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Original Research Article

Maternal BMI during Pregnancy: Effect on trace elements Status and Pregnancy Outcomes

Emmanuel I Ugwuja[1*]

Emmanuel I Akubugwo[2]

Onyechi Obidoa[3]

Ama U Ibiam[4]

[1]Department of Chemical Pathology, Faculty of Clinical Medicine, Ebonyi State University, P.M.B. 053 Abakaliki, Nigeria

[2]Department of Biochemistry, Abia State University, Uturu, Nigeria
[3]Department of Biochemistry, University of Nigeria, Nsukka

[4]Department of Biochemistry, Faculty of Biological Sciences, Ebonyi State University, Abakaliki

***For correspondence:**

Email: ugwuja@yahoo.com.

Tel: +2347035122010

Abstract

Purpose: To investigate the effects of maternal prenatal body mass index (BMI) on trace elements (copper, iron and zinc) status, haematological parameters and pregnancy outcomes among pregnant women in Abakaliki, south-eastern Nigeria.
Methods: Plasma levels of copper, iron and zinc of 349 pregnant women (gestational age ≤ 25 weeks; mean = 21.77±3.14 wks; aged = 15-45 years, mean = 27.04±4.75 yr) were analysed using flame atomic absorption spectrophotometer while haematological and biochemical parameters were determined using standard laboratory techniques.
Results: Four women (1.1%) were underweight, 40.7% had normal BMI, 35.5% were overweight, 17.2% were obese and 5.4% were morbidly obese. Maternal BMI was significantly positively related to age, parity and socioeconomic status. While a negative relationship was found between plasma copper and maternal BMI, significantly ($p < 0.05$) lower zinc levels were found in underweight and obese women when compared to women with normal BMI. Maternal anaemia was significantly lower in overweight/obese women. Also maternal BMI was related to one adverse pregnancy outcomes.
Conclusion: Both high and low prenatal BMI are associated with alterations in trace element status, haemoglobin concentrations and adverse pregnancy outcomes. In the face of concurrent deficiencies of micronutrient in this population, as in most developing countries, it appears that maintenance of appropriate weight and food diversification/fortification during pregnancy would be alternative ways of mitigating the consequences associated abnormal prenatal weight.

Keywords: Prenatal weight, Plasma Copper, Iron and zinc, Anaemia, Maternal morbidities, Foetal outcomes

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Introduction

Body mass index (BMI) is considered a measure of body composition/nutritional status [1] and in women, low pre-pregnancy BMI has been considered as a marker of minimal tissue nutrient reserve [2]. The impact of maternal pregnancy weight and weight gain during pregnancy on pregnancy outcomes has been reported. For example, weight gain in excess of 12 kg and between 6-11 kg for underweight and overweight women, respectively, has been associated with best pregnancy outcomes [3]. Also the risk of spontaneous preterm delivery has been found to be associated with a low 2nd and 3rd trimester weight gain (BMI < 19.5 kg/m^2).

It has been reported that obesity carries significant risks for the mother and foetus with the risk increasing with the degree of obesity and persists after accounting for other confounding demographic factors [4]. Maternal obesity has been associated with increased risk of structural anomalies [5-7], caesarean delivery [8] pre-term delivery, particularly if women were underweight or of average weight before of pregnancy [2]. While low maternal BMI is associated with pre-term delivery and low birth weight, especially if weight gain during pregnancy is inadequate [2], low pre-pregnancy BMI alone has been independently implicated as a risk factor for pre-term delivery. However, in women with low BMI, the overall outcome is favourable and several adverse outcomes are less common [9].

Similar association between low pre-pregnancy BMI and risk of pre-term delivery had been reported in Canada [10] and among Hispanic women in the United States of America [11] with trend towards a decreased risk of preterm birth with high BMI. On the contrary, in a survey of mothers aged 15-49 years in 36 developing countries for the purpose of defining reference BMI, Nestel and Rutstein [12] found that except for miscarriage and still birth, women with low BMI had worse neonatal and infant outcomes. Women with a low BMI were found to be more likely to have an infant that was smaller or of lower birth weight than infants born to mothers with either normal or high BMI. Also, several risk factors for IUGR have been associated with BMI [13-15].

Although evidence abound of women being pregnancy in economically backward settings of developing countries with lower BMI than their counterparts in industrialised countries, data is lacking on the possible effect of BMI on pregnancy outcomes. Thus the present study was undertaken to investigate the effect of maternal prenatal BMI on micronutrients (copper, iron and zinc) status, haematological parameters and pregnancy outcomes among pregnant women in Abakaliki, south-eastern Nigeria.

Methods

This study was conducted at the Department of Obstetrics and Gynaecology of the Federal Medical Centre, Abakaliki, Ebonyi State. The Ethics and Research Committee of the institution approved the protocol. The study population comprised 349 pregnant women attending antenatal clinic at the medical centre. After obtaining their consents, structured questionnaire was administered to each participant to obtain their sociodemographic data such as age, parity, occupation, literacy level, living accommodation, and last menstrual period. Thereafter, maternal anthropometric data (weight and height) were determined and their BMI (kg/m^2) values were calculated.

The women were recruited at gestational age ≤ 25 weeks and were followed up till delivery. At every follow-up, participants were evaluated by the attending obstetricians for concomitant illness such as diabetes (fasting plasma glucose > 7.8 mmol/l), and hypertension (blood pressure > 140/90 mmHg) and anaemia (Hb < 11.0 g/dl). At delivery, baby's birth outcomes such as weight (kg), length and head circumference (cm) as well as still birth, mode of delivery, and gestation age were recorded. Birth weight was determined using electronic weighing balance and recorded to the nearest 0.05 kg with the scale checked periodically throughout the study for accuracy while birth length and head circumference was determined by a measuring tape to the nearest 0.1 cm. Baby was considered underweight if the birth weight was ≤ 2.5 kg, pre-term if delivered at ≤ 37 weeks and post-term if delivered at > 42 weeks. The women were grouped into five BMI categories in accordance with Abram [16] and reported by Bhattacharya *et al* [17] as follows:

Categories	BMI (Kg/m^2) values
Underweight	≤ 19.9
Normal	20-24.9
Overweight	25-29.9
Obese	30-34.9
Morbidly obese	> 35.0

Five millilitres (5 ml) of venous blood was collected aseptically between 08.00-10.00 hr and dispensed into trace element-free heparinised bottles (3.0 ml) and EDTA bottles (2.0 ml). The plasma was isolated by centrifuging the heparinised blood at 2000 *g* for 5 min and frozen until analysis.

Sample analysis

Plasma copper, iron and zinc were determined by flame atomic absorption spectrophotometer. Blood haematocrit (HCT) was determined by microhaematocrit capillary tube method described previously [18], haemoglobin concentration (HBC) was determined by Cyanmethaemoglobin technique described previously [18] while white blood cell count was analysed using standard haematology procedure. Plasma total protein and albumin were determined by colorimetric Biuret [19], and bromocresol green [20] methods as described previously.

Data analysis

The data collected were analysed using Statistical Package for Social Science (SPSS version 10) using descriptive statistics (mean and standard deviation). One way ANOVA was used to test for differences between means and at 95% confidence interval p values ≤ 0.05 were considered significant.

Results

The sociodemographic characteristics of the subjects are provided in Table 1. Of the 349 women that completed the study, 4 (1.1%) were underweight, 143 (40.7%) had normal BMI, 124 (35.5%) were overweight, 60 (17.2%) were obese and 19 (5.4%) were morbidly obese. More women with higher BMI were from high socioeconomic class as indicated by their educational status, living accommodation and employment status. This is more remarkable in the groups that were obese and morbidly obese. Although the underweight had low numerical value, 75% of them were unemployed. While majority of the nulliparous and primiparous women were underweight, few were in the abnormally high BMI groups. However, significantly higher proportions of the overweight, obese and morbidly obese women were multiparous. The underweight women were significantly ($p < 0.05$) younger (mean age, 24.0 ± 5.0) than obese women while women in the overweight, obese and morbidly obese categories were significantly older (mean ages, 28.3±4.7, 28.3 ± 4.6 and 29.2±5.0 yr, respectively) than women with normal BMI (Table 2). However, the obese and the overweight women had comparable mean ages.

Maternal plasma iron and haematological parameters were significantly ($p < 0.05$) higher in overweight and obese women and significantly lower in underweight women when compared to women with normal BMI (Table 2). However, plasma total protein and albumin while comparable between the overweight and obese women, underweight women had significantly ($p < 0.05$) lower levels of both plasma total protein and albumin in comparison with the normal weight women. Again, while plasma copper was significantly higher in underweight, overweight, and morbidly obese women when compared with women with normal BMI, obese women had significantly lower ($p < 0.05$) copper level (8.13±7.38 µmol/l) than the normal weight women (9.58±10.52 µmol/l). Also, while significantly lower levels of plasma zinc were found in underweight, overweight, obese and

Table 1: Maternal sociodemographic characteristics in relation to their BMI groups (percentage in parenthesis)

Characteristics	Underweight (n = 4)	Normal (n = 143)	Overweight (n = 124)	Obese (n = 60)	Morbidly obese (n = 19)
Educational level					
None	1 (25)	4 (2.8)	2 (1.7)	1 (1.7)	-
Primary	-	20 (14.1)	15 (12.6)	7 (11.7)	-
Secondary	1 (25)*	75 (52.8)	65 (54.6)	24 (40*)	8 (44.4)*
Tertiary	2 (50)	43 (30.3)	37 (31.1)	28 (46.7)	10 (55.6)
Occupation					
Unemployed	3 (75)*	50 (35.0)	38 (30.6)	17 (28.3)	6 (31.6)
Civil servant	1 (25)	52 (36.4)	58 (46.8)	27 (45)	6(31.6)
Artisan	-	37 (25.9)	27 (21.8)	18 (30)	7 (36.8)
Farming	-	4 (2.8)	1 (0.8)	-	-
Living accommodation					
Single room	1 (33.3)+*	84 (58.7)	69 (55.6)	28 (46.7)	7 (38.9)
Flat	2 (66.7)*	49 (34.3)	46 (37.1)	29 (48.3)	10 (55.6)
Bungalow	-	10 (7.0)	9 (7.3)	3 (5)	1 (5.6)
Parity					
0	2 (50)	78 (54.5)	44 (35.5)*	10 (16.7)*	6 (31.6)*
1	2 (50)*	25 (17.5)	24 (19.4)	12 (20)*	3 (15.8)
2	-	20 (14.0)	18 (14.5)	12 (20)*	4 (21.1)*
3	-	6 (4.2)	16 (12.9)*	16 (26.7)*	2 (10.5)*
> 3	-	14 (9.8)	12 (9.7)	10 (16.7)*	4 (21.1)*

* $p < 0.05$

Table 2: Maternal haematological and biochemical parameters in relation to maternal BMI

Maternal parameters	Maternal BMI groups				
	Underweight (n = 4)	Normal (n = 142)	Overweight (n = 124)	Obese (n = 60)	Morbidly obese (n = 19)
Age (yrs)	24.0 ± 5.0*	25.2 ± 4.2	28.3 ± 4.7*	28.3 ± 4.6*	29.2 ± 5.0*
Haematocrit (%)	27.75 ± 5.56*	29.54 ± 3.57	30.73 ± 4.35*	30.68 ± 3.92*	31.68 ± 2.68*
Haemoglobin (g/l)	9.28 ± 1.91*	9.94 ± 1.25	10.63 ± 2.35*	10.29 ± 1.39	10.62 ± 0.9*
WBC (x 10^{-9})	5.80 ± 0.93	5.73 ± 1.52	5.55 ± 1.40	5.59 ± 1.37	5.23 ± 1.50
Total protein (g/l)	5.20 ± 0.69	5.64 ± 0.85	5.52 ± 0.83	5.73 ± 0.84	5.65 ± 0.81
Albumin (g/l)	2.78 ± 0.93*	3.50 ± 0.77	3.38 ± 0.80	3.50 ± 0.82	3.49 ± 0.84
Copper (µmol/l)	10.98 ± 8.49*	9.58 ± 10.52	10.04 ± 9.08*	8.13 ± 7.38*	11.15 ± 9.05*
Zinc (µmol/l)	6.42 ± 3.87*	9.27 ± 9.95	9.26 ± 8.94	9.07 ± 8.80*	6.16 ± 6.80*
Iron (µmol/l)	10.14 ± 2.51	9.80 ± 7.27	11.01 ± 7.75*	9.68 ± 8.31	10.43 ± 9.18*

Values are expressed as Mean ± S.D; *$p < 0.05$

morbidly obese pregnant women had comparable values with the normal weight women.

Table 3 shows the distribution of labour events, maternal and foetal outcomes in relation with BMI groups. While maternal anaemia was comparable between the BMI groups except for morbidly obese group which had significantly lower prevalence of anaemia (42.1%), there was statistically significant difference in maternal DM, hypertension, instrumental delivery, C/S delivery, pre- and post-term delivery as well as infants' weight below 2.5 kg (low birth weight

Table 3: Distribution of labour events and perinatal outcomes in relation to maternal BMI

Characteristics	Underweight (n = 4)	Normal weight (n= 142)	Overweight (n = 124)	Obese (n = 60)	Morbidly obese (n = 19)
Instrumental delivery*	1 (25)	18 (12.7)	4 (3.2)	5 (8.3)	1 (5.3)
Caesarean section	-	5 (3.5)	7 (5.6)	3 (5.0)	2 (10.5)*
LBW delivery*	-	23 (16.2)	15 (12.1)	5 (8.3)	2 (10.5)
Still birth	-	5 (3.5)	5 (4.0)	1 (1.7)*	1 (5.3)*
Maternal anaemia	3 (75.0)	108 (76.1)	89 (71.8)	44 (73.3	8 (42.1)*
Preterm delivery (< 37wks)	-	13 (9.2)	7 (5.6)*	2 (3.3)*	-
Post term delivery (> 41 wks)	2 (50.0)*	6 (4.2)	11 (8.9)*	3 (5.0)	1 (5.3)
Maternal DM*	-	1 (0.7)	5 (4.0)	6 (10.0)	1 (5.3)
Maternal hypertension*	-	1 (0.7)	2 (1.6)	1 (1.7)	-

Values are expressed as number (%), $^{*}p < 0.05$

Table 4: Foetal anthropometrics in relation to maternal BMI among pregnant women in Abakaliki

Foetal parameters	Maternal BMI groups				
	Underweight (n = 4)	Normal (n = 142)	Overweight (n = 124)	Obese (n = 60)	Morbidly obese (n = 19)
Birth weight (kg)	2.93 ± 0.45	3.01 ± 0.37	3.08 ± 0.49	3.21 ± 0.49*	3.25 ± 0.75*
Birth length (cm)	50.25 ± 1.17	50.37 ± 3.64	50.37 ± 2.97	53.37 ± 8.26*	51.39 ± 3.22*
Head circumference (cm)	33.25 ± 3.59*	33.34 ± 2.33	33.33 ± 2.61	34.61 ± 3.25*	34.56 ± 2.81*

Values are expressed as Mean ± SD; $^{*}p < 0.05$.

delivery) between the normal and/or underweight or overweight/obese/morbidly obese women. For example, except for instrumental delivery and post-term delivery which were significantly higher in the underweight pregnant women, maternal DM, hypertension, still birth and C/S delivery were higher ($p < 0.05$) in overweight/obese/morbidly obese women when compared with women of normal BMI. However, LBW and pre-term delivery were found to be lower in overweight and obese women.

Birth weight, birth length and head circumference were significantly ($p < 0.05$) higher in obese women when compared with the normal weight women but lower in the underweight women. However, while comparable birth length and head circumference was observed in overweight and normal weight women, the obese women had significantly higher values than women with normal BMI with underweight women having significantly ($p < 0.05$) lower head circumference.

Discussion

Low prevalence of underweight among pregnant women was identified in the study population. This may be an underestimation as women were recruited at ≤ 25 week gestational age, a time weight gain must have commenced. Regrettably, pre-pregnancy weight normally used in most literature was not possible in the present study as most women booked late into the pregnancy programme in the study site which is not unusual in Nigeria. Except for primigravidae and women with previous obstetric complications, antenatal booking is often late among pregnant women in Nigeria [21]. The significantly higher BMI in older age groups observed in the present study is in corroboration with the findings of earlier studies [17] and shows the normal physiological changes during aging. These changes are influenced by both environmental and genetic factors. For instances, increased dietary intake (in women from high socioeconomic class) may lead to excessive accumulation of tissues [22] which will ultimately lead to increased BMI as seen in the present study. Also, it has been reported that parous women retain more of their pregnancy weight, a condition that has been linked to long tome obesity [23]. The significantly higher levels of plasma iron and haematological parameters (haematocrit, haemoglobin), though below the reference ranges, together with higher plasma albumin (within reference range) in the overweight and obese pregnant women as well as significantly lower levels of the same parameters in the underweight women when compared to the normal weight women in the present study confirms the known fact, that the former groups were probably more nourished than the latter. All the relevant parameters used in this study have been consistently used in the assessment of nutritional status and well-being in clinical settings and in malnourished individuals the values of haemoglobin/haematocrit and albumin are usually low [24].

Although reports relating plasma zinc and copper levels with maternal BMI during pregnancy are rare, the present findings corroborate earlier findings of Tamura *et al* [25] where the highest BMI group had the lowest plasma zinc concentration. In obese pregnant diabetic women, minor alterations in some trace elements status have been reported [26] as in this study. In addition to obesity, plasma zinc level has been found to be dependent on age, race and parity [27]. Although there seems to be a relationship between maternal micronutrient status, plasma volume, pre-pregnancy BMI and birth weight, the mechanisms for such association still remain vague [28]. Also the mechanisms underlying the alterations in some trace elements in overweight/obese pregnant women have not been fully elucidated. However, it has been suggested that maternal micronutrient status play a role in the regulation of body size (cooper) and mediate plasma volume expansion [29]. Hence it has been proposed that in underweight women a low plasma volume during early pregnancy will result in a proportionately reduced cardiac out-put which will in turn results in lower uteroplacental blood flow and decreased transfer of nutrients to the foetus and may represent the mechanism through which micronutrients impacts on pregnancy outcomes. Thus, it could be argued that reduced plasma micronutrients such as Cu, Fe and Zn as demonstrated in the present finding may have impacted negatively on plasma volume expansion and resulted in more adverse pregnancy outcomes in the underweight malnourished pregnant women and in overweight/obese mothers. Several studies have shown that overweight women [13] and underweight women [14] are less responsive to zinc intervention than normal weight women. This is evident by the lower anthropometrics of children born to underweight mothers in comparison to the normal or overweight/obese mothers in the present study. It has been suggested that in malnourished underweight women, lower plasma expansion related to decreased micronutrients status might be associated with reduced foetal growth [30]. Studies have also documented an association between increased intakes of foods rich in micronutrients and reduction in intrauterine growth restriction leading to increased birth weight in women with low BMI [29, 31]. From the present study, both maternal underweight and overweight/obesity was found to be associated with one adverse pregnancy outcome or the other. Earlier studies [32,33] have reported an association between maternal pregravid body weight and some adverse pregnancy outcome. The finding of significantly more overweight and obese pregnant women having DM, hypertension, still birth and C/S delivery than their normal weight counterparts, corroborates earlier findings [17, 34-36]. This has been attributed to the fact that such pregnancy complications are often associated with difficulties during labour, due to foetal macrosomia [37]. Also obesity is a known risk factor for diabetes and hypertension, the two conditions that have been associated with adverse pregnancy outcomes [38]. As expected the low prevalence of LBW infants in overweight/obese pregnant women is in agreement with the findings of Bhattacharya *et al*. [17] where LBW remained significantly associated with underweight after adjusting for other confounders. It is also in corroboration of Nestel and Rutstein [12] findings. However, it has also been shown that macrosomia (birtweight > 4000g) are common in the obese and morbidly obese women respectively, compared to women with normal BMI [17]. Also the higher anthropometrics values for infants of overweight and obese women in comparison to the infants from underweight or normal weight women in the present finding supports the positive association between maternal and foetal anthropometrics. We could not understand the higher post-term and instrumental deliveries recorded in underweight pregnant women in the present study. Although women in this BMI group are few in number, we however speculate that higher post-dated and instrument-aided deliveries in these underweight women may be related to low foetal size (microsomia). Women with a low BMI were found to be more likely to have an infant that was smaller or of lower birth weight than infants born to mothers with either normal or high BMI [12]. Several risk factors for IUGR have been associated with low BMI [13-15]. For example, the IUGR reported in smokers and in women with poor psychological profile during pregnancy was found to be significant only in thinner women (BMI < 22) but not in heavier women [15]. Also the 140g increase in BW reported in women receiving low-dose aspirin prophylaxis against preeclampsia and among zinc supplemented pregnant women was found in thinner women [13] with BMI < 24 an d26 respectively when compared with women of higher BMI. Microsomic foetus may be less active to initiate labour at term and these post-term infants are often delivered by induction and aided by instruments. Additionally, underweight pregnant women may be nutritionally depleted [39] with concomitant anaemia and weakness to undergo normal spontaneous vaginal delivery [40]. We therefore conclude that both high and low pregnancy BMI is associated with alterations in trace element status. This may have adverse effects on the outcome of pregnancy. To mitigate the excessive weight gain/loss during pregnancy and its attendant consequences on pregnancy outcomes, especially in developing countries where micronutrient deficiencies is a problem, maintenance of appropriate weight and food diversification/fortification during pregnancy are recommended.

Contribution of Authors

We declare that this work was done by the authors named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. **EIU** conceived, designed, collected data and prepared the manuscript while **EIA** analysed and interpreted the data as well as revised the manuscript for important intellectual content.

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