.111	2.02±0.43	1.92±0.24	0.301
TG (mmol/L)	2.82±1.37	2.62±1.00	0.513	2.51±1.03	2.63±0.73	0.614
LDL-C (mmol/L)	3.61±0.65	3.44±0.60	0.277	3.51±0.68	3.21±0.65	0.080
TG/HDL-C	1.35±0.63	1.44±0.61	0.705†	1.39±0.89	1.35±0.43	0.795†
Postpartum characteristics						
Natural birth, n (%)	18 (60%)	21 (56.8%)	0.789	29 (60.4%)	15 (65.2%)	0.697
Neonatal weight (kg)	4.67±0.65	4.61±0.68	0.668	4.76±0.75	4.49±0.42	0.055

DM: diabetes mellitus; BG: blood glucose; TG: triglyceride.
†Adjusted *p*-value controlling for age, family history of DM and pre-pregnancy BMI.

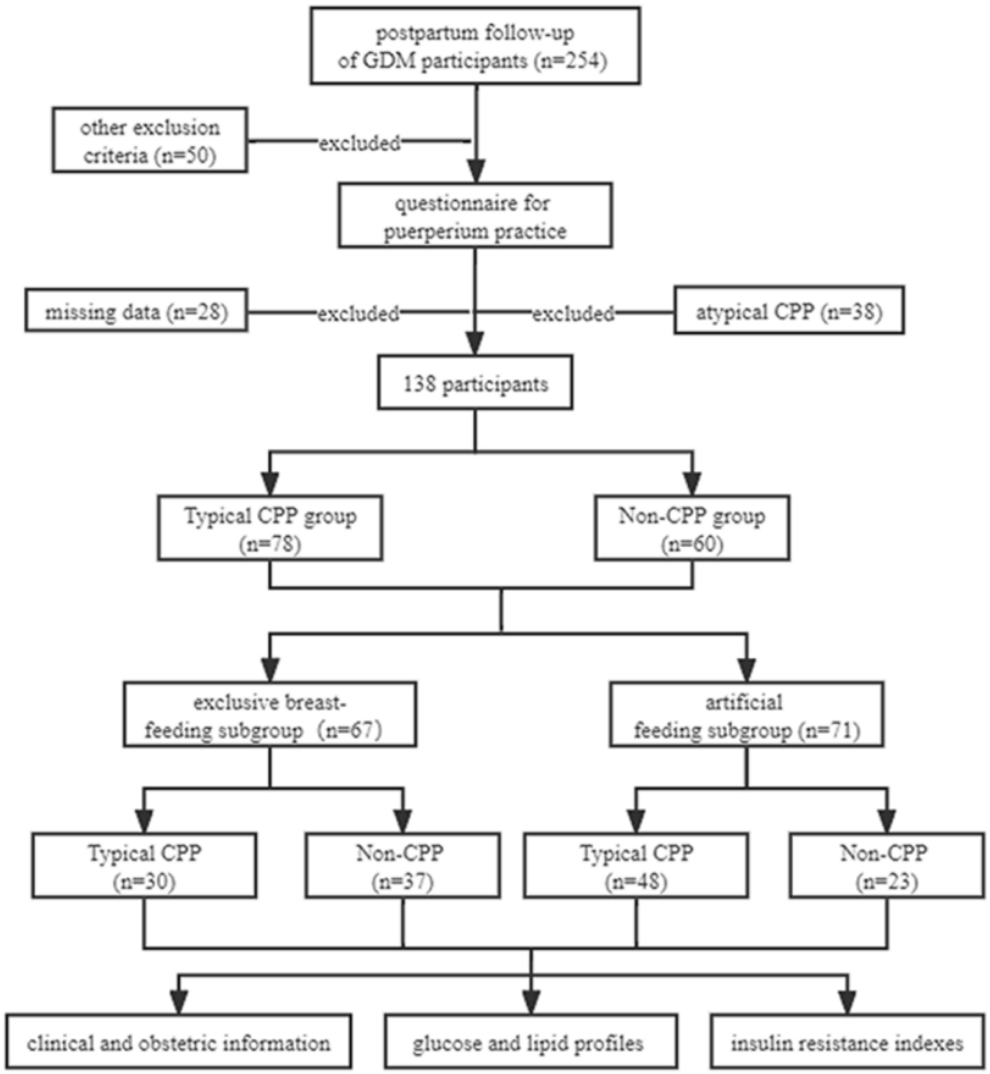

Figure 1. Flow diagram of participants enrolled and followed through the study.

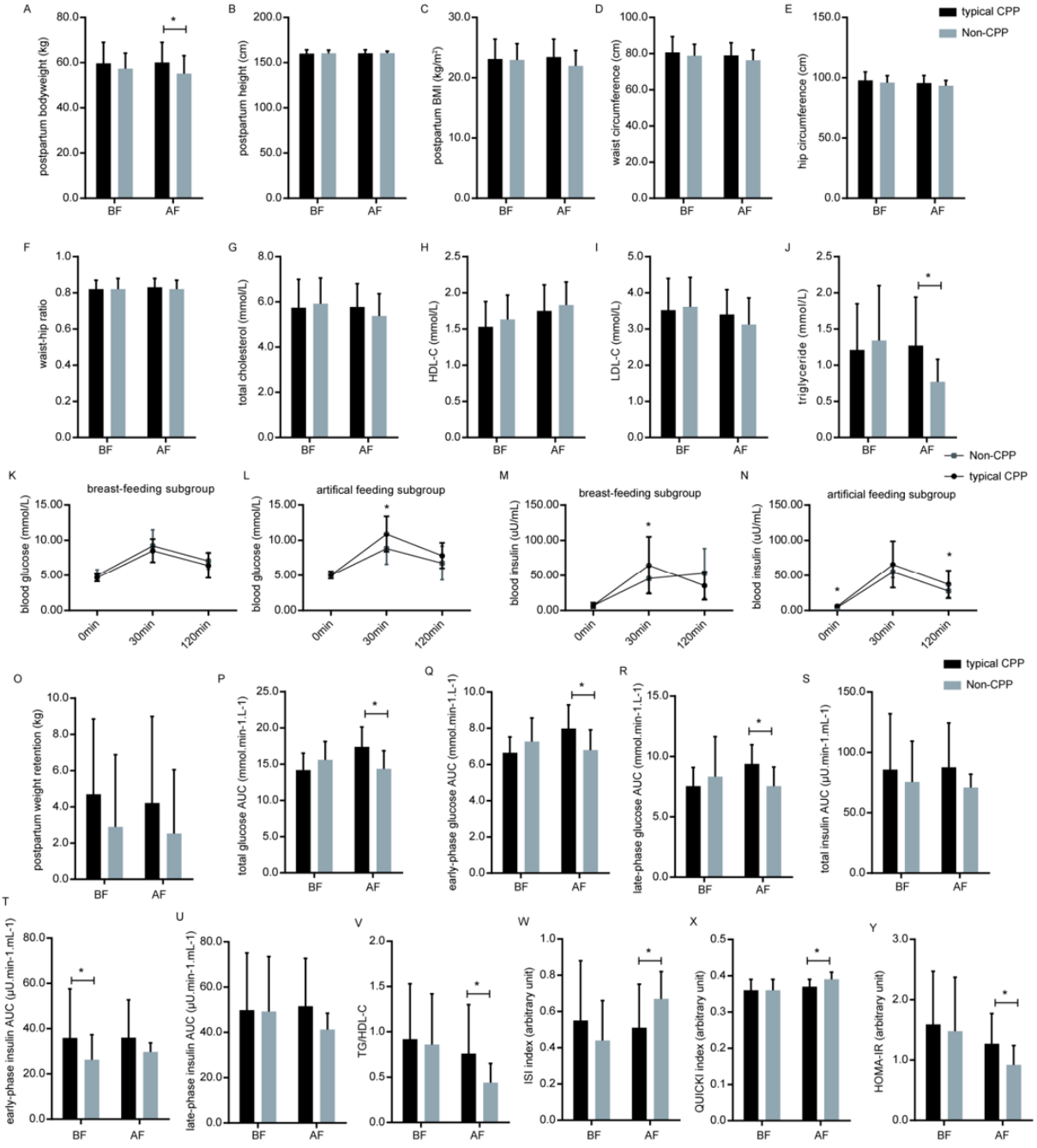

Figure 2. Postpartum anthropometry and metabolic indicators by feeding mode. Postpartum bodyweight (A), height (B), BMI (C), waist (D) and hip (E) circumference, waist-hip ratio (F), serum total cholesterol (G), HDL-C (H), LDL-C (I) and triglyceride (J) in the indicated group. K-N: Blood glucose and insulin over time after OGTT in the indicated group. Postpartum weight retention (O), OGTT glycemic (P-R) and insulin responses (S-U), and insulin resistance indexes (V-Y) in the indicated group. $^{*}p<0.05$ compared with the typical CPP group. BF: exclusive breast-feeding subgroup; AF: artificial feeding subgroup.