International Journal of Medicine and Biomedical Research
Volume 1 Issue 3 September – December 2012
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Original Article

Predictability of offspring birth weight using simple parental anthropometrics in a government hospital in Lagos, Nigeria

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Received: 29.09.12; Accepted: 17.10.12

ABSTRACT

Background: Birth weight is of interest to quantitative geneticists and to obstetricians being one of the most important complex traits that determine perinatal outcome. Moreover, It is a predictor of mother's and baby's health later in life. Accuracy of prediction of baby's birth weight is therefore central to perinatal success and the quality of life of the baby in adulthood. Current intrauterine procedures including ultrasonography are of inadequate predictive values. The possibility of combining parental anthropometric data with already existing predictive methods such as ultrasonography may increase accuracy of birth weight prediction for better peri- and postnatal management of low or high birth weight. **Aim:** The aim is to determine the parental anthropometric predictors of baby's birth weight in Lagos, Nigeria. Using parental explanatory variables to predict baby's weight could complement the already existing predictive methods such as ultrasonography for more accurate prediction of birth weight. **Methods and Materials:** Parental parameters such as weight, height, BMI and other anthropometric attributes were obtained from 250 couples. Baby's birth weight was taken immediately after birth. **Results:** Only three parental factors were needed to substantially predict offspring birth weight. These include mid-paternal weight which was the most explanatory variable, followed by parity, and then maternal weight. **Conclusion:** Complementing ultrasonographic and other data with information from parental variables, especially mid-paternal weight, parity and maternal weight might improve accuracy of prediction of low birth weight or macrosomic babies and therefore a reduction in perinatal failure.

Key words: Birth weight, anthropometrics, macrosomia, predictability, Nigeria

INTRODUCTION

The basic question in this investigation is: To what extent can the birth weights of babies be predicted from parental adult anthropometric parameters? This question is of great interest in obstetrics and public health, because birth weight is central to perinatal outcome, infant survival and development.[1] Like many other quantitative phenotypes, birth weight is a complex character determined by multiple genes and several environmental factors.[2] In many human societies, the first question that is often asked after knowing the sex of a newborn baby is: "What is the baby's weight?" This indicates the importance of birth weight as one of the most important neonatal anthropometrics. According to common knowledge and popular assumption, a big baby is a healthy baby.

In clinical medicine, neonatal birth weight is also of considerable significance as an indicator of perinatal survival and a predictor of health in infancy and later in life. It has been shown that birth weight is related to a wide range of health variables such as later blood pressure,[3] grip strength,[4] social adjustments,[5] psychosocial distress,[6] and intelligence.[7] Specifically, low birth weight is related to an increased risk of coronary heart disease, diabetes, hypertension, and intellectual impairment later in life.[8] High birth weight has been identified as a risk factor for some childhood leukemias and certain cancers that develop in adulthood.[9,10] Furthermore, Paltiel *et al.*[11] recently reported that mothers of babies with high birth weight are also at risk of leukemia.

It is now well established that genetic and environmental factors play important roles in determining a baby's body weight at birth;[2] however, there is still some disagreement as regards differential paternal and maternal contribution to birth weight. For instance, Magnus *et al*.[12] reported that paternal birth weight has a greater influence on offspring birth weight than maternal birth weight. In contrast, Grifith *et al*.,[13] in a more recent study, concluded that maternal weight contributed more significantly to offspring's birth weight than paternal weight. Such discrepancies might be a reflection of considerable inter- and intra-population heritability and environmentality of birth weight.

Currently, in several quantitative genetic studies, attempts are being made to establish heritability estimates for birth weight in many populations, especially in Caucasian populations.[2,9,12] Such estimates might be useful in predicting high or low birth weights in such populations. However, heritability is a population parameter, and it therefore depends on population-specific factors such as allelic frequencies, effect of gene variants, and variation due to environmental factors that usually vary from population to population. Thus, heritability and predictability of birth weight are expected to be different between populations, and, therefore, results from one population cannot be extrapolated on the other. Extensive literature search indicated that while there are many reports on parental contribution, heritability and, therefore, predictability of birth weight in many Caucasian populations, little or no reports were found on most African populations especially on Nigerian and other African populations.

The present study was therefore carried out to determine predictability of offspring birth weight from simple, non-invasive, and easy-to-measure parental anthropometric parameters that include body weight, height and body mass index (BMI). If the results from the study suggest that offspring birth weight is predictable from such parental parameters, current predictive strategy including ultrasonography should be complemented with parental anthropometrics and other easily accessible data (e.g. parity) from parents for more accurate prediction of birth weight. This may increase accuracy of prediction of low or high birth weight for better prenatal and perinatal management.

MATERIALS AND METHODS

Subjects and administration of questionnaires

A random sample of 730 couples was initially included in the study. The mothers were antenatal patients attending the Maternity Care Unit of the Lagos State General Hospital, Randle, Lagos, Nigeria. Ante-partum haemorrhage, uterine fibroid, or any other abnormalities of the uterus or placenta as determined by ultrasonography were some of the exclusion criteria. Mothers with medical conditions such as diabetes mellitus, hypertension, malnutrition, anaemia, HIV/AIDS, fibroid, cancer or any form of malignancy were also excluded from the study. Other exclusion criteria included smoking, manifestation of preeclampsia/eclampsia, late commencement of antenatals (later than 8 weeks gestational age), multiple births, and delivery of unhealthy baby. Ethical approval for the study was obtained from the Hospital Ethical Committee.

Questionnaire and their administration

After a thorough explanation of what the study entails to the subjects, they were asked to fill consent forms and then answer questionnaires. The questionnaire consists of 7 sections as follow: personal information, obstetric history, family social history, medical history, delivery information, maternal and paternal parameters. Sections 1-3 were filled by the subjects while sections 4-7 were completed by the authors. After thorough screening of the subjects, 430 subjects failed the inclusion criteria. Thus, only 300 couples that satisfied the inclusion criteria had their data fed into the computer for statistical analysis.

Measurement of offspring birth weight and parental anthropometrics

The body weight of both parents was obtained using a multipurpose scale. At the time of measurement, it was ensured that nothing was put on except a very light garment in order to get their body weight as accurately as possible. The body weight of the baby was taken using a baby scale after cleaning the baby of blood and other post-delivery fluids. To avoid major influences on birth weight associated with multiple births, only singleton births were considered. Preterm births were excluded from the analysis. Parental body mass index (BMI) was calculated using the formula below:

BMI (kg/m^2) = weight (kg)/height (m^2)

Mid-Parental parameters, for instance, mid-parental weight, were calculated as an average weight of both parents using the formula below:

Mid-Parental Weight = (Paternal weight + maternal weight)/2

Data analysis

The sample size (n) was determined using:

$$n = [(Z_{\alpha/2})^2 P(1-P)]/E^2$$

Thus, given a population proportion (P) of 0.5 with a margin of error (E) of 0.07 at 95% confidence level i.e. $Z_{\alpha/2}$=1.96, the appropriate sample size (n) was found to be 196 couples (taking a couple as a unit). In view of this, the sample size of 250 couples used for this study was considered adequate.

Ten variables (Table 1) were subjected to statistical data analysis in the study. Baby's birth weight was the dependent variable while others were the independent predictor variables obtained from the parents. The raw data were analyzed statistically using Microsoft Excel (Version 2010) and IBM SPSS Statistics (Version 19) software packages. The initial analysis was to obtain descriptive statistics of the data. Comparison of mean$\pm$SE was by Student's t-test.

Descriptive statistics was followed by simple correlation procedure to generate a pairwise correlation matrix. Based on the result of correlation analysis, dimension reduction using principal component analysis was done to remove redundant highly correlated variables from the data to produce smaller number of uncorrelated variables which could effectively explain and predict birth weight. The procedure involved partial correlation analysis within each component to determine the variable that correlated most highly with birth weight. Models generated through unstandardized and standardized multiple regression procedure were subjected to analysis of variance (ANOVA) to see how well the regression equations model the dependence of birth weight on parental predictor variables. Validity of the generated model was assessed through a hierarchical clustering algorithm using single linkage method to produce a cluster tree. In all cases involving data analysis, *p*<0.05 was considered statistically significant.

RESULTS

The distribution (Figure 1a) and the mean+birth weight of male babies was not significantly different from that of female babies (P>0.05). The respective variances (male=0.17; female=0.20) were also not significantly different (F ratio=1.13; P>0.05). Therefore, to increase the power of analysis, the birth weight data of babies were combined irrespective of gender. The distribution of the pooled birth weight was approximately normal as could be observed in Figure 1b.

The descriptive statistics of birth weight (the dependent variable or DV) and other variables (the independent variables or IVs) were summarized in Table 1. Men were generally taller and weigh more than their wives as revealed by their mean height and body weight (P<0.05). Judging from the coefficient of variation, parity showed the greatest variability (coeff. of var.=55.5) while mid-parental height showed the least (coeff. of var.=4.4). The frequencies of low and high birth weight were 13(5.2%) and 3(1.2%) respectively. The mean$\pm$SD weight of babies with low birth weight was 2.24$\pm$0.33kg while the mean$\pm$SD value of babies with high birth weight was 4.17±0.06kg. The pooled mean birth weight (3.17±0.43kg) was located between the two extremes as expected.

Many of the studied variables showed intercorrelations as shown in Table 2. Mid-parental height and maternal height were the most correlated variables ($r=0.899$; $P<0.001$). Other pairs of highly correlated variables included mid-parental height/paternal height ($r=0.874$; $P<0.001$), mid-parental weight/maternal weight ($r=0.862$; $P<0.001$), and mid-parental weight/paternal weight ($r=0.776$; $P<0.001$).

Maternal height and parity had the least correlation coefficient of 0.0 and may therefore be considered as the most uncorrelated pair among the studied variables. Principal component analysis (PCA) revealed that the 9 predictor variables can be reduced to 3 components (Table 3). The 3 components explained 86.2% of the variation observed in the data; this implied only 13.8% loss of detail. Considering a factor loading with an absolute value greater than 0.3 as significant, mid-parental height, mid-parental weight, and parity were the variables with the most significant loading on their respective components. In order to prevent multicollinearity, maternal weight was chosen as the representative predictor variable in component 2, because mid-parental height also had significant loading with component 1. Thus, the most explanatory variables of birth weight were considered to be mid-parental weight, maternal weight, and parity.

The result of partial and simple correlation analysis between each factor and birth weight within a particular component is shown in Table 4; the Table revealed differences between partial and simple correlation coefficients, because many correlations observed, when simple correlation analysis was done, vanished under partial correlation analysis. Standardized multiple regression equation that models prediction of offspring birth weight from parental parameters was found to be:

$$Y = 0.255X_1 + 0.044X_2 + 0.097X_3$$

($F=8.53$; $P<0.001$)

where Y=birth weight, X_1 = mid-parental weight; X_2 = maternal weight and X_3 = parity

Hierarchical clustering using the extracted independent variables produced a cluster tree with 2 major clusters (Fig. 2): Parents of babies with low birth weight clustered separately as one group (Low) while parents of babies with high birth weight clustered as another group (High).

Table 1: Descriptive of Parental and Offspring Parameters Considered in the Study

	Min.	Max.	Range	Mean	Std. Dev.	Coef. of Var.
Paternal Wt.(kg)	60	101	41	78.28	6.845	8.7
Maternal Wt. (kg)	42	90	48	68.10	8.519	12.5
Parity	1	6	5	1.63	0.904	55.5
Paternal Ht.(cm)	150	196	46	173.94	7.948	4.6
Maternal Ht. (cm)	139	198	59	168.11	8.833	5.3
Birth weight (kg)	1.2	4.2	3.0	3.173	0.4320	13.6
Paternal BMI (kg/sqm)	14.5	35.1	20.6	25.896	2.6589	10.3
Maternal BMI (kg/sqm)	14.8	46.6	31.8	24.283	3.8031	15.7
Mid-Parental Wt. (kg)	57.0	89.0	32.0	73.190	6.3286	8.6
Mid-Parental Ht. (kg)	145.0	197.0	52.0	171.024	7.4460	4.4

DISCUSSION

Birth weight is a complex trait under the control of several genetic and environmental factors.[1,2] Thus, predictability of birth weight using parental parameters is best accomplished by multivariate data analysis. The purpose of simple pair-wise correlation analysis to generate a correlation matrix was to see if there was multicollinearity between the independent variables. This was an important consideration because a model consisting of intercorrelated variables has doubtful validity. The results of simple correlation analysis actually revealed multicollinearity or intercorrelation between several variables being studied. This might reflect the mating pattern for some physical traits such as weight and height in Lagos, possibly, in Nigeria. For instance, a highly significant correlation between paternal weight and maternal weight was observed. This does not agree with the observation of Magnus et al.[12] that paternal-maternal correlation for weight was low in his study of Norweigian population. The significant positive spousal correlation between paternal weight and maternal weight in this study might reflect positive assortative mating for weight in Nigeria. If studies in other populations show different trends, it may be suggested that mating pattern for body weight is different from population to population. It had long been pointed out by Falconer [15] that assortative mating is of importance in human populations, where it occurs with respect to stature and some other attributes.

Table 2: Correlation Matrix Showing Intercorrelations between the Studied Variables

	Paternal Wt.(kg)	Maternal Wt. (kg)	Parity	Maternal Ht. (cm)	Birth Wt (kg)	Mat. BMI (kg/m²)	Paternal Ht.(cm)	Mid-Par. Wt. (kg)	Mid-Par. Ht (kg)	Pat. BMI (kg/m²)
Paternal Wt.(kg)	1	0.35**	-0.00	0.25**	0.21**	0.11	0.46**	0.78**	0.39**	0.46**
Maternal Wt. (kg)		1	-0.02	0.22**	0.26**	0.68**	0.08	0.86**	0.17**	0.25**
Parity			1	0.00	0.09	-0.03	0.09	-0.02	0.05	0-.06
Maternal Ht. (cm)				1	0.08	-0.53**	0.57**	0.28**	0.90**	-0.28**
Birth weight (kg)					1	0.14*	0.10	0.29**	0.10	0.06
Maternal BMI (kg/m²)						1	-0.36**	0.51**	-0.50**	0.42**
Paternal Ht.(cm)							1	0.30**	0.87**	-0.51**
Mid-Parental Wt. (kg)								1	0.33**	0.42**
Mid-Parental Ht (kg)									1	-0.44**
Paternal BMI (kg/m²)										1

Significant Correlation: *P<0.05; *P<0.001.

Table 3: Factor Loading of the Independent Variables into three Components

	Components		
	1	**2**	**3**
Paternal Wt.(kg)	0.358	0.717	-0.245
Maternal Wt. (kg)	0.027	0.871	0.152
Parity	0.035	0.016	0.878
Paternal Ht.(cm)	0.882	0.120	0.134
Maternal Ht. (cm)	0.870	0.101	-0.064
Paternal BMI (kg/m^2)	-0.502	0.551	-0.350
Maternal BMI (kg/m^2)	-0.612	0.665	.176
Mid-Parental Wt. (kg)	0.212	0.974	-0.030
Mid-Parental Ht (kg)	0.987	0.124	0.034

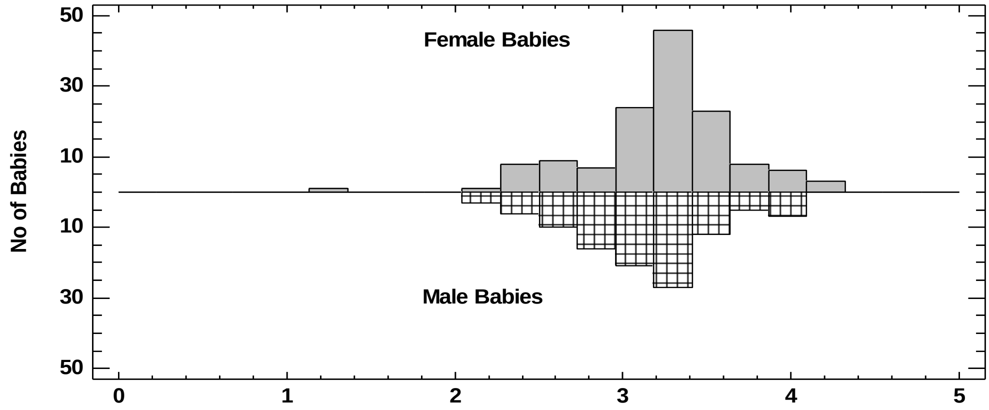
Table 4: Simple and Partial Correlations between Parental Variables and Baby's Birth weight

	Birth weight					
	Component 1		Component 2		Component 3	
	Zero-Order	Partial	Zero-Order	Partial	Zero-order	Partial
Mid-Parental Height (cm)	0.102 (0.109)	0.000				
Paternal Height (cm)	0.103 (0.104)	0.029 (0.657)				
Maternal Height (cm)	0.079 (0.215)	0.000				
Paternal Weight (kg)	0.213 (0.001)	-0.035 (0.587)				
Mid-Parental Weight (kg)	0.292 (<0.001)	0.206 (0.001)				
Maternal Weight (kg)			0.262 (<0.001)	0.228 (<0.001)		
Maternal BMI (kg/m^2)			0.143 (0.025)	-0.050 (0.435)		
Paternal BMI (kg/m^2)			0.058 (0.360)	0.009 (0.883)		
Parity					0.092 (0.152)	0.107 (0.094)

Table 5: Extracted Factors of Parents of Low and High Birth weight Babies.

	Mid-Parental Weight(kg)		Maternal Weight(kg)		Parity	
	Low	High	Low	High	Low	High
Mean	71.8	73.2	66.5	74.0	1.4	1.3
Min.-Max.	63.5-80.0	68.0-77.5	55.0-76.0	68.0-80.0	1-3	1-2
Range	16.5	9.5	21	12	2	1
Std. Dev.	5.6	4.8	8.0	6.0	0.8	0.6

(1a): Distribution of Birth Weight of Male and Female Babies



1b: Approximation to Normality of Pooled Birth Weight of Male

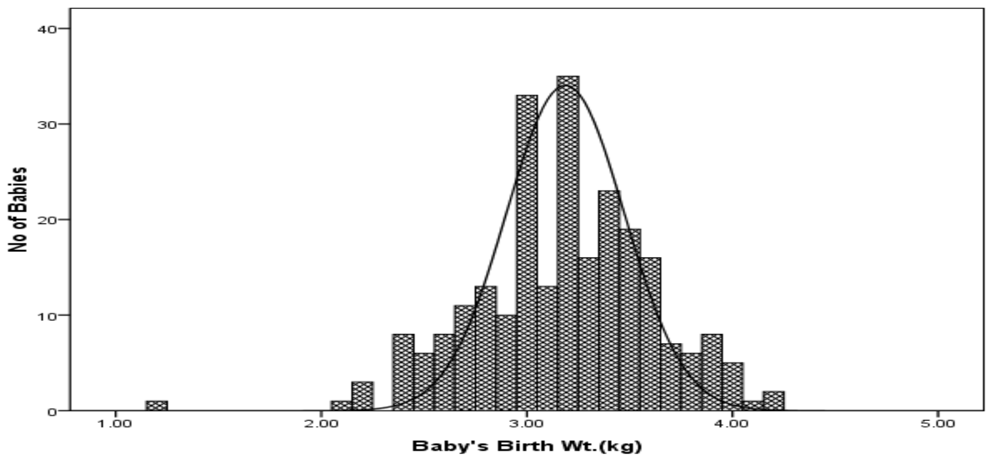


Fig. 1: Distribution of Birthweight of Babies Showing (1a) Similarity in the Distribution of Birth Weight of Male and Female and (1b) Approximation to Normality of Distribution of Pooled Birth Weight of Male and Female Babies

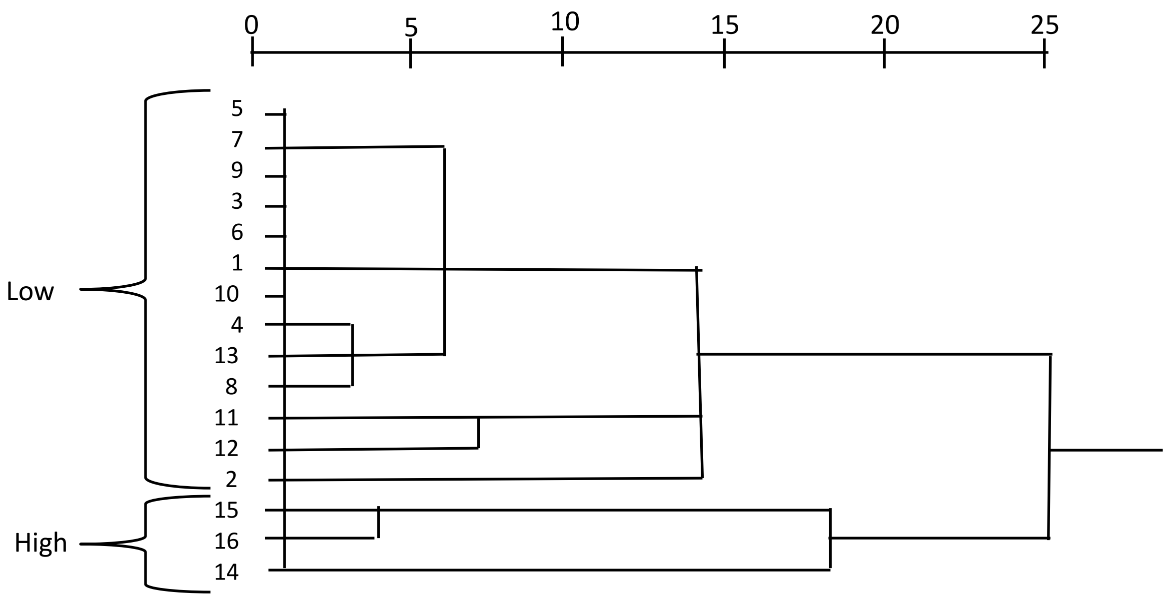


Fig. 2: A Dendrogram Produced from Hierarchical Cluster Analysis Showing Clustering of Parents into Two Major Clusters

The presence of multicollinearity necessitated dimension reduction using principal component analysis (PCA). Three components that explained 82.6% (a loss of 18.4% detail) of the variation were obtained. This was considered acceptable because producing a predictive model with a loss of 18.4% detail was better than generating an invalid model that explains 100% of variation in birth weight. From the multiple regression analysis that was carried out after PCA, it was observed that only three parental variables were important in predicting baby's birth weight. Since the partial regression weights associated with each variable in the model was an indication of the importance of the independent variable in predicting birth weight, the order of significance of the parental variables was observed to be: mid-parental weight>parity>maternal weight. This model appear to be better than chance in predicting birth weight because the p-value was very low (P<0.001). This opinion was further strengthened by hierarchical clustering algorithm that produced two major clusters: one for parents of babies with low birth weight and the other for parents of babies with high birth weight. It should be noted that parity was included in the model despite the fact that it is not an anthropometric variable; it was included in view of the significant regression weight associated with it in the generated model. Moreover, parity is parental information that is easily obtainable along with other parental anthropometric data during antenatal period.

In an earlier study by Magnus *et al*.[12] they concluded that paternal birth weight is a very good predictor of offspring birth weight when compared to other explanatory variables. In contrast, a recent report by Grifiths *et al*.[13] indicated that maternal adult weight exerts a greater influence than paternal adult weight on birth weight. The reason for this discrepancy is not yet clear; it could have been more elucidating if these earlier workers had considered mid-parental variables such as mid-parental weight in their studies. A contribution of this study is that mid-parental weight was the most explanatory variable of baby's weight. Its inclusion in birth weight prediction may be recommended at least in Nigerians living in Lagos.

ACKNOWLEDGEMENT

We thank the staff of Lagos State General Hospital, Randle, Lagos. We specially appreciate the efforts of nurses and doctors in the Maternity Ward of the hospital.

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doi: http://dx.doi.org/10.14194/ijmbr.138

How to cite this article: Taiwo I.A, Akinde O.R. Predictability of offspring birth weight using simple parental anthropometrics in a government hospital in Lagos, Nigeria. Int J Med Biomed Res 2012;1(3):206-214.

Conflict of Interest: None declared