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Prediction of low birth weight from other anthropometric parameters in Nnewi, south eastern Nigeria

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Abstract *Background:* Low birth weight is a global problem but presents a major burden on the neonatal services in developing countries such as Nigeria, and brings to bear a greater strain on the meagre resources available for health care delivery and family financing. In a resource-constrained setting as ours, proper weighing of all newborn infants and medical surveillance of low birth weight infants, although highly desirable, are often not achieved due to unavailability of suitable, functional weighing scales. There are serial cut-off points for the various anthropometric indices for the normal birth weight babies below which any baby is termed low birth weight. This study assessed the predictive values of anthropometric measurements in the detection of low birth weight newborn babies and also determined the local specific cut-off points for these measurements in Nnewi, Southeast Nigeria.

Methods: This was a cross-sectional study in which length, occipitofrontal circumference, mid-arm circumference and maximum thigh circumference of 428 singleton babies were ascertained within 24 hours of delivery. Data were analysed using the Statistical Package for Social Sciences (SPSS) software. Correlation and linear regression analyses were done to examine the linear relationship between the predictors and birth weight. The sensitivity, specificity and predictive values were calculated at serial cut–off points and the points of best discrimination determined.

Results: The low birth weight prevalence was 15.2%. Maximum thigh circumference attained the highest correlation with birth weight (r = 0.904), greatest coefficient of determination (r^2=0.817), and least measure of dispersion around the actual birth weight. Thus maximum thigh circumference, which has a cut-off point of 16.75cm, was the best predictor of low birth weight, with 98.5% sensitivity, 92.3% specificity and diagnostic accuracy of 93.2% (P<0.001).

Conclusion: Routine measurements of maximum thigh circumference in resource-poor countries is an effective proxy for weight at birth in prenatal assessments and epidemiologic surveys.

Key words: anthropometric parameters, low birth weight, newborn, Nigeria

Introduction

Low birth weight (LBW) defined as weight at birth below 2500g[1] is a global problem, but developing countries of Africa, Asia and Latin America bear the brunt of the clinical problems[2]. WHO/UNICEF[3] reported that 15.5 per cent of all births, or more than 20 million infants worldwide, are born with low birth weight. The level of low birth weight in developing countries (16.5 per cent) is more than double the level in developed regions (7 per cent). More than 95 per cent of low birth weight babies are born in developing countries. There is significant variation in low birth weight incidence across the main geographic regions, ranging from 6 per cent to 18 per cent. The highest incidence of low birth weight occurs in the subregion of South-Central Asia, where 27 per cent of infants are low birth weight. Overall, almost 70 per cent of all low birth weight births occur in Asia. Low birth weight levels in sub-Saharan Africa are around 13 per cent to 15 per cent, with little variation across the region as a whole. Central and South America have, on average, much lower rates (10 per cent) while in the Caribbean, the level (14 per cent) is almost as high as in sub-Saharan Africa. About 10 per cent of births in Oceania are low birth weight. Among the more developed regions, North America averages 8 per cent, while Europe has the lowest regional average at 6 per cent[3]. In Nigeria, a study in the Southwest[4] recorded a rate of 11.4% while another from the North[5] gave 12.2%.

Problems associated with LBW constitute a great strain on the meagre resources available for health care delivery and family financing. Identification of LBW is crucial as affected infants, either preterm or growth restricted, have higher than normal mortality in the neonatal and perinatal period. Even in survivors, a high risk of growth retardation and of impaired mental development with attendant learning disabilities and attention disorders affecting their performance in school abound[6, 7]. LBW results from preterm and small for gestational age deliveries and is directly related to the anthropometric measurements of the new born babies[8,9].

In developing countries, it is estimated that approximately 60%-80% of births occur outside orthodox health care facilities[10,11]. Most deliveries take place either in private homes or in rural maternities and are attended by relatives, neighbours or ill-equipped attendants. This is probably responsible for the finding that as simple as the weighing procedure is, about two-thirds of newborn babies in Sub-Saharan Africa are not weighed at birth[12]. Some primary health care centres and secondary health facilities may lack suitable, functional, weighing scales, hence the need to find alternative ways of identifying low birth weight babies. Anthropometric techniques like body length, occipitofrontal circumference, mid-arm circumference, maximum thigh circumference, calf circumference and foot length require the use of measuring tapes and are relatively simple to perform. This confers on them a major advantage over the use of routine analogue weighing scales in determining LBW in infants.

Several studies have shown that some simple anthropometric measurements at birth can reliably predict birth weight and can be used as valid indicators of LBW[13-15]. There are serial cut-off points for the various anthropometric parameters for normal birth weight babies, below which any baby is termed low birth weight. Information concerning the relative values of these measurements in the identification of those at risk for postnatal morbidity and mortality in Southeast Nigeria is lacking. The World Health Organization (WHO)[14, 16] in consonance with other workers[8,17,18] have recommended that countries should derive their own serial cut-off points for determining LBW using anthropometric measurements. This stems from the observation of variations in values in different localities and different ethnic groups resulting from perceived differences in psychosocial, economic and demographic variables by many researchers[7,8].

The current study was carried out to evaluate the predictive values of alternative anthropometric measurements of length, occipitofrontal circumference, mid-arm circumference and maximum thigh circumference of the newborn babies) in detecting LBW babies and also to determine the local specific cut-off points for these measurements in Nnewi, Southeast of Nigeria.

Subjects and methods

The study site was Nnamdi Azikiwe University Teaching Hospital (NAUTH), Nnewi, a tertiary health institution located in Anambra state, Southeast Nigeria. It offers maternal and child health services to people of the town, and constitutes a major referral centre for all hospitals in the state and indeed some neighbouring states in Nigeria.

The study design was cross-sectional involving babies delivered at the maternity unit of NAUTH Nnewi, and the neonates admitted into the Special Care Baby Unit from other hospitals. Consecutive recruitment of all singleton, live-born infants and those referred to the Special Care Baby Unit during the study period was carried out. All assessments were done within 24 hours of delivery of those babies after informed parental consent. Stillborn babies, infants with clinically evident congenital anomalies, those with oedema and asymmetry of the extremities from any cause were excluded from the study for obvious reasons. Parents were given the liberty to withdraw at any stage of the research, however, none declined. Ethical approval for the research was given by the Ethics Committee of the hospital. Data was collected over a 6- month period from a total number of 428 babies. Measurements taken were birth weight, maximum thigh circumference, length, occipitofrontal circumference and mid-arm circumference using standard methods[16]. All circumferences were assessed to the nearest 0.1cm with non-stretchable plastic coated insertion type circumference tapes.

Birth weight (BW): BW was assessed with a Salter spring scale (0-10kg), a simple to use tool with a sensitivity of 0.1kg. The balance was tested against standard set of weights at the onset of the study and weekly thereafter. Babies were weighed in a warm room without clothing or diapers.

Occipitofrontal circumference (OFC): The head was measured at the largest occipitofrontal diameter with the tape passing above the supraorbital ridges and glabella anteriorly, and the occiput posteriorly.

Length (L): Length was measured using a horizontal stadiometer to the nearest 0.1cm.

Mid-arm circumference (MAC): MAC was taken at the mid-point between the tip of the acromium and the olecranon process of the bare left upper arm, gently to avoid compression of the soft tissue[6,7] the tape being snugly applied around the arm.

Maximum thigh circumference (MTC): This was measured with the infant lying supine and without a diaper. The tape was then placed around the circumference of the left thigh which was a little extended at the hip joint. The tape is placed anteriorly below and parallel to a line that runs from anterior superior iliac spine to the pubic symphises, through the medial side of the thigh to lie at the level of the lowest crease in the gluteal region posteriorly, with the tape lying perpendicular to the long axis of the lower limbs.[19]

Statistical analysis

Data were entered, validated and analysed using the Statistical Package for Social Sciences (SPSS) software version 18. Correlation and linear regression analyses were done to examine linear relationship between two or more continuous variables. For validity testing, the sensitivity, specificity, positive predictive value and negative predictive values were calculated at serial cut-off points. To define the cut-off point which best discriminates between low birth weight and normal birth weight, the value which yielded the highest accuracy, or percentage of correct classification was determined. Also using the chi-square analysis and the student t test, the accuracy of all the variables in identifying LBW infants were compared. Probability (p) value less than 0.05 was considered statistically significant.

Results

Four hundred and twenty eight Igbo neonates were recruited for the study. Using the World Health Assembly cut-off value of <2500g, a total of 65(15.2%) babies were LBW. Table 1 shows the means, standard deviations and ranges of anthropometric variables.

Table 1: Anthropometric data of the 428 neonates studied

Anthropometric Parameter	Range	Mean ± SD
Birth Weight (kg)	0.8 – 5.00	3.066 ± 0.686
Length (cm)	33.50 - 59.00	49.60 ± 3.93
Occipitofrontal circumference (cm)	23.00 - 44.00	34.12 ± 2.25
Mid-arm circumference (cm)	6.00 - 14.00	11.06 ± 0.49
Maximum thigh circumference (cm)	9.00 - 24.00	17.89 ± 2.52

Table 2 indicates that all the anthropometric variables had significant, linear, positive correlation with birth weight ($p < 0.001$). MTC attained the highest correlation with birth weight ($r = 0.904$) while OFC attained the lowest ($r = 0.818$).

Table 2: Correlation between birth weight and anthropometric variables of the neonates

Anthropometric Variables (cm)	Pearson Correlation Coefficient (r)	P-Value
Length	0.828	<0.001
Occipitofrontal circumference	0.818	<0.001
Mid-arm circumference	0.871	<0.001
Maximum thigh circumference	0.904	<0.001

Table 3 shows that MTC had the highest coefficient of determination (r^2 value= 0.817) while OFC (r^2 value = 0.668) had the smallest value. This implies that MTC has the highest proportion (81.7%) of variation in weight that could be explained by difference in MTC. For MTC, over 95% of the data fell within two standard errors of the estimates of the predicted value.

Table 3: Simple Linear Regression analysis of the anthropometric parameters of the neonates

Predictor Variables (cm)	R^2	Measure of dispersion	Constant	Unstandardized coefficient (95% CI)	p-value
Length	0.685	0.770	– 4.104	0.144 (0.135, 0.154)	<0.001
OFC	0.668	0.790	– 5.444	0.249 (0.233, 0.266)	<0.001
MAC	0.759	0.674	– 1.389	0.403 (0.381,0.424)	<0.001
MTC	0.817	0.586	– 1.333	0.246 (0.234,0.257)	<0.001

R^2 = Coefficient of determination
L = Length
OFC = Occipitofrontal circumference
MAC = Mid-arm circumference
MTC = Mid-thigh circumference

Table 4 demonstrates that length of 48.6cm, OFC of 34.15cm, MAC of 10.5cm and MTC of 16.75cm were the corresponding cut-off values with the best combination of sensitivity, specificity and predictive values ($p < 0.001$) for identifying infants with birth weights of <2500g. Furthermore, the table illustrates the superiority of MTC over other anthropometric indicators in the identification of LBW with 98.5% sensitivity, 92.3% specificity and diagnostic accuracy of 93.2% ($p<0.001$). The order of superiority of the anthropometric indicators was MTC > MAC > Length > OFC.

Table 4: Best cut-off points of anthropometric indicators for detecting neonates with birth weight less than 2500g

Anthropometric indicators (cm)	Cut-off value (cm)	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Diagnostic accuracy (%)
Length	48.60	93.85	80.72	46.57	98.65	82.71
OFC	34.15	96.92	55.10	27.88	99.01	61.45
MAC	10.50	98.46	87.60	58.72	99.69	89.25
MTC	16.75	98.46	92.29	69.57	99.70	93.22

Discussion

The findings in this study are in agreement with those of several previous studies on the reliability of different anthropometric measurements specifically MTC and MAC in the estimation of BW in a newborn population in Nigeria. The high prevalence rate of LBW 65(15.2%) found in this study though smaller than the 37.15% and 17.26% reported by Gozal et al[8] in Cameroon and Ezeaka et al[17] in Lagos respectively, may reflect the prevailing medical and demographic, environmental and socioeconomic conditions in Nnewi Southeast of Nigeria vis à vis the West African subregion [20-22]

The mean birth weight of 3.060 ± 0.686 and a range of 0.8 – 5kg recorded in this study is similar to the 3.046 ± 656 reported by Ezeaka et al[3] in Lagos, the WHO[23 , 24] and some other authors for Nigerian neonates. However, this figure is higher than the mean birth weight ranges reported for the Indian subcontinent (2.493 ± 0.477)kg and 2694g ± 698 reported by Gozal et al[8] in Cameroon but lower than the mean birth weight recorded for British (3650g) and North American (3300g) infants. These variations in mean birth weight could be explained by racial differences of the babies and a reflection of nutritional and economic conditions prevalent in those areas. A study by Goldenberg et al[9] showed that in America, intrinsic and extrinsic factors associated with race account for smaller black babies and for much of the racial differences in birth weight.

The mean anthropometric measurements recorded among the neonates in this study corroborate the findings of other authors.[20, 26, 27] The mean MTC of 17.89 obtained in this study is comparable to the figure of 17.59cm with a mean birth weight of 3.046kg reported by Ezeaka et al[17] in Lagos. However both mean MTC values from Nigeria are higher than 15.10cm (mean birth-weight 2679g) and 16.02cm (mean birth-weight 2875g) reported by Hugue et al[26] in Bangladesh and Shahidullah et al[27] in India respectively. The mean MAC value of 11.06cm recorded in this study is higher than the mean MAC value of 10.4cm (mean birth-weight 3.046cm), 10.30cm (mean BW 2.917kg) and 10.03cm (mean BW 2694g) reported by Ezeaka et al[17], Ngowi et a[13] and Gozal et al[8] respectively.

This study proves that a strong positive correlation exists between birth weight and other anthropometric variables ($p<0.001$). This agrees with the results of similar studies done by various authors[13, 14]. The findings also show that MTC has the highest correlation with birth weight ($r = 0.904$) while OFC has the least ($r=0.818$). Ezeaka et al[17], Sharma et al[19] and Shahidullah et al[27] showed similarly strong correlations between birth weight and MTC, with coefficients, r = 0.95, 0.918 and 0.845 respectively. A correlation for MAC of $r = 0.871$ from this study compares favourably with correlation for MAC with coefficients of (r) = 0.88, 0.91, 0.811 and 0.842 reported by Ezeaka et al[17], Gozal et al[8], Bhargava et al[28] and Hugue et al[26] respectively.

The establishment of specific cut- off points for each anthropometric variable for each country and a given locality has been recommended by many authors[13,14,18,28] to enable optimal identification of LBW neonates who are born where proper weighing is not available and where mortality rates are high. The present study has shown that length of 48.6cm, OFC of 34.2cm, MAC of 10.5cm and MTC of 16.8cm were the best cut-off points for identifying LBW. These values are marginally higher than the values of length of 47.7cm, OFC value of 33.6cm, MAC value of 9.6cm and MTC of 15.5cm reported by Ezeaka et al[17] in Lagos. This could be explained by the marginally higher mean birth weight of babies born in Nnewi compared to Lagos(3.06 ± 0.686 and 3.046 ± 0.656 respectively).

This same reason of higher mean birth weight in this study will explain the higher cut-off values of 10.5cm for MAC than the MAC cut-off value of 9.5cm retained by Gozal et al[8] in Cameroon and by Sauerborn et al[18] in Burkina Faso. The values recorded for the Indian subcontinent are even significantly lower for the same reason. Sharma et al[19] reported a cut-off value of ≤ 14.5cm for MTC and ≤ 8.6cm for MAC for the Indian subcontinent with a mean birth weight of 2.493 ± 0.477kg when compared with that of 3.066 ± 0.686kg in the present study. The establishment in each country and locality of their specific cut-off points i.e. normative data on the various anthropometric measurements and their relative predictive values as recommended by WHO[14, 16] and other studies[13, 18] seems therefore justified.

Conclusion

In conclusion, measurements of application of the cut-off points for MTC and MAC in our locality where the majority of the neonates are delivered by traditional birth attendants who lack both the skills and scales necessary for weight determination can effectively be used as surrogates for LBW. Infants whose anthropometric measurements fall below the identified cut-off values should be considered as high risk for early postnatal diseases requiring immediate medical intervention, thereby, increasing their chances for survival and optimal development. This could serve as a selective criterion for either early neonatal discharge or continuing medical surveillance. This policy would ultimately lead to earlier treatment and would possibly result in a reduction of the present unacceptably high third world infant mortality and morbidity rates.

Author's Contributions

Achebe C: Conceptual design of research; data collection and management; paper write-up.

Ugochukwu EF: Data management; vetting and final write-up of the study.

Adogu POU : Statistical analysis and presentation.

Ubajaka C: Data collection and collation.

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References

1. World Health Organization. International Classification of Diseases 1975 Revision. Vol. 1. Geneva, WHO, 1977.
2. Mosly WH, Chen LC. An analytical framework for the study of child survival in developing countries. *Bull World Health Org 2003; 81(2): 140-145.*
3. UNICEF/WHO 2004 NEW REPORT: Low birth weight - Country, regional and Global Estimates.
4. Olowonyo T, Oshin S, Obasanjo-Bello I. Some Factors Associated with Low Birth Weight in Ogun state, Nigeria. *Niger Med Pract 2006; 49(6): 154-157.*
5. Wright EA. Low birth weight in the Plateau region of Nigeria. *East Afr Med J 1990; 67(12): 894-9.*
6. Kramer MS. The epidemiology of adverse pregnancy outcome: An overview. *J Nutr 2003; 133(5): 1592-1596.*
7. Development of indicators for monitoring progress towards health for all by the year 2000. Health For All Series. General WHO, 1981 (4) : 92
8. Gozal D; Ndombo PK, Ze Minkande J, Kago I, Ekpe T, Mbebe J. Anthropometric measurements in a newborn population in West Africa. A reliable and simple tool for the identification of infants at risk for early postnatal morbidity. *J Paediatr 1991;118: 800 –5.*
9. Goldenberg RL, Cliver SP, Cutter GR, Hoffman HJ, Cassidy G, Davies RO, Nelson KG. Black-White differences in newborn anthropometric measurements. *Obstetrics & Gynecology 1991; 78: 782-788.*
10. Nigerian Demographic and Health Survey (2003 NDHS). Maternal and Child Health; 121-123.
11. Isenalumhe A.E. Integration of TBA into Primary Health Care. *WHO Forum 1990;11: 192 – 8.*
12. Darmstadt GL, Hussein MH, Winch PJ, Haws RA, Gipson R, Santosham M. Practices of rural Egyptian birth attendants during the antenatal, intrapartum and early neonatal periods. *J Health Popn Nutr 2008; 26(1): 36 – 45.*
13. Ngowi JA, Lallinger RR, Hirji KF. An assessment of the use of anthropometric measurements for predicting low birth weight. *J Trop Paediatr 1993; 39: 356 – 60.*
14. WHO. Use of simple anthropometric measurements to predict birth weight: WHO collaborative study of birth weight surrogates. *Bull World Health Org 1993;71:157 – 63.*
15. Landicho B, Lechtigi A, Idein E. Anthropometric Indicators of low birth weight. *J Trop Paediatr 1985; 31: 301- 5.*
16. WHO: The use of and interpretation of anthropometric measurements. Technical Report Series, *Geneva 1995; 824:12-60.*
17. Ezeaka VC, Egri –Okwaji MT, Renner JK, Grange AO. Anthropometric measurements in the Detection of low birth weight infants in Lagos. *Niger Postgrad Med J 2003;10(3):168 - 7.*
18. Suaerborn R, Quiminga RM, Kone B, Sama R, Oepen C, Ebrahim G J. Neonatal MAC is a valid proxy for birthweight. *Trop Med Parasitol 1990; 41: 65-67.*
19. Sharma JN, Saxena S, Sharma U. Thigh circumference at birth as the best predictor of LBW babies. *Ind Pediatr 1989; 26:19-26.*
20. Kleinman JC, Kessel SS. Racial differences in LBW: trends and risk factors. *N Engl J Med 1987; 317: 403 – 8.*
21. Lieberman E, Ryan KJ, Monson RR, Schoenbann SC. Risk factors accounting for racial differences in the rate of premature birth. *N Engl J Med 1987; 317: 743 – 8.*
22. Behrman RE. Premature births among black women. *N Engl J Med 1987;317:763– 5.*
23. World Health Organisation. The Incidence of LBW: A critical review of available information. *World Health Stat Q 1980; 33: 197 – 204.*
24. World Health Organization. Public health aspects of low birth weight: Expert Committee on Maternal and Child Health. Technical Report Series 1981; 217
25. Effiong CE, Laditan A AO, Aiamakhu CE, Ayeni O. Birth weights of Nigerian children. *Nig Med J 1976; 6: 63 – 8.*
26. Huque F, Hussian AMZ. Detection of low birth weight newborn babies by anthropometric measurements in Bangladesh. *Ind J Pediatr 1991; 58: 223 – 31.*
27. Shahidullah MD. Birth Weight: relationship with other anthropometric parameters. *Ind Pediatr 1989; 21: 830 – 8.*
28. Bhargava S.K., Ramji S. Kumar A., Moham M, Marwah J. Mid-arm and chest circumference at birth as predictors of low birth weight and neonatal mortality in the community. *BMJ 1985; 291: 1617 – 9.*