Niger. J. Physiol. Sci. 28(December 2013) 211–219
www.njps.com.ng

Niger. J. Physiol. Sci.

Relationship between anthropometric and haematological parameters among third trimester pregnant women in Sokoto State, Northwest Nigeria

[*1] Bamaiyi A.J., [2]Adelaiye A.B. and [1]Igbokwe V.U.

Department of Physiology, [1]College of Health Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria and [2]Faculty of Medicine, Ahmadu Bello University, Zaria, Nigeria.

Summary: The pregnancy state in a woman's life is a unique state in terms of the desirable physiological changes and the exciting reversal of the changes soon after the termination of the pregnancy. It is considered essential that to guarantee a good feto-maternal outcome the attainment of optimum anthropometric and haematological parameters are key. Our study assessed the anthropometric and haematological changes and also looked at the relationship that exists between these parameters among pregnant women.We carried out a cross-sectional descriptive study which considered 160 apparently healthy, singleton, third trimester pregnant women attending ANC at the State Specialist Hospital and 58 apparently healthy non-pregnant controls sourced from the Sokoto metropolis population. Each subject or control enrolled was contacted 3 times at 2 weekly intervals. And at each occasion they are assessed for changes in the anthropometric and haematological parameters. The response rate was 93.6% (3 pregnants and 11 controls were loss to follow up). The pregnant and control subgroups mean ages were 28.02 ± 6.81 years and 26.89 ± 5.84 years respectively ($p = 0.265$). Weekly weight gains of 0.48kg among the pregnant sub-group against 0.13kg obtained in the control group were recorded. BMI increase of about 0.19kg/m^2 per week among the pregnant sub-group and only 0.05kg per week in the controls. 95% of the distribution of pregnant sub-group has haemoglobin and haematocrit of ≥8.9g/dL and ≥26% respectively. Among the pregnant sub-group, mean weekly haemoglobin and haematocrit drop of 0.24g/dL and 0.74% were respectively recorded. A steady rise in WBC was recorded but platelets counts dropped at an average of 5.04 x 10^3 /µL per week. A positive correlation between BMI and haemoglobin levels was observed ($r > 0$ and $p < 0.05$). No particular regularity in the relationship between BMI and WBC was noticed. We conclude that there was optimum weight gain and good haematological indices for those with good BMI during the third trimester of pregnancy. There was a positive correlation between BMI and plasma haemoglobin level but WBC showed no particular relationship with the anthropometric changes. We therefore, recommend that good education to improve the socio- economic wellbeing of the girl-child be encouraged to boost self sufficiency for better weight gains and to facilitate access to good healthcare so that the ideal anthropometric and haematological parameters can be achieved during pregnancy to guarantee good feto-maternal outcome.

Keywords*:* Singleton, Trimester, Anthropometry, Haematological, Gestation, Parity.

**Address for correspondence:* abamaiyi@yahoo.com or gbentede@gmail.com

Manuscript Accepted: December, 2013

INTRODUCTION

The pregnant woman experiences changes in her body system, some of which are normal, others are abnormal and in few instance it is the existing conditions that are modified (Ebeigbe *et al*, 2011). At the background usually is the surge in the pregnancy hormones mainly progesterone and oestrogens (Ganong, 2003; Heidmann, 2003) to meet the metabolic needs of the fetus, placenta and the expanding uterus especially in the third trimester (Ciliberto and Gertie, 1998).

Earlier studies on pregnant women have established the necessity of the pregnant mother to achieve some optimum prenatal values of anthropometry and haematological parameters in order to guarantee optimum feto-maternal outcomes. But we have not found in Sokoto environment any study that determines the relationship between these parameters among third trimester pregnant women from our literature search. Against this background our study on third trimester pregnant women set out to find such relationship and also to suggest what can be considered as optimum for third trimester pregnant women as regards these parameters in our environment using the 95% of the distribution criterion for the subjects examined. We also hope that the relationship when established may serve as a yardstick to use either of the parameters to predict the result of the other and by extension predict the feto-

maternal outcome. Meanwhile, Godhia *et al* (2012) in their work in Mumbai, India found a positive correlations between maternal third trimester haemoglobin concentration and birth weight, Deval *et al*, (2011) and WHO (2001) linked baby's birth weight as well as infant morbidity and mortality to how much weight the mother gain during pregnancy. Also maternal height has been suggested to be a proxy for obstetric risk (Eliman, 2010; WHO, 1990) and Lawoyin (1997) in Saudi Arabia found mothers with low birth weight babies has significantly low Body Mass Index (BMI). Similarly, Lopez and colleagues (2010) in Argentina wrote to propose that mother's Mid Upper-arm Circumference (MUAC) of 24.5cm, 255.5cm and 26.5 for 16, 28 and 36 weeks of gestation respectively be a proxy to detect Low Birth Weight (LBW) and Fakokunnde (1999) in Essex, United Kingdom wrote that haemoglobin >13.3g/dL may be associated with poor pregnancy outcome and Lawoyin (1997) further associated preterm low birth weight babies with hemoglobin lower than the acceptable lower limits at delivery.

Ugwuja and Akubugwo (2011) from Abakaliki, south-eastern Nigeria on the other hand found that parous pregnant women had significantly higher BMI but had low plasma haemoglobin levels when they studied the impact of maternal *Helicobacter pylori* infection on trace elements. Also in Baltimore, USA, Chang *et al* (2003) found women with low pre-pregnancy BMI were associated with low haemoglobin levels during gestation and Lawoyin, (1997) again in Tabuk, Saudi Arabia suggested attention to optimum weight gain in the third trimester of pregnancy to prevent anaemia. And studies such as the one by Tovar *et al* (2010) linked overweight/obesity during pregnancy to risk of development of obesity.

MATERIALS AND METHODS

We carried out our study over six (6) months period among pregnant women attending antenatal clinic (ANC) in the state specialist Hospital, Sokoto and the non-pregnant controls were drawn from Sokoto metropolis. Sokoto metropolis includes the whole of sokoto North and south local government Areas (LGAs) and almost the whole of Kware, Wamakko and Dange-shuni LGAs (Sokoto State Urban and Regional planning Board, 2012) with a total population of about 937, 471 (National Population Commission, 2006).

Study Design and Population:

It was a cross-sectional study to assess the changes in anthropometric and hematological parameters and establish the relationships among the parameters so determined among normal singleton third trimester pregnant women attending ANC in the state specialist Hospital and apparently healthy non-pregnant volunteer controls who are age matched and resident in Sokoto metropolis.

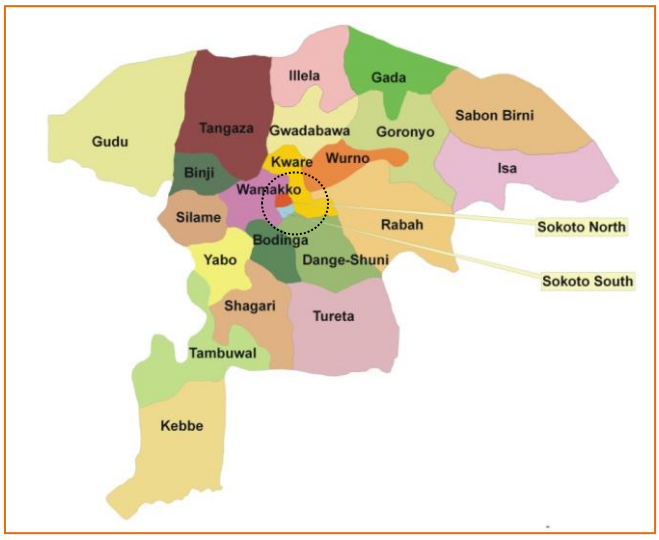

Fig 1. Map of Sokoto state showing the LGAs and highlighting the metropolis

Ethical Clearance

Before the commencement of the study, ethical approvals were obtained from the ethical committee of the State Specialist Hospital, Sokoto and informed consent was obtained from each woman that was enrolled in the study

Eligibility/inclusion criteria:

Pregnant women resident in the metropolis and in the age bracket 18 – 40 years, in their early third trimester, carrying singleton pregnancy and free of systemic illnesses like hypertension and diabetes. Also, apparently healthy non-pregnant age matched female volunteer controls resident in the metropolis were also considered.

Exclusion Criteria:

Pregnant women who smoke, consume alcohol, on other medications different from the normal haematinics or those who resides outside the metropolis during the index pregnancy were excluded.

Sample size Estimation:

The study being a cross-sectional descriptive one and since the population of pregnant women residing in the metropolis is not exactly known the formula for calculating sample size for infinite population was used to calculate the minimum sample size for the study (Nkwo, 2011). We therefore used Z^2pq/d^2 to estimate minimum sample size, n.

Where Z = Standard Normal deviate
P = Prevalence or proportion of success
q = Proportion of failure = (1-p)
d = Precision

Given 85% as the prevalence of pregnant women with inadequate iron status and at risk of developing anemia in pregnancy (Milman, 2011). n = 196.

Adjusting for attrition, minimum sample size n_s =n/0.9 (Ibrahim 2009)= 218.

Stage1

A list of the five (5) secondary health facilities in the sokoto metropolis was made and a systematic sampling of three of them after alphabetical arrangement was done as follows; Maryam Abacha Hospital, Noma Children Hospital, State Specialist Hospital, University Health Centre and Women and Children Welfare Clinic and eventually a health facility was selected randomly among the three (3).

Stage 2

Subjects or controls were classified into eligible and ineligible. For subjects or controls who could not read or understand the screening tools and the structured questionnaire, the lead investigator who has a good command of Hausa, Yoruba and some Igbo language took time to explain to them.

The study sample consisted of 160 eligible pregnant women seen at the ANC clinic of the state specialist Hospital, sokoto and 58 non-pregnant eligible controls seen in sokoto metropolis, spread over the 6 months study period.

A proportional allocation of number of subjects to the metropolitant LGAs was adapted to arrive at the 218 sample size (160 pregnant and 58 non-pregnant controls) according to the LGA's contribution to the metropolitant population. Thus, we had;

Sokoto North: **P** = $\frac{233012\ x\ 160}{937471}$ = (40), **NP** = $\frac{233012\ x\ 55}{937471}$ = (14)

Sokoto south: **P** = $\frac{197686\ x\ 160}{937471}$ = (34) **NP** = $\frac{179246\ x\ 58}{937471}$ = (13)

Wamakko: **P** = $\frac{179246}{937471}$ = (31) **NP** = $\frac{199246\ x\ 58}{937471}$ = (11)

Dange-shuni: **P** = $\frac{193443\ x\ 160}{937471}$ = (32) **NP** = $\frac{193443\ x\ 58}{937471}$ = (12)

Kware: **P** = $\frac{134084\ x\ 160}{937471}$ = (23) **NP** = $\frac{134084\ x\ 58}{937471}$ = (8)

P= pregnant, **NP** = Non-pregnant

Procedure protocol

- Contacts with subjects were by appointment at 2 weekly intervals.
- At each visit, the following were carried out on each woman in the presence of a female chaperon;
- Subjects/Volunteer controls were recalled by their numbers; Serial number (SN) or Control number (CN)
- The vital signs including Blood Pressure (BP) Pulse Rate (PR) and Temperature were taken to ascertain the health or otherwise of the subjects and controls
- Weight (Kg) measurement and recording.
- Height (m) measurement and recording (1st visit only).
- BMI derived (kg/m^2).
- Mid upper Arm circumference (MUAC) measurement and recording (cm).
- 2mls blood was drawn and transferred into an EDTA – 2 bottle specific for each subject and maintained at room temperature.
- Samples transferred to the laboratory for analysis within 4hours of collection.
- Results of blood analysis were extracted from the slips of automation and entered into their respective templates, the same day.

Measurement

Weight

During each contact time, a subject weight (kg) was measured on bare feet and in light clothing using a simple, mechanical, portable weighing scale (Camry, China, ISO 9001: 2008 certified by SGS, model: BR9012), with the following accuracy, 0-60kg ± 1.2 digits, > 60kg ± 2.0 digits. It was standardized each day using a known weight. The knob at the rear of the weighing scale makes it possible that the reader on the calibration was adjusted to the zero point before each weigh is taken.

Height

Each subject's height (m) was measured on bare feet at first visit using a portable (6kg) standiometer, Seca 217. It has a robust base plate that guarantees a sturdy stance. The measuring range is 20-250cm; the graduation is 1mm, dimensions of 328 x 21485 x 574mm.

Body Mass Index (BMI)

At each visit and for each subject and volunteer control that had her weight and height recorded the BMI was calculated as follows;

$$BMI = \frac{Weight\ (kg)}{Height\ x\ Height\ (m2)}$$

Mid-Upper arm Circumference (MUAC)

A simple, inelastic (China, Butterfly) measuring tape, was used throughout the study. The MUAC was taken to be the measurement obtained when the tape was applied around the upper arm at the mid-point between the tips of the Olecranon and the Acromion processes (Obidike, 2004) of the same arm placed akimbo.

Haemotological parameters:

Automation method was used to determine the Haemoglobin, Haematocrit, Total White Blood Count and differential and platelets count. Full automatic Blood cell counter, PCE – 21OE, ver. 5.10 (Erma, Tokyo) was used throughout the study. And 2mls single-use syringes and needles were used to withdraw whole blood in accordance with global best practices (WHO, 2002) and the withdrawn blood transferred into 5mls tubes anticogulated with EDTA – 2k and gently but thoroughly mixed. Venous bloods were taken in accordance with the standard described by Bachorik (1982). Samples later transferred to the laboratory within 6hours when the best results are expected (Bain and Bates, 2011). The

application of hospital Buckle type elastic strap tourniquet, GFO3D; size 2.5m x 40cm (Firstar, China, mainland) to any suitable arm were done and where possible, median cubital vein were used for easy accessibility (Moore and Dally, 1999).

Statistical analysis

Data were entered into and analyzed using statistical package for social sciences (SPSS), version 20. All values were expressed as the mean ± S.D of either the pregnant group (n=160) or the non-pregnant, control group (n=58). Data were presented using tables for frequency and percentage of variables. t-test was used for comparison of sample mean and Pearson correlation coefficient was used to determine relationship between parameters. The level of statistical significance for the test was set at $P \leq 0.05$.

RESULTS

Of the 218 respondents enrolled in the study 14 (3 pregnant and 11 non-pregnant controls) were lost to follow up, bringing the response rate to 93.6% which is better than 90% projected. The mean age for the pregnant was 28.02 ± 6.81yrs and 26.89 ± 5.84 years for the non-pregnant controls group (p=0.265). In the study, Hausas were the majority; 72.6% and 42.6% for the pregnant and non-pregnant controls sub-groups respectively. Also, Muslims were the dominant; 86.6% and 63.8% for the pregnant and non-pregnant sub-groups. Most of the pregnant sub-groups had education levels less than secondary schools contrary to the non-pregnant control group with majority of them having acquired education above secondary schools certificate. Majority (70.7%, n=157) of the pregnant respondents were dependent. Similarly majority (61.7%, n = 47) of the control sub-group were dependent. We found a mean weekly weight gain of 0.48kg among the pregnant subgroup against mean weekly change of 0.13kg in the control group. This is shown in table 1 below.

The mean heights were 1.60 ± 0.06m and 1.61 ± 0.07m for the pregnant and non-pregnant control sub-groups, respectively. The BMI increase steadily in the third trimester of pregnancy, at about 0.19kg/m^2 per week among the pregnant sub-group and only 0.05kg/m^2 for the non-pregnant control sub-group per week. Details of the BMI changes in both groups are as shown in Table 2. The MUAC does not appear to have changed significantly. A mean weekly change of only 0.07cm (27.73 ±3.94 - 27.89 ± 4.00) between two consecutive visits for the pregnant which is comparable to the 0.06cm (29.91± 4.90 - 30.04 ±4.96) between two consecutive contacts of the non-pregnant controls. These are shown in table 3.

Table1: Mean weight changes among the pregnant and the non-pregnant women during the study

	PREGNANT WOMEN n=157			**NON-PREGNANT WOMEN n = 47**	
Visit	1st	2nd	3rd	1st	2nd
Mean weight (kg)	66.62±12.47	67.61±12.54	68.59±12.57	67.70±16.20	67.96± 16.16
Ranges (kg)	45 – 102	46 – 103	47 – 104	45 -112	47 – 112

Weight change/week for the pregnant group = 0.48kg, (p<0.05) Weight change/week for the non-pregnant group = 0.0.13kg, (p =0.914)

Table 2: The changes in mean BMI of the pregnant and the non-pregnant groups during the studying period.

	PREGNANT WOMEN n=157			**NON-PREGNANT WOMEN n=47**	
Visit	1st	2nd	3rd	1st	2nd
BMI (kg/m^2)	26.02 ±4.67	26.41 ±4.69	26.78 ±4.69	26.18 ±6.07	26.27 ± 6.05
Ranges (kg/m^2)	18.03 – 40.68	18.43 – 41.09	18.83 – 41.50	17.56 – 45.45	17.85 – 45.45

BMI change/week for the pregnant group = 0.19kg/m^2, (p = 0.302) and BMI change/week for the non-pregnant group = 0.04kg/m^2, (p = 0.915)

Table 3: MUAC changes observed among the pregnant and non-pregnant control groups during the contact period.

	PREGNANT WOMEN n=157			**NON-PREGNANT WOMEN n = 47**	
Visit	1st	2nd	3rd	1st	2nd
MUAC (cm)	27.73 ±3.94	27.89 ± 4.00	28.01 ±4.00	29.91± 4.90	30.04 ±4.96
Ranges (cm)	20 -42	21 – 42	21 – 42	23 – 42	23 – 43

Mean MUAC change/week for the pregnant group = 0.07cm, and Mean MUAC change/week for the non-pregnant group = 0.06cm, (p >0.05)

Table 4: The changing patterns of haemoglobin concentration and Haematocrit in both the pregnant and non-pregnant sub-groups during the study period.

	PREGNANT WOMEN n=157			**NON-PREGNANT WOMEN n=47**	
Visit	1st	2nd	3rd	1st	2nd
Haemoglobin (g/dL) Ranges (g/dL)	11.54 ± 1.76 8.5 – 21.2	11.03 ±1.21 7.0 – 14.9	10.55 ±_1.07 6.2 -13.5	13.18 ± 1.25 10.2 -15.3	13.04 ± 1.25 8.8 – 15.1
Haematocrit (%) Ranges (%)	34.05± 5.04 22.0-58.4	32.87±3.41 19.9-41.9	31.08±3.41 14.4-38.4	39.74±3.46 30.9-46.5	39.54±3.70 28.5-42.7

Mean fall in haemoglobin/week in the pregnant group was 0.26g/dL (p<0.05) but it was 0.08g/dL among the non-pregnant group (p = 0.046).Mean fall in haematocrit/week in the pregnant group was 0.74% (p = 0.004) but it was 0.1% among the non-pregnant group (p = 0.731).

Table 5: White Blood Count variations in the pregnant and non-pregnant sub-groups studied

	PREGNANT WOMEN n=157			**NON-PREGNANT WOMEN n=47**	
Visit / Parameters	1st	2nd	3rd	1st	2nd
Total WBC x10^3/µL Ranges	7.59 ± 2.33 (3.1 – 14.5)	8.13 ± 1.73 (4.4 – 13.3)	8.78 ± 1.83 (3.8 – 12.6)	7.39± 2.94 (4.2 - 16.7)	6.51 ± 1.95 (3.9 – 12.2)
LymphocyteX10^3/µL Ranges	0.87 ± 0.6 (0.1 – 3.8)	0.89 ± 0.4 (0.0 – 2.8)	0.93 ± 0.3 (0.1 – 3.0	1.65 ± 1.4 (0.2 – 7.3)	1.29 ± 0.9 (0.1 – 4.3)
MococytesX10^3/µL Ranges	0.26 ± 0.1 (0.1 – 0.8)	0.31 ± 0.1 (0.1 – 0.7)	0.34 ± 0.2 (0.1 – 1.4)	0.43 ± 0.3 (0.1 – 1.7)	0.42 ± 0.2 (0.1 – 1.2)
GranulocytesX10^3/µL Ranges	6.46 ±2.1 (2.6 – 12.2)	6.93 ± 1.7 (3.2 – 12.2)	7.55 ± 1.8 (2.9 – 11.2)	5.31 ± 1.6 (2.5 – 9.2)	4.81 ±1.5 (2.1 – 8.4)

Table 6: platelet count changes among pregnant women in the third trimester compared with their non-pregnant controls studied

	PREGNANT WOMEN n=157			**NON-PREGNANT WOMEN n=47**	
Visit / Parameter	1st	2nd	3rd	1st	2nd
Platelets x 10^3/µL	221.10± 65.4	212.04 ±61.4	200.83 ±57.7	255.06 ±70.5	247.11 ± 63.1
Ranges x 10^3/µL	56 – 436	54 – 465	97 – 421	96 – 405	68 – 380

Table 7: Relationship between BMI and Haemolobin Patterns during the third trimester of pregnancy.

		Hb1		**Hb2**		**Hb3**
	R	P-value	R	P-value	R	p-value
BMI1	.209	0.009	.182	0.023	.1491	0.062
BMI2	.221	0.005	.185	0.022	.148	0.064
BMI3	.222	0.005	.182	0.022	.149	0.062

BMI1, BMI2 and BMI3 = Mean Body Mass Indices during first, second and third visits respectivelyHb1, Hb2 and Hb3 = Mean Haemoglobins during first, second and third visits respectively

Table 8: Relationship between BMI and Haemoglobin pattern among the non-pregnant control.

	Hb1		**Hb2**	
	R	p-value	R	p-value
BMI 1	.393	0.006	.229	0.121
BMI 2	.382	0.008	.222	0.133

Key: *BMI1and BMI2 = Mean Body Mass Indices of the non-pregnant women during first and second contacts respectively Hb1 and Hb2 = Mean Haemoglobins of the non-pregnant women during first and second contacts respectively*

Table 9: Relationship between BMI and TWBC in the third trimester of pregnancy.

	WBC 1		**WBC 2**		**WBC 3**	
	R	P-value	R	P-Value	R	p-value
BMI 1	.045	0.573	-.051	0.528	.061	0.451
BMI 2	.046	0.567	-.051	0.526	.066	0.409
BMI 3	.044	0.582	-.048	0.549	.069	0.391

Key: *BMI 1, BMI 2 and BMI 3 = Mean Body Mass Indices during first, second and third visits respectively WBC 1, WBC 2 and WBC 3 = Mean total white blood counts during first, second and third visits respectively*

Table 10: BMI and TWBC relationship among non-pregnant control sub-group.

	WBC 1		**WBC 2**	
	R	P-value	R	P-value
BMI 1	.177	0.234	.074	0.623
BMI 2	.176	0.236	.076	0.610

Key: *BMI 1 and BMI 2 = Mean Body Mass Indices of the non-pregnant women during first and second contacts respectively. WBC 1 and WBC 2 = Mean total white blood counts of the non-pregnant women during first and second contacts respectively*

The mean hemoglobin concentrations of the pregnant and non-pregnant sub-groups are 11.04 ±1.4g/dL & 13.11±1.2g/dL, respectively. Both mean Haemoglobin concentration and haematocrit drops as pregnancy advances in the third trimester. Haemoglobin concentration drops at about 0.24g/dL per week. On the contrary no weekly pattern was found among the non-pregnant sub-group. Table 4 below shows the details. There was a steady rise in total white blood counts and the differentials in the third trimester of pregnancy, mean weekly rise of about 0.29 x10^3/µl. The result of the non-pregnant control was found to have even fall on the average of 0.44x10^3/µL per week. Other details are as shown in table 5. The platelets counts got depleted more as pregnancy advance in the third trimester at about 5.04x10^3/µL per week. Generally platelet count among the pregnant women was lower (211.32 ± 62.0x10^3/µL) when compared with the mean value for the non-pregnant control of (251.09 ± 66.6x10^3/µL) (P = 0.000). Other details are as shown in table 6.

Correlations between the anthropometric and haematological parameters:

BMI and Haemoglobin

We found a positive correlation between BMI and haemoglobin levels ($r > 0$and $p<0.05$). The correlation gets stronger with increase in BMI values and drops with decrease in haemoglobin levels. This pattern was not seen among the non-pregnant group even though they showed a positive correlation between BMI and Haemoglobin. Other details are as shown in table 7 & 8.

BMI and Total White Blood Count (TWBC)

Our study revealed that there was no particular regularity in the relationship between the BMI and TWBC in the third trimester of pregnancy despite a consistent trend in the BMI and TWBC. Other details are as shown in table 9 & 10.

DISCUSSION

Our study revealed a steady weight gain in the third trimester of pregnancy, an average of about 0.48kg per week. This is similar to the opinion of Borton (2009) in the United Kingdom where it was said that normal weight gain in pregnancy is about 0.50kg per week for the last 20 weeks of pregnancy. The 0.02kg deficit in our results may be explained by the differences proposed to exist among pregnant women of different or same age, weight, height, ethnic background and socio-economic status reported in the Healthy People 2010: Objectives for the United States and cited by Deval and colleagues (2011). Besides, Ronald (2000) in the Healthy People 2010, also reported that teenagers and black women gain less than recommended weight during pregnancy and are vulnerable to poor feto-maternal outcomes. And Bisesenden *et al* (1981) in Birmingham found Asian mothers to have smaller and lighter babies compared to their European counterparts. We however could not state clearly that this is an ideal weight gain per week in the third trimester of pregnancy as we don't have *ab initio* the records of pre-pregnancy BMI of the pregnant women as recommended by Institute of Medicine (IOM, 2009).

The mean height of both sub-groups of the respondents were within normal and above the cut-off value (<1.50m) predicted for risky labour and low Birth weight (WHO, 1991).

There was also steady increase in the BMI in the third trimester of pregnancy similar to the findings of Gaya *et al* (2009) in Kaduna State, Nigeria and Benefice *et al* (1996) in Senegal, where they wrote that BMI increases in pregnancy, particularly in the second and third trimesters.

The MUAC was relatively stable consonance to the position of W.H.O (1991) that MUAC during pregnancy is stable in developing countries. A mean increase of about 0.07cm for the pregnants sub-group which is not significantly differences from the non-pregnant controls 0.06cm ($p>0.05$). The mean MUAC of the pregnant group of 27.73$\pm$ 3.9cm and 28.01 $\pm$ 4.0cm at weeks 28^{th} and 36^{th} respectively were above the cut-off 25.5cm and 26.5cm at weeks 28^{th} and 36^{th} respectively opined by Lopez *et al* (2010) in Argentina to be a proxy to detect women that will give birth to LBW babies. Our mean values were also above the 27cm MUAC which Elshibly and Schmalish in Sudan suggested to increase the relative risk of LBW babies

Our results showed consistent drops in mean haemaglobin and haematocrist in the third trimester of pregnancy. This is comparable to results obtained by Heidman (2000), Kenneth *et al* (2012), Fakokunde (1991) and Borton (2009). The mean haemoglobin, 11.04 ± 1.4g/dL and mean haemotocrit, 32.67 ± 4.2% is similar with the results Hb = 11.0 and Hct = 33.0 obtained in clinical studies carried out among European women on iron supplements during third trimester pregnancy by the CDC and reported in Mobility and Mortality Weekly report/MMWR (1998) and cited by Deval *et al*, (2011). And it is in conformity with the opinion of Borton (2009) who suggested consideration for dilutional anaemia of pregnancy if Hb is between 10.5g/dL to 13.5g/dL and our results are also consistent with the 10 – 13.5g/dL which Fakokunde (1999) considered as normal in pregnancy. The non-pregnant control sub-group showed higher mean haemoglobin and haemotocrit levels of 13.11 ± 1.2g/dL and 39.63 ± 3.6% respectively. These however fell short of the 14g/dL which Sabry (2005) in Cairo, Egypt suggested as normal but within the 35 – 42% normal haematocrit range he suggested. In our results we have found that only pregnant women with mean haemoglobin of <8.9g/dL or mean haematocrit of <26% in the third trimester can be considered to be anaemic; less than the 5^{th} percentile of the distribution of haemoglobin or haematocrit (Deval *et al*, 2011) Our cut-off value for these parameters are however lower than that set by Ramsey (2010), WHO (1991) and Massot and Vanderpas (2003). We will want to explain our finding to the opinion of change *et al* (2003) where they reported high rate of anaemia in African – American and Massot and Vanderpas (2003) also noted that other ethnic population outside the Caucasian population showed lower third trimester haemoglobin. In addition, our study revealed that most of the pregnant subjects are poorly empowered (70.7% dependent) and lack the capacity to access quality cares as majority of them (51.6%) have education levels less than secondary school. Further, they mighty have entered pregnancy with low haemoglobin stores or with dietary deficiencies

of iron and folic acid as opined by Massot and Vanderpass (2003). These summarily affirm the position of Ramsey (2003) that "it is hard to define a normal reference range for haemoglobin during pregnancy and the limit for diagnosing anaemia".

We found a gradual rise in TWBC similar to the findings of Borton (2009), Heidman (2000) and Ramsey (2003). We also noticed a gentle rise in the pregnant sub-group of lymphocyte count, although the mean count is significantly less than the mean for the non-pregnant control ($P<0.05$). This is possibly due to the presence of immunosuppressant factor in the serum of pregnant women suggested by Ramsey (2013). Similarly, Monocyte count was significantly higher among the normal non-pregnant group than the pregnant ($p<0.05$). Nevertheless, the monocyte count rose among the pregnant subjects gently during the visit period. The granulocytes counts rise gradually among the pregnant sub-group. This was significant ($p = 0.007$). This is similar to the finding of Heidman (2000), Borton (2009) and Ramsey (2013)

Platelets count consistently drop, a mean of $10.08x10^3/\mu L$ similar to the results presented by Ramsey (2013) and Heidman (2000). For the explanation we will err on the evidences provided by earlier researchers such as Ramsey that there is possibility of hyper- destruction of platelet during pregnancy orchestrated by the fall in the number and increase in their cell size of individual platelets. Younger platelets are bigger in size (Ramsey, 2013).

We found in our results that pregnant women in the third trimester with higher mean body mass index (BMI) had a corresponding higher mean haemoglobin levels and those with lower haemoglobin levels have lower BMI. This is similar to the finding of Chang *et al* (2003) in a study among African – American adolescents in Baltimore, USA where they found women with low pre-pregnancy BMI were significantly associated with lower haemoglobin levels during gestation. In a related study by Lawoyin (1997) in the kingdom of Saudi Arabia a similar finding was reported.

Ugwuja and Akubugwo (2011) worked in the South – East Nigeria but on the impact of maternal *helicopter pylori* infection on trace elements and on the contrary found women with *helicobacter pylori* infection to have significantly higher BMI but low plasma levels of haemoglobin. The reason may be because these categories of women might have loss some haemoglobin from bleeding acid peptic disease which is common sequelae of *helicobacter pylori* infection in humans (Kumar and Clark, 2000).

This pattern exhibited by our results was only noticed among the pregnant women. The control only showed a positive correlation between BMI and haemoglobin and not vice versa.

No particular patterns was obtained between the total WBC and BMI in both the pregnant and non – pregnant groups, probably there is no relationship between the parameters.

We therefore concluded that theadequacy of formal education among pregnant women in Sokoto is low and is accompanied by high dependence rate. Consequent to these we believe are the poor weight gains and lower haemoglobin levels during pregnancy which several studies have associated with increase in rate of low birth weights, risky labour events and increased morbidity and mortality that could otherwise be forestalled.

Screening for Sexually Transmitted Infections/STI (HIV, Syphilis), Pre-eclampsia and Toxaemia/PET (Blood Pressure, urinalysis) and one or two occasions of Haematocrits are some of the good practices carried out on women undergoing antenatal care in the state specialist hospital, but monitoring other physiological changes like anthropometric and other haematological parameters during pregnancy, especially in the second and third trimesters are not routinely done. By this, we mean a record of pre-pregnancy weight, Body Mass Index, Full Blood Count and during antenatal visits, serial results of weight gain, Body mass Index, Mid-Upper-Arm Circumference and Full Blood Count that will help to tale-tell the feto-maternal wellbeing are lacking. We have found an average weekly weight gain of 0.48kg and haemoglobin or haematocrit of $\geq$ 8.9g/dL or $\geq$ 26% respectively as normal during the third trimester of pregnancy. Generally, there was optimum weight gain and good haematological indices for those with good Body Mass Index during the third trimester of pregnancy. Within the limit of experimental errors, we found that the higher the Body Mass Index the better the haematological indices. The White Blood Counts on the other hand showed no particular relationship with the anthropometric changes.

REFERENCES

Bachorik P.S. (1982). Collection of Blood Sample for Lipoprotein Analysis. *Clin. Chem.* 28: 1375-8.

Bain B.J. and Bates I., (2001). Basic Haematological Techniques; Dacie and Lewis Practical Haematology, 9th Ed. P 19 – 43, Section 3. Churchill Livingstone.

Benefice E., Simondon K. and Robert M.M., *(*1996). Physical Activity Pattern and Anthropometric Changes in Senegalese Women Observed Over a Complete Seasonal Cycle. *American Journal of Human Biology* 8:251-261.

Heidman B.H., (2000). Changes in maternal Physiology during Pregnancy: *Updates in Anaesthesia.* 12; 42

Bissenden J.G., Scott P.H., Hallum J., Mansfield H.N., Scott P and Wharton BA, 1981. *Anthropometric and Biochemical Changes During Pregnancy in Asian and European Mothers Having Well Grown Babies.* British Journal of Obst and Gynae; an International Journal of Obstetric and Gynaecology, 88, Issue 10, P992 – 998.

Borton C, 2009.*Physiological Changes in Pregnancy*. *Patient.co.uk* Document ID: 740; version: 25

Centre for Disease Control, 1989. *Criteria for anaemia in children and childbearing age women*. Morbidity Mortality Weekly Report (MMWR); 38: 400-404.

Chang SC, O'Brien KO, Nathanson MS, Mancini J and Witter FR, 2003. *Haemoglobin concentrations Influence Birth Outcomes in* pregnant *African-American Adolescents.* J. Nutri 133 (7): 2348 – 55.

Ciliberto CF and Gertie FM, 1998. *Physiological Changes Associated With Pregnancy*, Dept of Anaesthesiology, Albert Eistein College of Medicine, New York, USA. Physiology, Issue 9 Article 2: page 1-3.

Deval L Patrick, Timothy P. Murray, Juddy Ann Bigbu, John Auerbach, Ron Benham, Judy Hause and Hafsatou Diop, 2011. *Pregnancy Nutrition Surveillance System/PNSS; 2009 CDC PNSS Report for Massachusetts.*

Edict 7, 1995. *Establishing and Empowering Sokoto State Urban and Regional Planning Board (SSURPB) To Control Development In All The Local Governments In The State.*

Elimam MAA, Elsadig YM, Abdalla SM and Osman AOM, 2010. *Age, Anthropometric Measurements and Mode of Delivery in Nulliparous Women at Omdurman Maternity Hospital*. Khartoum Medical Journal Vol 03, No. 03, pp. 489-492.

Elshibly EM and Schmalisch G, 2008.*The Effect of Maternal Anthropometric Characteristics and Social Factors on Gestational Age and Birth Weight in Sudanese Newborn Infants.*BMC Public Health.18, Jul 8:244.

Fakokunde AF, 1999. *Haemodynamic Changes in Pregnancy*. Dokita - Heart and Lungs Edition, August; vol. 26, No 1, P55 & 56. ISSN 0046 0508.

Ganong WF, 2003. *Endocrine Changes in Pregnancy*, Review of Medical Physiology; 21st Ed, Section IV, Unit 23. Lange Medical Books/McGraw- Hill Medical Publishing Division–ISBN 0-07-140236-5, ISSN 0892-1253.

Gaya BI, Garba HT and Adelaiye AB, 2009. *Cardiopulmonary Changes in Pregnant Women In Sabon-Gari Local Govrnment Area, Of Kaduna State, Nigeria.* The Internet Journal of Health.

Heidemann BH, 2003. Updates in Anaesthesia. *Changes in Maternal Physiology During Pregnancy*. British journal of anaesthesia, CEPD review; vol 3 number3.

Institute of Medicine (IOM) Report Brief, 2009. *Weight Gain During Pregnancy: Reexamining The Guidelines.* www.iom.edu/pregnancyweightgain.

Instruction Manual, Full Automatic Blood Cell Counter. PCE – 210E, Ver. 5.10.

Kenneth AB, 2012. *Haematological Changes in Pregnancy*. Clinicians Institutions Group Practices Patient

Kumar and Clark, 2003. *Helicobacter pylori* infection; Gastrointestinal Disease in Clinical Medicine P253 – 333, chp 6, 5th edition. Saunders, Elsevier Science Limited. Printed in the UK by Bath press Limited.

Lawoyin TO, 1997. *The Relationship between Maternal Weight Gain in Pregnancy, Haemoglobin Level, Stature, Antenatal Attendance and Low Birth Weight.* Southeast Asian Journal of Tropical Med Public Health. 28 (4): 873-6

Lopez LB, Calvo EB, Poy MS, del Valle Balmaceda Y and Camera K, 2010. *Changes in Skinfolds and Mid-Upper Arm Circumference During Pregnancy in Argentine Women.* Matern Child Nutr. 7(3):253-62.

Massot C and Vanderpas J, 2003. *A Survey of Iron Deficiency Anaemia During Pregnancy in Belgium: Analysis of Routine Hospital Laboratory Data in Mons*. ActaClinBelg, May–Jun, 58 (3): 169-77.

Moore KL and Dally AF, 1999.*Venipuncture of the Upper Limb; Clinically Oriented Anatomy,* 4th Ed. p684, Ch6. Published by Lippincott Williams and Wilkins. ISBN; 0683061410.

National Population Commission, 2011. *2006 Population and Housing Census of the Federal Republic of Nigeria.*Administrative Report, March 2011, Abuja, Nigeria.

Nkwo PO, 2011. *Low Prevalence of Pregnancy-mask Among Igbo Women in Enugu, Nigeria*, Annals of Medical Health Sciences Research. 1: 141-7.

Obidike EK, 2004**.** *Measurements; Essential of Clinical Methods in Paediatrics.*Ch14, p112. Published by Institute for Development Studies, University of Nigeria, Enugu Campus, Enugu-Nigeria. ISBN: 9782409030.

Okpala OC, Onyenekwe CC, Ogbuagu CN, Okpala EC and Eke AC, 2012. *Assessment of Renal Function in Pregnant Women Using Biochemical and Radiological Techniques in Nigeria*. The

Internet Journal of Laboratory Medicine. Vol 5, Number 1. DOI: 10.5580/2a7c.

Paxton A, Lederman SA, Heymsfield SB, Wang J, Thornton JC and Pierson RN Jr, 1998. *Anthropometric Equations for Studying Body Fat in Pregnant Women.*Am J ClinNutr : 67:104 – 10.

Ramsay M, 2013. *Normal Haematological Changes During Pregnancy and Puerperium* The Obstetric Haematology Manual.Cambribge University Press, p3 – 12. Online ISBN: 9780511676451, Hardback ISBN: 9780521865647.

Ronald M Davis, 2000. Healthy people 2010: Objectives for the United States: BMJ; 320(7238): 818 - 819

Sabry M, 2001. Blood and Body Fluid; Human Physiology for Medical Students. 5th Edition.

Survey Division, Ministry of Land and Housing, Sokoto State. Nov. 2012.

Tovar A, Chasan-Taber L and Bermudez OI, 2010. *Knowledge, Attitudes and Beliefs Regarding Weight Gain during Pregnancy Among Hispanic Women* .Maternal Child Health Journal. Nov; 14 (6):pp 938- 949.

Taofeek Ibrahim, 2009. *Sample Size Determination; Research Methodology and Dissertation Writing for Health and Allied Health Professionals*.Ch 5 p70-5.Published by Cress Global Link Limited, Abuja. ISBN: 978-978-906-838-8.

Ugwuja EI and Akubugwo EI, 2010. *Impact of Maternal Helicobacter pylori Infection on trace elements (Copper, Iron and Zinc) and Pregnancy Outcome.* Online Journal of Health and Allied Sciences. ID Code: 6976.

World Health Organization, 2001. *Healthy Eating for Pregnancy and Lactation*; Booklet for Mothers by WHO Regional Office for Europe. EUR/01. 5028598.

World Health Organization, 2002. "First, do no harm"-Introducing Auto-disable Syringes and Ensuring Injection Safety in Immunuzation systems of Developing Countries. WHO/V & B/02.26.

World Health Organization, 1991**.** *Maternal Anthropometry for Prediction of Pregnancy Outcome* Memorandum from USAID/WHO/PAHO/ Mother Care Meeting. Bulletin of the WHO, 69 (5): 523-532