Prevalence of Metabolic Syndrome Markers among Women at 1-year Postpartum as per Prepregnancy Body Mass Index Status: A Longitudinal Study

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Abstract

Introduction: Maternal body composition (BC) changes during lactation. Increased prepregnancy obesity is associated with poor obstetric outcomes. The aim was to study changes in maternal BC postpartum (PP) to 1-year PP with reference to their prepregnancy body mass index (BMI) status. **Methods:** The study design was a 1-year follow-up study. Sixty-five apparently healthy primiparous women (28.6 ± 3.4 years delivered full-term infants) were randomly selected from December 2010 to June 2013 and postclassified on the basis of their prepregnancy BMI status. Anthropometry, sociodemographic status, physical activity, diet, clinical examination, biochemical tests, and BC at total body (dual energy X-ray absorptiometry, GE, Lunar DPX) were collected using standardized protocols. **Results:** Forty-one women were classified in Group A with normal prepregnancy BMI (20.4 ± 2.0 kg/m²) and 24 women in Group B with overweight/obese (OW/OB) prepregnancy BMI (26.1 ± 1.9 kg/m²). At 1 year, 75% of women returned to normal BMI in Group A, whereas all 100% of women from Group B remained in OW category at 1-year PP. Nearly 43% of Group B women showed the presence of at least two metabolic syndrome risk factors as compared to 36% in Group A at 1 year. **Conclusion:** Women with OW/OB prepregnancy BMI accumulated higher visceral fat with a higher prevalence of metabolic risk factors at 1-year PP. Our study underlines the importance of maintaining BMI status in reference range in reproductive years.

Keywords: Android fat, body composition, dual energy X-ray absorptiometry, insulin resistance

INTRODUCTION

Reports indicate that prevalence of obesity is increasing among women of reproductive age. As per the National Family Health Survey data, 23% of women from India are either overweight or obese (OW/OB).[1,2] Major weight gain in women has been reported during pregnancy and lactation.[3] With the alarming rate of obesity in women of the reproductive, the incidence of obesity is reported to be between 18.5% and 38.3% among Western pregnant women.[4]

Based on recommendations by the Institute of Medicine, the Asian guidelines suggested by Ee *et al*. for optimal weight gain during pregnancy for women with body mass index (BMI) within normal range is around 14 kg; for OW women, it is 8 kg; and for OB women, it is 2 kg.[5] Previous studies indicate that increased prepregnancy BMI, that is, OW/OB before conception is associated with risk of poor obstetric outcomes and complications for both mother and infant such as preeclampsia, gestational diabetes, preterm delivery, stillbirth, large for gestational age infants, caesarean section,[6] and excess postpartum (PP) weight retention.

Changes in body composition (BC) using different methods during PP period have been reported by several studies.[7-9] Increase in weight and visceral fat has been reported in our earlier cross-sectional study. This increase in PP weight retention is further linked to cardiometabolic risk development in Indian women.[10]

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About 13% of urban Indian women have been reported to have markers of metabolic syndrome (MS) in a study by Sawant *et al*.[11] MS is further associated with the development of cardiovascular disease and type II diabetes**.**

However, there is a paucity of data in the urban Indian context with respect to prepregnancy weight status of women, their BC PP, and the risk of MS. Therefore, the objectives of this longitudinal study were to:

- Study changes in BC in primiparous Indian women from after delivery to 1-year PP with reference to their prepregnancy BMI status
- Study prevalence of markers of MS at 6 months and 1 year among these women.

Methods

Study participants

Selection of study participants

Participant recruitment was performed during the study period of December 2010 to June 2013. These women were admitted for full-term delivery at a tertiary level health-care center with catchment area of a population residing in affluent areas of Pune, Western India. Monthly per capita income of the women was determined (14,551 ± 8344 Indian rupees) to class them as middle socioeconomic class as per Kuppuswamy scale.[12] One hundred and sixty apparently healthy women were selected randomly for the study. Out of them, 65 women (mean age [±standard deviation] 28.1 ± 3.2 years) participated in this longitudinal study. The inclusion criteria were primigravid, full-term, noncomplicated pregnancy and mothers without any preexisting disease conditions (including hypertension and gestational diabetes and mothers of twins/intrauterine growth restriction infants/small for gestational age infants). Ethical approval was obtained from the Institutional Ethics Committee. Written and signed informed consent was obtained from all study participants. All the parameters were measured at three time points, that is, within a week postdelivery (mean 3.0 ± 1.1 days postdelivery), at 6-month PP, and at 1-year PP.

Data collection

Participant mothers' standing height was measured using calibrated stadiometer (Leicester Height Meter, UK, range 60–207 cm) to the accuracy of 1 mm. Weight was measured using weighing scale to the nearest 0.1 kg, and waist circumferences were recorded using a nonstretchable tape to the nearest 1 mm.[13] Prepregnancy weight of mothers was obtained from their prenatal medical record maintained by the hospital records section. BMI was computed using the formula - weight in kilogram/height in square meter. Further, the cohort was classified into two groups based on pregravid BMI. Group A included mothers whose prepregnancy BMI was within the reference range (BMI <23.5 kg/m^2) for Asians.[14] Group B included OW/OB prepregnant women (BMI >23.6 kg/m^2). Trained physicians performed the clinical health assessment,

and blood pressure (BP) was recorded in sitting position using sphygmomanometer at every visit after a 5 min rest.

Body composition

Lunar DPX-PRO total body pencil beam densitometer (GE Healthcare, WI, USA) was used for measuring BC at all three time points, that is, immediately PP, 6-month PP, and 1-year PP for total body using a medium mode scan (software Encore 2005 version 9.30.044, GE Healthcare, Wisconsin, USA). The precision of the Lunar DPX for repeat measurements in adults is 1.1% for total body.[15] Measurements were standardized by running daily quality assurance scans. All scans and scan analyses were performed by the same operator.

MS is a cluster of conditions including central adiposity, dyslipidemia, high BP, and hyperglycemia.[16] When,

- Abdominal obesity (waist circumference >80 cm in women)
- Hypertriglyceridemia (>150 mg/dl)
- Low level of high-density lipoprotein (HDL) cholesterol (<40 mg/dl)
- High BP (>130/85 mmHg)
- Elevated fasting blood glucose (>110 mg/dl).

As per definition, participant with the presence of any of the above three or more parameters was considered to have MS.

Biochemical parameters

After an overnight fast (of minimum 10 h), venous blood sample (total 8 ml) was collected from each participant at all three time points, that is, immediate PP, 6-month PP, and 1-year PP using plain mineral free vacutainers (BD Franklin Lakes, NJ, USA). Samples in plain vacutainers were immediately centrifuged at 2500 rpm for 15 min, and the serum separated and frozen at −80°C until analysis. Lipid profile was estimated on a Siemens analyzer (Dade Dimension RXL Max) with enzymatic procedures for measurement of total cholesterol, triglycerides (TGs), and HDLs. The LDL cholesterol concentrations were calculated using the Friedewald equation.[17] Blood sugar level was estimated immediately from plasma using Siemens analyzer (Dade Dimension RXL Max). Serum insulin was estimated using ELISA technique by standard protocols using DRG kits. Homeostatic model assessment-insulin resistance (HOMA-IR) was calculated using formula – fasting insulin (mIU/L) × fasting glucose (mg/dl)/405.[18]

Physical activity

Daily physical activity was recorded at every visit using validated and structured questionnaires. Daily activity was classified as inactivity, light activity, and moderate activity.[19]

Dietary intakes

These were assessed by 24 h diet recall on 3 nonconsecutive weekdays including one weekend. These recalls were administered at every visit to the participants by a trained investigator through face-to-face interview. Macronutrient intakes were calculated using C Diet software (Xenios technology, Pune, Maharashtra, India).[20]

Sample size estimation

Based on standard deviation of BMI from previous studies,[21] sample size was estimated to be sixty pairs of women PP to detect the differences at two-sided 5% level of significance and 8% margin of error so as to achieve a power of the study to be at 80%.

Statistical analysis

Data were analyzed using SPSS software for Windows (version 16.0, SPSS Inc., Chicago, IL, USA). Normality of all the variables was tested before analysis. Nonnormally distributed variables are reported as median (interquartile range). Differences in means of all the groups for parameters such as anthropometric, biochemical, and BC parameters, and nutrient intakes were analyzed with paired *t*-test at baseline (BL) (that is immediately PP) and 6-month PP among each group separately and using repeated measure ANOVA for three time points (BL, 6-month, and 1-year PP). Level of significance was set at $P < 0.05$.

RESULTS

Based on pregravid BMI status, 41 women were classified in Group A with normal prepregnancy mean BMI (mean 20.4 ± 2.0 kg/m^2) and 24 women in Group B with OW/OB prepregnancy BMI (mean BMI = 26.1 ± 1.9 kg/m^2). Mean age (27.4 ± 3.3 and 28.0 ± 2.9, respectively), height (157.7 ± 4.6 and 155.9 ± 5.9, respectively), and BPs (systolic BP [SBP] = 116 ± 7.8, diastolic BP [DBP] = 75 ± 5 and SBP = 114 ± 5.0, DBP = 75 ± 5, respectively) of both the groups were similar ($P > 0.1$) immediately postdelivery. Weight gain during pregnancy was similar in both the groups (14.8 ± 5.1 vs. 14.1 ± 4.5 kg, respectively, $P > 0.1$) [Diagram 1].

Forty-one women of Group A and 24 women from Group B were followed for 6 months. Table 1 describes changes in both

the groups at 6 months as compared to BL (i.e., immediate PP period). There was a significant reduction in waist circumference, weight, and BMI ($P < 0.0001$) in either Group (A and B).

Android fat (%) increased significantly among both the groups. However, gynoid fat (%) reduced significantly ($P < 0.0001$)
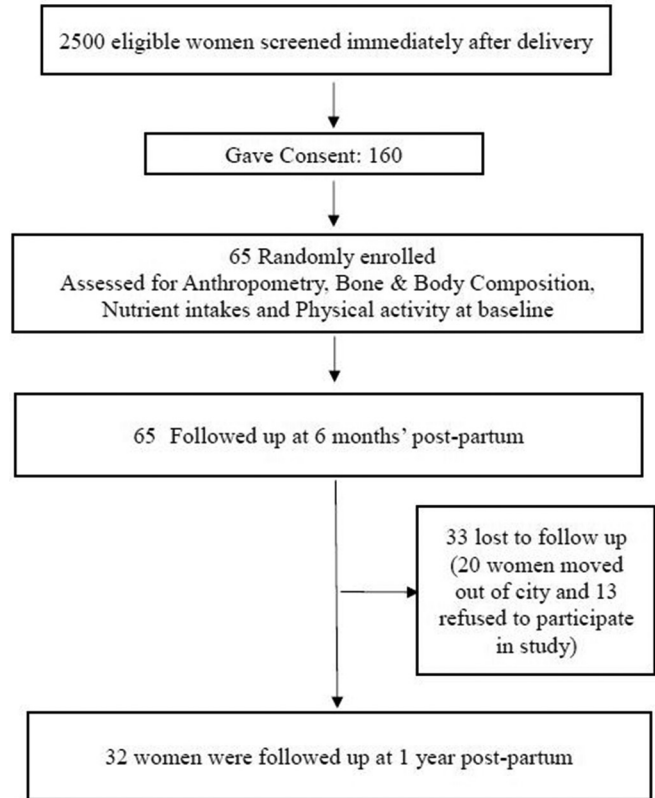

Diagram 1: Patient consort diagram during study

Table 1: Changes in anthropometric and biochemical measurements at baseline (immediately postpartum) and 6 months, among normal weight versus overweight/obese women

Parameter	Group A (BL)	Group A (6 months)	P	Group B (BL)	Group B (6 months)	P
n	41	41		24	24	
Waist (cm)	95.2±8.0	88.0±5.4*	0.0001	103.7±7.1	94.8±6.0*	0.0001
Weight (kg)	59.3±7.6	55.1±6.8*	0.0001	72±8.8	67.4±10.6*	0.0001
BMI (kg/m^2)	23.9±2.8	22.2±2.7*	0.0001	29.3±1.9	27.4±2.8*	0.0001
Android fat (%)	42.1±6.3	46.1±6.6*	0.0001	47.5±3.8	53.0±4.7*	0.0001
Gynoid fat (%)	51.9±3.6	49.8±4.1*	0.0001	55.3±3.8	55.1±5.5	0.771
Total fat (%)	41.2±4.5	41.1±4.7	0.403	46.9±3.4	48.1±5.1¹	0.071
TC (mg/dL)	221±41	175±33*	0.001	214±32	176±22*	0.001
HDL cholesterol (mg/dL)	52±14	49±10	0.305	55±15	49±12¹	0.082
LDL cholesterol (mg/dL)	130±36	106±32*	0.002	121±25	103±26*	0.006
TC-HDL ratio	4.5±1.2	3.7±0.9	0.528	4.1±1.0	3.7±0.9¹	0.057
LDL-HDL ratio	2.6±1.0	2.3±0.8	0.588	2.4±0.8	2.3±0.7	0.103
TG (mg/dL)	196±79	80±33*	0.001	190±65	95±44*	0.001
Serum fasting insulin (IU/L)	6.8±4.9	11±10¹	0.069	8.9±6.8	13.7±6.9*	0.07
HOMA-IR	1.2±0.8	2.1±1.8*	0.035	1.8±1.8	3.0±1.6*	0.08

*Significantly different from other groups (*P*<0.05), ¹Marginally significant from other groups (*P*<0.1). BMI: Body mass index, LDL: Low-density lipoprotein, HDL: High-density lipoprotein, TC: Total cholesterol, HOMA-IR: Homeostatic model assessment-insulin resistance, TG: Triglycerides, BL: Baseline

in Group A, whereas Group B showed no change in gynoid fat (%) (*P* = 0.771). Further, at 6-month PP, total fat showed no change in Group A, whereas increased slightly among Group B women (*P* < 0.1).

In the biochemical parameters, lipid profile parameters (LDL, TGs, and total cholesterol) reduced at 6 months in both the groups (*P* < 0.05) except HDL cholesterol, whereas serum insulin and insulin resistance increased a little although not significantly in both groups at the end of 6 months as compared to BL state (*P* < 0.1).

Duration of sleep reduced significantly in both Groups (A and B) at 6 months (*P* < 0.01) as shown in Table 2. Similarly, inactivity reduced and level of light activity increased significantly in both groups (*P* < 0.01). Energy intakes reduced significantly in Group B (*P* < 0.05) from BL to 6-month PP. However, Group A consumed similar energy at BL and 6-month PP.

Dietary protein intakes were similar in both groups at BL and 6 months (*P* > 0.1). Although 93% and 90% of women were below recommended dietary allowance (RDA) in both groups at BL and 6 months, respectively. Although carbohydrate intakes in both groups were similar at BL and 6 months, ratio of CHO: protein: fat was not balanced as per RDA requirements. At BL, both groups consumed 300% higher dietary fat than the RDA.[22] Daily consumption of dietary fat reduced at 6 months in both the groups. Even so, 100% of women at BL and 97% of women at 6 months were above RDA from both groups. Thus, both groups were similar in activity and energy intakes at 6-month PP.

Table 3 shows changes in anthropometric and BC measurements from BL to 1 year in the two groups. We could follow up 23 women from Group A up to 1-year PP, whereas 9 women agreed to come for a follow-up at 1 year from Group B. Waist

Table 2: Physical activity and nutrient intakes at baseline and 6 months in normal versus overweight/obese women

Parameter	Group A (BL)	Group A (6 months)	P	Group B (BL)	Group B (6 months)	P
Sleep (min/day)*	480 (420,540)	420 (360,480)	0.004	480 (420,540)	420 (360,443)	0.002
Inactivity (min/day)*	833 (780,901)	120 (60,420)	0.0001	840 (700,900)	120 (30,240)	0.0001
Light activity (min/day)*	120 (110,150)	810 (608,915)	0.0001	120 (90,191)	885 (701,960)	0.0001
Energy intake (kcal/day)	2405±550	2270±508	0.283	2366±385	2125±372	0.036
CHOs (g/day)	353±78	365±88	0.557	351±68	341±66	0.605
Protein (g/day)	56±14	58±15	0.492	55±12	53±11	0.490
Fat (g/day)	90±29	63±16	0.0001	87±25	60±17	0.0001
Percentage CHO	59±5.7	65±5.2	0.0001	59±6.7	64±5.6	0.021
Percentage protein	9.3±1.6	10.1±1.0	0.001	9.4±1.4	10.1±1.0	0.06
Percentage fat	33±6.2	25±4.4	0.0001	33±7.2	25±5.5	0.0001

*Non normally distributed variables. (Values expressed as Median (IQR), *P* value/significance expressed using non parametric - Wilcoxon signed -rank test). For normally distributed variables values are expressed as mean±SD. CHOs: Carbohydrate intakes, BL: Baseline, IQR: Interquartile range, SD: Standard deviation

Table 3: Changes in anthropometric and body composition measurements at baseline, 6 months, and 1 year in normal versus overweight/obese women

Parameter (time point)	Group A			Group B		
	BL	6 months	1 year	BL	6 months	1 year
n	23	23	23	9	9	9
Waist (cm)	98±6	90±5[a]	91±5[a]	106±7	94±6[a]	96±9
Weight (kg)	61±6	57±6[a]	57±6[a]	69±5	63±4	63±4
BMI (kg/m²)	24±2	22±3[a]	22±3[a]	29±2	27±2	27±2
Prevalence of OW or OB (% women)	54.5	23	25	100	100	100
Android fat (%)	43±7	47±7[a]	45±8[b]	47±4	52±5[a]	52±5[a]
Gynoid fat (%)	52±4	50±5[a]	49±5[a]	54±4	54±6	54±7
Total fat (%)	41±5	42±5	39±6[a,b]	45±3	46±5	46±6
TC (mg/dL)	219±42	172±35[a]	168±27[a]	203±39	167±28	171±26
HDL cholesterol (mg/dL)	52±12	49±11	45±8[a]	51±20	51±15	47±13
LDL cholesterol (mg/dL)	130±39	107±30[a]	104±23[a]	115±26	99±19	105±21
LDL-HDL ratio	2.6±0.9	2.4±0.7	2.4±0.5	2.6±1.1	2.0±0.5	2.4±0.6
TC-HDL ratio	4.5±1.0	3.8±0.9	3.9±0.7	4.4±1.3	3.4±0.8	3.8±0.9
TG (mg/dL)	190±77	78±35[a]	94±46[a,b]	189±53	84±50[a]	97±62[a]
Serum fasting insulin (IU/L)	7.2±5.3	8.2±5.7	6.7±3.0	12.1±9.3	10.6±5.4	11.2±5.8
HOMA-IR	1.3±0.9	1.7±1.3	1.4±0.7	2.7±2.7	2.4±1.3	2.5±1.4

[a]Significantly different from Group A, [b]Significantly different from Group B. Level of significance *P*<0.05. BMI: Body mass index, LDL: Low-density lipoprotein, HDL: High-density lipoprotein, TC: Total cholesterol, HOMA-IR: Homeostatic model assessment-insulin resistance, OW: Overweight, OB: Obese, BL: Baseline, TGs: Triglycerides

circumference reduced significantly at 6 months in Group A and then remained at same level till 1 year, whereas in the Group B women, waist circumference reduced significantly than at BL and 6 months ($P < 0.05$). At the end of 1 year, 75% of women returned to normal BMI in Group A, whereas all 100% of women from Group B remained in OW category at 1-year PP.

BC also changed at 1-year PP as compared to BL values. Group A women increased android fat at 6 months significantly ($P < 0.05$), further at 1-year, android fat decreased significantly than at 6 months ($P < 0.05$), whereas Group B women showed an increase in android fat, which remained the same till 1-year PP. Gynoid fat decreased among Group A at the end of 1 year, and in Group B, it remained unchanged.

Lipid profile and serum fasting insulin concentrations showed a steady decrease in both groups from BL to 1-year PP as shown in Table 3. Mean values of HOMA-IR in both groups were similar at three time points.

Figure 1 shows percent change in anthropometric measurements at 6-month and 1-year PP in both groups. At 6 months, weight, waist, and BMI decreased in both groups. However, at 1 year, BMI showed a significant increase in Group B women ($P < 0.05$).

Figure 2 demonstrates the prevalence of women with HOMA-IR above two in both groups. Group B women had a higher prevalence of HOMA-IR at BL, 6-month, and 1-year PP. Above 55% of women from Group B had HOMA-IR above two at 6-month and 1-year PP.

Figure 3 illustrates the prevalence of MS parameters in both groups. As per definition, the presence of any three MS factors is an indicator of MS in a person.[23] Since at BL, women have increased girth, we considered the prevalence at 6-month and 1-year PP. At 6 months, 4% of Group B women showed three and above MS risk factors as compared to none in Group A, whereas 43% of Group B women showed the presence of at least two MS risk factors as compared to 36% in Group A at 1 year.

Discussion

In our longitudinal study on urban lactating mothers, in spite of gaining similar weight during gestation by women from both groups, waist circumference decreased initially at 6 months in Group A women and then remained unchanged till 1 year, whereas there was slight increase in waist circumference at 1 year as compared to 6 months in Group B. At the end of 1 year, 75% of women returned to normal BMI in Group A, whereas all 100% women from Group B remained in OW category at 1-year PP. These OW Group B women showed an increase in android fat, which remained constant at 1-year PP. Above 55% of women from Group B developed insulin resistance and 43% of Group B women showed the presence of at least two MS risk factors at 1-year PP. Thus, our study demonstrates that urban, middle class women who were OW/
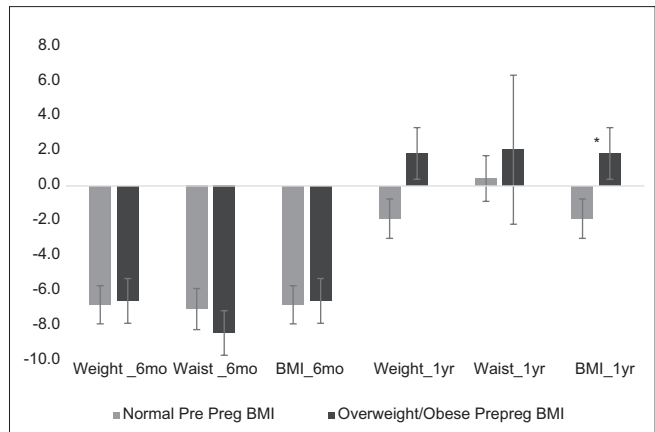

Figure 1: Percent change in anthropometric measurements from baseline to 6-month and 1-year PP in normal versus overweight/obese groups. *Level of significance $P < 0.05$
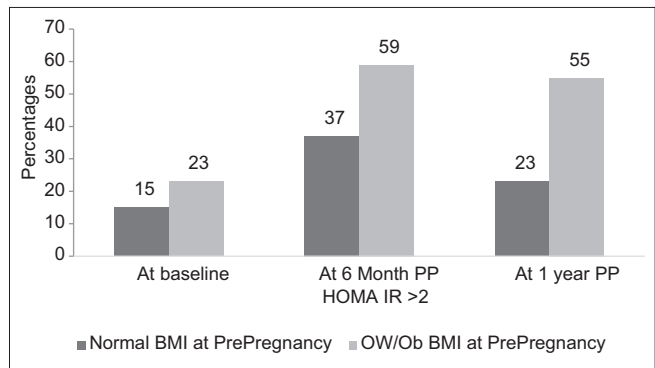

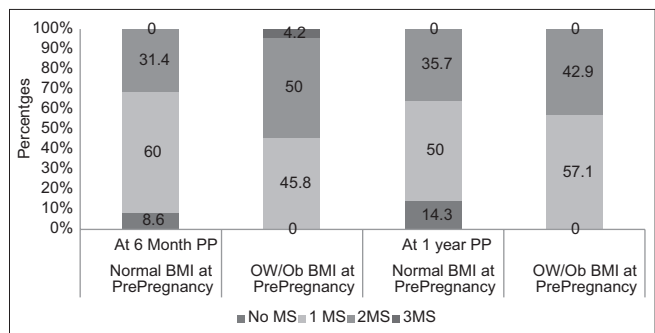**Figure 2:** Percentage of women with homeostatic model assessment-insulin resistance above 2

Figure 3: Prevalence of metabolic syndrome among prepregnant body mass index categories

OB in the prepregnancy period and who consumed high amount of fat and were relatively inactive during post-partum period, were still OW/ OB at one year post-partum, had increased central obesity, insulin resistance and risk factors for MS.

In our study, we found that women who were OW/OB in the prepregnancy period remained the same after 1-year PP. A higher postpartum weight retention (PPWR) has been linked to cardiometabolic risk factors as reported in our previous cross-sectional studies.[10] Gunderson has also identified

maternal OW/OB in the prepregnancy period, followed by excessive gestational weight gain as independent risk factors for PPWR.[24] However, Ohlin and Rössner have reported no association between pregravid weight and PPWR due to lifestyle changes and changes in eating pattern during PP period.[25]

Women in our study had increased android fat and total body fat at 1-year PP; this was more pronounced in women who were OW/OB in the prepregnancy period. Cho *et al.*, using bioelectric impedance, have reported that the PP period is associated with increased visceral fat.[7] Cheng has also reported 12% increase in waist circumference at the end of 6-month PP as compared to the prepregnancy period among primiparous women.[26] We did not have records for the prepregnancy waist circumference for our study participants; however, after an initial decrease in waist circumference by about 8% at 6-month PP, waist circumference again increased in these OW women at 1-year PP.

Improvement in lipid profile was observed in our study despite high dietary fat intakes (300% of RDA) as these mothers were breastfeeding for more than 6 months and beneficial effects of breastfeeding practices have been documented in earlier studies.[27] Our study shows that HOMA-IR (IR) was increased or higher in Group B women. Fifty-five percent of OW/OB women had increased HOMA-IR (>2) at the end of 1 year. OW during the pregravid state has also been shown to be an independent risk factor for the development of gestational diabetes and childhood obesity.[28,29]

One of our major limitations was the dropout rate at the end of 1 year. This was chiefly because primiparous Indian women usually return to their own homes by 1 year (most of them are with their mothers in the PP period) and hence were difficult to reach. Further, we could not report on the prevalence of hypertension or raised blood sugar concentrations as these were part of our exclusion criteria. Nevertheless, we have, to the best of our knowledge, reported for the first time, longitudinal changes in BC parameters and metabolic risk factors in urban middle-class PP Indian women with reference to the prepregnancy BMI.

Conclusions

In spite of similar gestational weight gain during pregnancy, similar physical activity, and nutrient intakes, at 1-year PP, women who were OW/OB in the prepregnancy period accumulated more visceral fat and remained OW/OB as compared to prepregnant women with normal weight. These OW women also showed a higher prevalence of metabolic risk factors. The findings of our study underline the importance of normal BMI status before entering motherhood.

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Conflicts of interest

There are no conflicts of interest.

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