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Newborn Anthropometry: Effects of Socio-demographic Factors and Maternal Anthropometry

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Summary

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Background: The size of the newborn at birth is affected by maternal nutrition. It is therefore conceivable that birth weight would also be influenced by maternal anthropometry which in turn, is often influenced by maternal nutrition and socio-economic factors. In this study, the effects of maternal anthropometry and socio-demographic factors on the newborn weight, length, and occipito-frontal circumference (OFC), were evaluated.

Methods: Consecutive apparently healthy term newborns on the postnatal wards of the University of Benin Teaching Hospital (UBTH), Benin City were recruited for the study. Their birth weights, lengths and OFC were measured and recorded. The weights, heights, parities and socioeconomic status of their mothers which had earlier been determined at their first antenatal visits, were also recorded. The effects of maternal socio-demographic variables on their babies' weights, lengths and OFC were then evaluated by multivariate logistic regression models.

Result: Four hundred and forty three babies were recruited for the study; 235 (53.05 percent) of them were females. The mean weight, length and OFC were 3.210 ± 0.493 kg, 49.3 ± 2.4 cm and 34.1 ± 1.7 cm, respectively. The mean maternal age, weight, height and body mass index (BMI) were 29.93 ± 4.69 years, 71.04 ± 12.80 kg, 162.84 ± 9.34 cm and 26.90 ± 5.56 kg/m^2, respectively. The logistic regression model showed that higher values of maternal weight and BMI independently had significant positive impact on the neonatal birth weight. The model had a good power of prediction, R^2 = 54.30 percent. The models for length and OFC were not so predictive, R^2 being 26.86 percent and 20.93 percent, respectively.

Conclusion: Larger babies are likely to be born to heavier mothers. The neonatal weight can be more accurately predicted by the maternal weight and BMI, than the neonatal length and OFC. Educating mothers on appropriate nutrition should contribute to normal birth weight for babies born at term.

Introduction

NEWBORN anthropometric measurements are important in evaluating intrauterine growth and predicting childhood survival.[1,2] The birth weight in particular, is useful in identifying low birth weight (LBW) which is an important contributor to infant morbidity and mortality.[3,4] The size at birth also has implications for morbidity and mortality in adulthood. Kajanitie *et al*[5] in Finland showed that small size at birth as a consequence of impaired intrauterine growth, was associated with cardiovascular related mortality at all ages in adult women. Small birth size has also been associated with cardiovascular disease in men.[5] Furthermore, the association of a small size and subsequent risk of developing type 2 diabetes, hypertension and neuro-developmental impairments have been reported in other studies.[6-8]

The newborn size at birth is influenced by maternal nutrition both before and after conception,[9,10] the environment and genetics.[4,11] In attempting to evaluate sources of variation in maternal nutrition with respect to birth size, Moore *et al* demonstrated

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that the percentage of energy derived from protein food sources during pregnancy was positively associated with birth weight.[12] The positive influence of maternal weight gain pattern in early pregnancy on birth size has also been documented in another study.[13] Some maternal non anthropometric factors such as parity have been shown to influence birth weight, with primiparous mothers having smaller babies compared to multiparous mothers.[14]

Maternal anthropometric measurements of weight, height and body mass index (BMI) at any point during pregnancy are influenced by the socio-economic status (SES) of the mothers.[15] It can therefore be deduced that the SES of the mother would probably influence the birth size. In their study of birth weights of babies in northern Nigeria, Airede *etal* showed that mothers from the high social class had bigger babies than those from the lower social class.[15] The effects of maternal size on the baby's other anthropometric measures were however, not evaluated. In another study in northern Nigeria,[16] using a multivariate logistic regression model, maternal age, weight, height, education and ethnicity were all shown to have a significant impact on birth weights. The influence of these maternal variables on the baby's other anthropometric parameters were again not investigated. In an earlier retrospective study conducted by Ogbeide and Alakija in 1985 in Benin City,[17] only the birth weights of newborn babies were determined. In a later study by Eregie in 1991,[18,19] occipito-frontal circumference (OFC) and mid-arm circumference were prospectively measured to determine their usefulness in evaluating gestational maturity. The influence of maternal socio-demographic factors on birth size was not evaluated. The present studywas therefore carried out to evaluate the effects of socio-demographic variables on newborn size at the University of Benin Teaching Hospital (UBTH), Benin City.

Subjects and Methods

Consecutive newborns delivered at the UBTH and who were in the postnatal ward during the nine-month period of studywere recruited for the study. Their birth weights, crown-heel lengths and OFC were measured and recorded. The maternal age, weight, height, BMI, parity, level of education and SES were also recorded. The maternal weight and height were those that had earlier been taken at first antenatal visits, usually within the first and second trimesters. The SES was determined using the methods described by Olusanya *etal*.[20] All the babies with obvious congenital abnormalities and those requiring admission into the neonatal wards were excluded. Mothers whose first visit was during the third trimester were also excluded from the study. The gestational age of each infant was determined by dates using mother's last menstrual period and by early ultrasound where available. The gestational maturity was evaluated using the Dubowitz and Dubowitz chart.[21] The babies were weighed soon after birth by the midwives. They were weighed without clothes, using a Bassinet infant weighing scale. The length was measured with a non distensible tape with the baby lying supine and the lower limbs in an extended position. The OFC was measured also with a non distensible tape using the supraorbital ridges and the maximum occipital prominence as landmarks.[22] The babies were classified as appropriate for gestational age (AGA), small for gestational age (SGA) or large for gestational age (LGA), using the Dubowitz and Dubowitz chart.[21] The length and OFC were measured by four investigators who were all physicians.

Statistical Analysis

The data obtained were coded and fed into the computer using the SPSS 13 version. The weight, length and OFC of the babies were reported as means with standard deviations. The ANOVA and Turkey-Cramer tests were used for multiple comparisons between groups based on the anthropometric parameters, maternal age groups, the socioeconomic classes, the gestational age and gestational maturity categories. Two tailed t test was employed to compare the difference in means between the anthropometric parameters in babies born to mothers with height < 160cm and those ≥ 160 cm, babies of mothers with BMI < 30 and those with BMI ≥ 30. The 5^{th}, 10^{th}, 50^{th}, 90^{th} and 95^{th} percentiles of the weight, length, OFC, BMI and Ponderal index (PI) were determined using the same package. The independent effects of maternal age, weight, height, BMI, level of education and socioeconomic class on the babies' weight, length and OFC were investigated by a multivariate logistic model. Statistical significance level was set at $p = 0.05$.

Results

General maternal and neonatal characteristics

There were 443 babies recruited for the study; 235 (53.05 percent) of them were females and 208 (46.95 percent) males. The mothers' mean $\pm$ SD and range values for age, height, weight, BMI and parity were 29.9 $\pm$ 4.7 (range 14 – 45) years, 162.8 $\pm$ 9.3 (range 94 – 190) cm, 71.0 $\pm$ 12.8 (range 45 – 118) kg, 26.9 $\pm$ 5.6 (range 10 – 74) kg/m^2 and 1.94 $\pm$ 1.52 (range 1 – 8), respectively. Analysis of the distribution of the maternal age groups (Table I) shows that 198 (44.70

percent) of the mothers were aged 26-30 years, and that 216 (47.6 percent) of them were from a high socioeconomic background. The mean gestational age of the babies was 39.3 ± 1.4 (range 37 – 43) weeks. The mean weight, length and OFC of the babies were 3.210 ± 0.493 (range 1.8 – 4.7) kg, 49.3 ± 2.4 (range 41 – 58) cm and 34.1 ± 1.7 (range 23 – 45) cm, respectively. The mean weight of the male newborns was significantly higher than that of the females ($p = 0.0052$, Table I). Furthermore, the males were significantly longer than the females ($p = 0.0001$), while there was no significant gender difference in the OFC (Table I). There were 25 low birth weight babies giving a low birth weight rate of 5.64 percent. The 5th, 10th, 50th, 90th, and 95th percentiles of both male and female babies for weight, length and OFC are shown in Figures 1-3.

Effects of maternal age, height, weight, parity, BMI and level of education on the babies' mean weight, length and OFC

Fig 4 shows the effect of maternal age on the birth weight. Babies of younger mothers were significantly smaller than those of older mothers ($p = 0.003$). The mean weight of babies born to mothers aged 14 – 20 years was significantly lower than that of those born to all other mothers aged 26 and above ($p < 0.05$ for those 26 – 30 years, 31 – 35 years and 36 – 40 years, and $p < 0.001$ for those > 40 years). The

Table I

Characteristics of the Mothers and Babies

Characteristics	*Females*	*Males*	*Total (%)*	*p value*
Birth weight(kg)	3.151 ± 0.460	3.277 ± 0.483	3.21 ± 0.493	0.0052
Length (cm)	49.0 ± 2.5	50.0 ± 2.5	49.3 ± 2.4	0.0001
OFC(cm)	34.0 ± 2.0	34.2 ± 1.4	34.1 ± 1.7	0.229
Socioeconomic class				
High	115	101	216(48.76)	
Middle	47	53	100(22.57)	0.385
Low	73	54	127(28.67)	
Mother's level of formal education				
Nil/Primary	26	30	56(12.64)	
Secondary	89	78	167(37.70)	0.552
Tertiary	120	100	220(49.66)	
Mothers' age groups (yrs)				
14 – 20	3	6	9(2.03)	
21 – 25	31	32	63(14.22)	
26 – 30	105	93	198(44.70)	
31 – 35	64	51	115(25.95)	
0.599				
36 – 40	26	24	50(11.29)	
>40	6	2	8(1.81)	

OFC = Occipitofrontal circumference

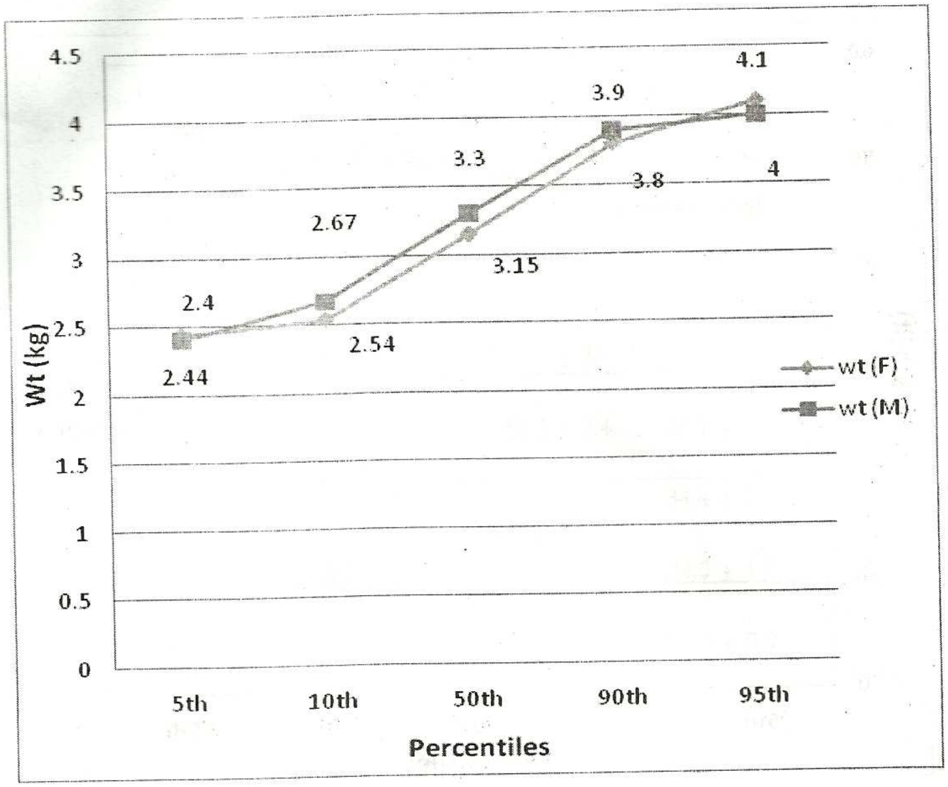
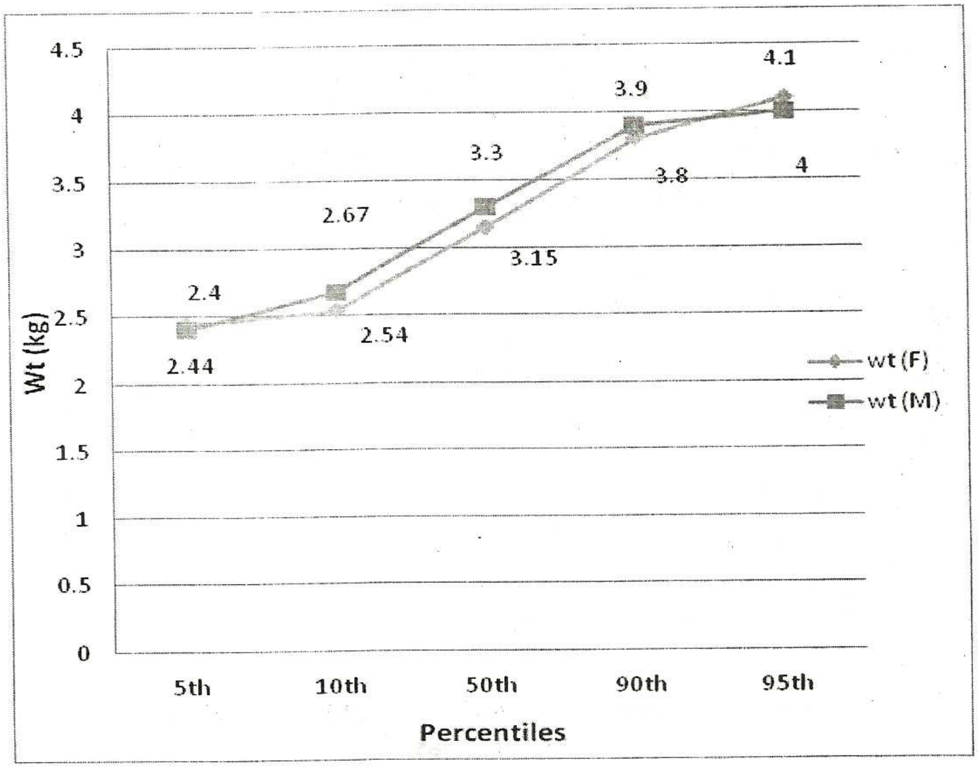


Fig 1. The distribution of the 5th, 10th, 50th, 90th and 95th percentiles of the weights (wt) of male and female babies. F - female, M - males

Table II

Distribution of Mean Anthropometric Parameters by Gestational Age

Gestational Age	*Weight (kg)*	*Length(cm)*	*OFC (cm)*
37 weeks	2.9 ± 0.5	47.7 ± 2.0	33.4 ± 2.4
38 weeks	3.1 ± 0.5	48.8 ± 2.4	33.9 ± 1.2
39 weeks	3.2 ± 0.5	49.2 ± 2.6	34.1 ± 2.0
40 weeks	3.4 ± 0.4	50.2 ± 2.4	34.4 ± 1.6
41 weeks	3.4 ± 0.4	50.1 ± 2.6	34.4 ± 1 4
42 weeks	3.2 ± 0.5	49.9 ± 1.6	34.0 ± 1.7
43 weeks	3.5 ± 0.6	52.0 ± 4.2	34.0 ± 0.0
P values	0.0001	0.001	0.08



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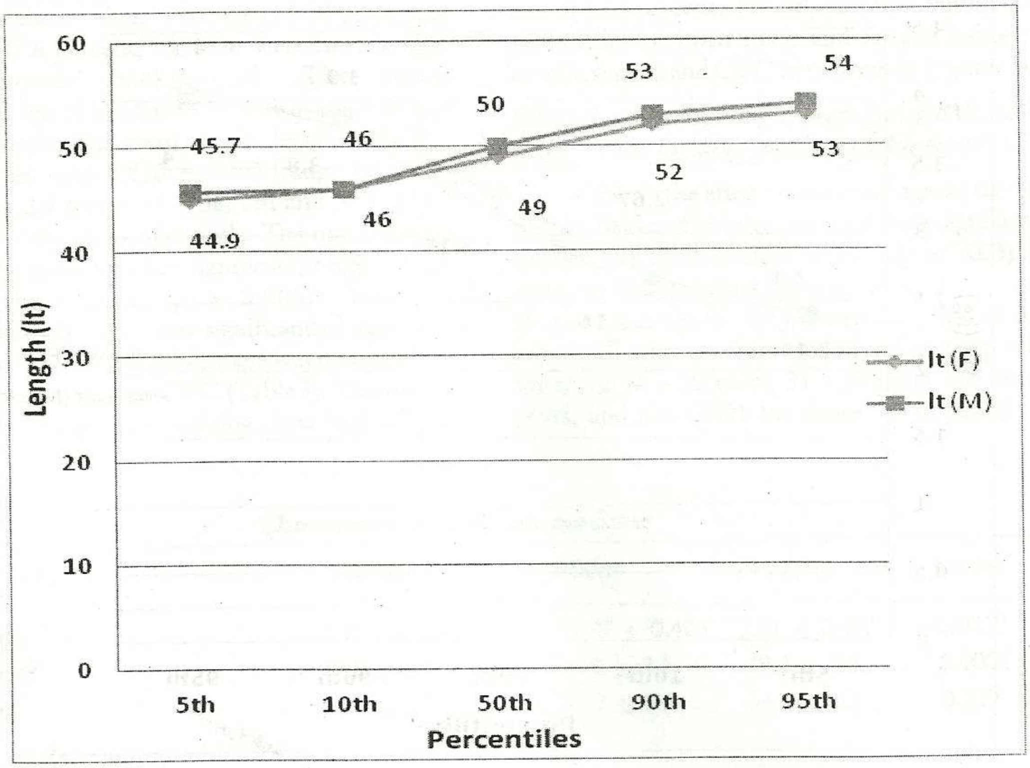

Fig 2. The distribution of the 5th, 10th, 50th, 90th and 95th percentiles of the birth lengths (lt), of the male and female babies. F - female, M - males

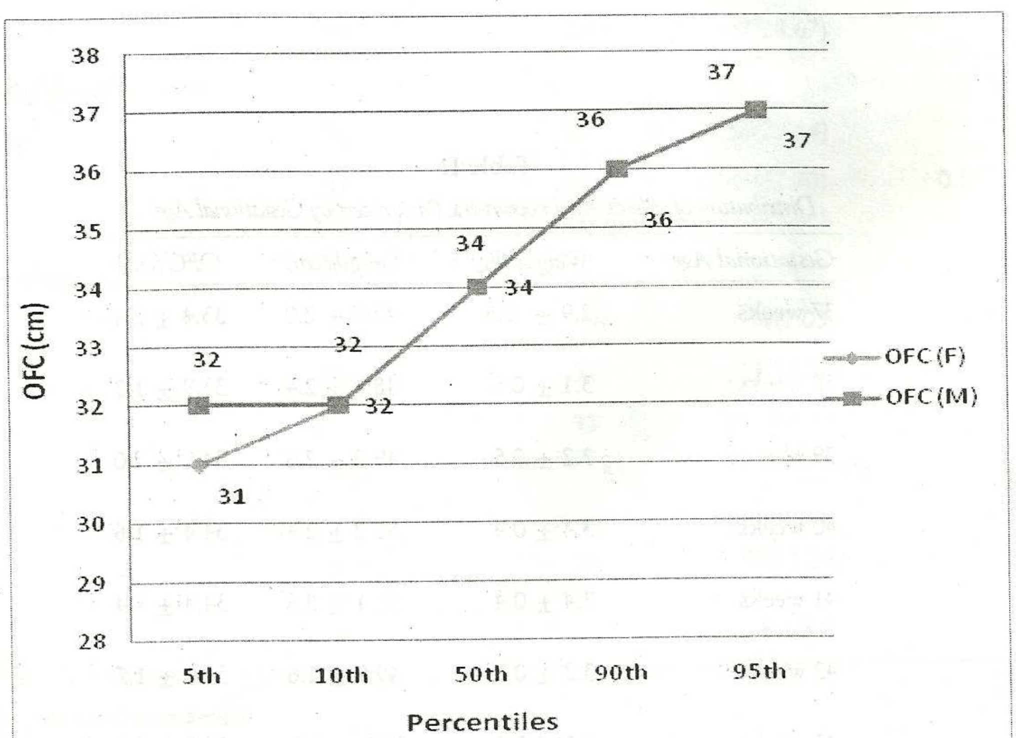

Fig 3. The distribution of the 5th, 10th, 50th, 90th and 95th percentiles of the occipitofrontal circumference (OFC) of the male and female babies. F - female, M - males

Table II

Distribution of Mean Anthropometric Parameters by Gestational Age

Gestational Age	*Weight (kg)*	*Length(cm)*	*OFC (cm)*
37 weeks	2.9 ± 0.5	47.7 ± 2.0	33.4 ± 2.4
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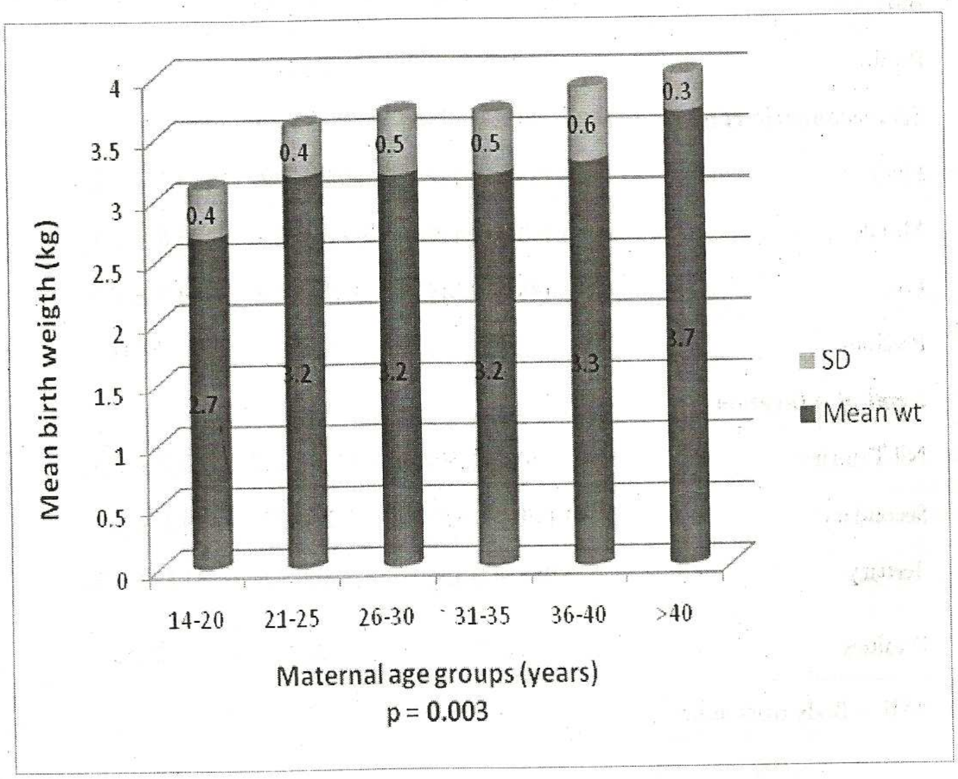

Fig 4. The relationship between maternal age and birth weights

Table III

Distribution of Mean Anthropometric Parameters by Maternal Characteristics

Maternal Characteristics	*Weight (kg) Mean ± SD*	*Length (cm) Mean ± SD*	*OFC(cm) Mean ± SD*
Height			
< 160 cm	3.150 ± 0.468	49.1 ± 2.4	34.0 ± 1.5
≥160 cm	3.264 ± 0.478	49.6 ± 2.5	34.2 ± 1.8
P values	0.029	0.058	0.281
Weight			
< 66 kg	3.104 0.500	49.1 2.6	33.9 1.5
≥66 kg	3.277 0.457	49.5 2.4	34.2 1.8
P values	0.0009	0.139	0.112
BMI BMI			
< 30	3.185 ± 0.484	49.3 ± 2.5	33.9 ± 1.7
BMI ≥30	3.327 ± 0.467	49.5 ± 2.5	34.6 ± 1.8
P values	0.018	0.522	0.0013
Socioeconomic class			
High	3.266 ± 0.487	50.0 ± 2.6	34.3 ± 1.8
Middle	3.190 ± 0.419	48.8 ± 2.4	33.8 ± 1.4
Low	3.148 ± 0.549	49.0 ± 2.3	34.0 ± 2.0
P values	0.083	0.0001	0.044
Level of education			
Nil/Primary	3.053 ± 0.507	48.4 ± 2.3	33.7 ± 2.3
Secondary	3.199 ± 0.529	49.2 ± 2.3	34.1 ± 1.6
Tertiary	3.255 ± 0.451	49.5 ± 2.6	34.2 ± 1.8
P values	0.022	0.011	0.180

BMI = Body mass index

Table IV

Logistic Regression Model of Maternal Sociodemographic Factors with Birth Weight as Independent Variable

Maternal Variables	*t ratio*	*SE coefficient*	*P values*	*95% CI*
Constant	2.09	-1.2, 0.58	0.038	-2.36, 0.07
Level of education	0.51	-0.02, 0.04	0.61	-0.09, 0.05
Gestational age	4.05	0.06, 0.014	<0.0001	0.03, 0.08
SES	0.20	0.0035, 0.018	0.84	-0.03, 0.04
Weight	15.80	0.94, 0.04	<0.0001	0.82, 1.06
Height	1.78	0.08, 0.04	<0.077	- 0.008, 0.17
Age	1.28	0.03, 0.02	0.203	-0.01, 0.07
BMI	2.00	0.10, 0.05	0.049	0.001, 0.19

R^2 = 54.30 %

differences in mean lengths and OFC of the babies with respect to maternal age groups were not significant (p = 0.203 and p = 0.087 respectively, for length and OFC).

The mean weight of babies of mothers with height <160cm was 3.150 ± 0.468 kg and this was significantly lower than the 3.264 ± 0.478 kg in babies born to mothers whose heights were >160cm (p = 0.029). The differences with respect to the length and OFC, were not statistically significant (p = 0.058 and p = 0.281, respectively, . Table III). The mean weights of newborns delivered by mothers who weighed <66kg was significantly lower than that of newborns of mothers whose weights were ≥66kg (p = 0.0009). The babies of mothers with BMI <30 had significantly lower weights and OFCs than those of mothers with BMI ≤30 (p = 0.018 and 0.0013, respectively). There were no significant differences between the mean weight, length and OFC of babies whose mothers were primiparous and those whose mothers were multiparous (p = 0.150, p = 0.578, p = 0.124, respectively). There was also no significant difference in the mean weight of babies born to mothers from the different SES (p = 0.083). However, the mean length and mean OFC of babies from high SES were significantly higher than those from the low SES (p <0.001 and p <0.05, respectively), while the mean length of babies from high SES was also greater than that from the middle SES (p < 0.001; Table III). The maternal level of education was significantly related to birth weight (p = 0.022). The mothers with no formal or only primary level of education had significantly lighter babies and babies with shorter birth lengths than those with tertiary education (p <0.05 and p <0.05, respectively). There was no significant difference in OFC in relation to maternal level of education.

Using a multivariate logistic regression model, the independent influences of the maternal age, weight, length, level of education and SES on the birth weight, length and OFC were investigated. The model on weight showed that the maternal weight and maternal BMI independently, were the most significant predictors of birth weight (p< 0.0001, p<0.0001 and p = 0.049 respectively, Table IV). The model had a good power of predicting the newborn birth weight (R^2 = 54.30 percent). The models for birth length and OFC had less power of prediction, R^2 being 26.86 percent and 20.93 percent, respectively.

Maternal weight was the best predictor of birth length ($p < 0.0001$), while maternal weight and BMI were best predictors for OFC ($p < 0.0001$ and $p = 0.013$, respectively).

Discussion

The influence of maternal anthropometric measures and socioeconomic factors on the birth weight, length and occipito-frontal circumference was evaluated in this study. The babies born to younger mothers were smaller than those born to older mothers. This finding is consistent with results from previous studies.[23-25] The mothers who were < 20 years had significantly lighter babies than the older age groups. This emphasizes the high rate of low birth weight babies among teenage mothers. The attendant morbidity and mortality of babies born to teenage mothers are well documented.[26] Maternal size had a positive correlation with their babies' weights. The bigger and taller mothers had significantly bigger babies and taller babies respectively, while mothers with BMI > 30 in the first two trimesters of pregnancy had significantly bigger babies. These findings are in agreement with previous reports.[23,24,27] The maternal age and size seem to be interrelated. Increasing age tends to be associated with increasing parity and increasing weight gain. Also, increasing age may be positively related to better educational attainment, socioeconomic status and thus better nutrition and possiblyweight gain. All of these factors have been associated with bigger babies.[23-25, 27] The association of taller mothers with bigger babies may also have some genetic or constitutional basis.

There was no significant difference in birth weight with respect to socioeconomic status contrary to some previous reports.[15,26] However, the SES had a significant effect on the birth length and occipito-frontal circumference of the babies, while the maternal level of education had a significant effect on the birth weight and length. The effect of these social factors on at least one of the anthropometric parameters sustains their definite influence on the birth size. The mothers in the high SES are more likely to be educated, attend antenatal clinics and receive nutritional advice during pregnancy and would thus tend to have bigger babies.

The multivariate logistic regression model of the maternal socio-demographic factors on the babies' weight, length and OFC showed that the factors had the most predictive power on weight, followed by length and OFC. In contrast to a similar model by Ebomoyi *et al*,[16] where several maternal socio-demographic variables significantly influenced birth weight, only maternal weight and BMI independently had significant impact on birth weight in our study. Maternal weight was consistent in predicting birth length and OFC, but its power of prediction was much more for the babies' weight as shown by the R^2, 54.30 percent for weight and 26.86 percent and 18.81 percent respectively for length and OFC. The maternal size especially the weight, had a greater impact on the baby's anthropometric indices than the socio-economic variables. This finding of the effect of maternal weight on the baby's anthropometric indices was similarly noted in the Ilorin and Indian series.[16,23]

In this study, the values of the various anthropometric indices appear to be higher than those from an earlier study conducted in the study locale.[17] The mean birth weight for males and females of 3.277 kg and 3.151 kg respectively in this study, were higher than the 3.154 kg and 3.072 kg for males and females respectively, recorded by Ogbeide *et al*[17] in the same locale over 20 years ago. The difference may have been due to improvement in socioeconomic situation possibly translating into improvement in the nutrition of the mothers in our study.

Our findings on birth weight are comparable to those in a more recent study by Onyiriuka[28] in 2006 in a mission hospital in Benin where the mean weight of 3.249 kg in the babies delivered during the dry season was similar to the mean weight in our study. The mean birth weight of babies in our study was slightly higher than the 3.1kg recorded in a Jos study,[29] the 3.17kg obtained in a multicentre study in eastern Nigeria,[30] the 3.167 kg at Ilorin[31] and the 3,065 kg reported from Sokoto.[15] The lower value in the Jos study might have been due to the high altitude of the study locale and inclusion of preterm babies in the study population. On the other hand, the eastern Nigerian and Sokoto studies like our own, included term babies only; therefore the differences observed with respect to the latter studies may be attributable to probable differences in socioeconomic environments.

While the mean occipitofrontal circumference in this study of 34.1 ± 1.7cm, compares favourably with one of 34.2 ± 2.6cm in an earlier series reported from Benin,[18,19] it is slightly higher than the 33.8 ± 2.9cm and 33.7 ± 2.4cm recorded in Jos[29] and Cameroonian studies,[1] respectively. The lower figure reported from Jos may have been due to the inclusion of preterm babies, while the present study considered term babies only. Several reports on the anthropometry of Indian babies have revealed smaller sizes in comparison to babies born elsewhere suggesting a racial reason for the difference. The mean birth length of 49.3 ± 2.4 cm in babies in our study was higher than the 47.2 ± 5.0 cm recorded in the Jos study.[29] Again, the inclusion of preterm babies in the study population might have been responsible.

In conclusion, the maternal BMI and weight had the most impact on birth weight, length and OFC. These factors had a higher predictive power on the birth weight than the birth length and OFC. The mean weight in the present study while comparing favourably with previous studies carried out in recent times in the study locale was however, slightly higher than the mean weight of babies reported decades ago in the same locale.

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