

Neonatal Maximum Thigh Circumference Tape: An Alternative Indicator of Low Birth Weight

VC Ezeaka*, MTC Egri-Okwaji**, JK Renner**, AO Grange***

Summary

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Background: The birth weight of an infant is a significant determinant of morbidity. Birth weight measurement is not always feasible in developing countries thus necessitating alternative measurements as surrogates.

Objective: This study was undertaken to determine the most appropriate maximum thigh circumference (MTC) measurements corresponding to birth weights of <2500g and <2000g respectively, and to propose the design of a standardized tricoloured MTC Tape to identify low birth weight (LBW) neonates promptly, for appropriate intervention.

Methods: Anthropometric measurements were carried out on 788 neonates within 24 hours of delivery. The MTC measurements were then correlated with other anthropometric values. Based on the results obtained, a maximum thigh circumference tape that would be capable of distinguishing neonates with birth weights <2500g and <2000g, respectively, was proposed.

Results: The mean MTC of the neonates increased as the birth weights (F statistics = 80.66; $p < 0.0001$) and gestational ages increased (F statistics = 136.73; $p < 0.001$). A strongly positive correlation was obtained between birth weight and MTC ($r = 0.95$; $p < 0.0001$) with a regression equation of $y = 8.25 + 0.003x$, followed by MAC ($r = 0.86$), length ($r = 0.85$), gestational age ($r = 0.66$) and OFC ($r = 0.64$). MTC values of ≤ 15.5 cm and ≤ 14.9 cm had the best combination of sensitivity and specificity for predicting newborns with birth weights of <2500g and <2000g, respectively.

Conclusion: Using the cut-off values obtained, the neonates were categorized into three risk groups ("high risk", "moderate risk", and "low risk"), and a tricoloured MTC Tape was subsequently designed, using these inferences.

Key words: Maximum thigh circumference, low birth weight, indicator.

Introduction

THE birth weight of an infant is probably the single most important factor that affects neonatal mortality, as well as being the significant determinant of post neonatal infant and childhood morbidity.^{1,2} However, the determination of birth weight is not feasible in many developing countries due to the unavailability of suitable weighing scales.^{3,4} To overcome this, various

workers have proposed several anthropometric indices as possible surrogates for birth weight. These include length,^{4,5} chest circumference,^{5,6} head circumference,⁷ mid-arm circumference⁸⁻¹⁰ and foot length measurement.¹¹ The thigh circumference is another anthropometric parameter that has been used as a reliable and sensitive surrogate for birth weight.¹²⁻²⁰ Whereas some studies have shown the mid thigh circumference to be significantly correlated to birth weight,¹²⁻¹⁴ others have reported the maximum thigh circumference to have the best statistically significant sensitivity, specificity and predictive value for detecting LBW neonates.¹⁵⁻¹⁷ Lawoyin^{13,14} in Ibadan, showed that a mid thigh circumference of ≤ 13.9 cm had a high sensitivity and specificity for predicting low birth weight infants. Furthermore, a non-stretch plastic strip (Law

College of Medicine, University of Lagos, Nigeria.

Department of Paediatrics

* Lecturer

** Senior Lecturer

*** Professor

Correspondence: V.C Ezeaka

strip) has been validated and used by traditional birth attendants and village health workers in a village in Nigeria.^{13,14} The thigh, at its maximum circumference, has the body's largest cross-section of soft tissue which does not encompass internal organs, and hence easily reflects nutritionally caused differences in muscle mass and fat stores.¹⁸ Studies have shown that the maximum thigh circumference does not differ by sex in the preschool age range, thus making it a potentially more accurate, simplified indicator for use in both male and female infants than most of the other anthropometric measurements which are marginally larger in males than females.¹⁸⁻²¹

Another major advantage of the maximum thigh circumference is that its larger size and wider spread make it significantly less likely that intra and inter-observer errors will produce large spurious differences in its ability to discriminate between normal birthweight and low birthweight neonates on subsequent measurements.^{18,19} Furthermore, the maximum thigh circumference was used by some of the cited studies because of the ease of measurement.^{15-20, 22-23} With the mid-thigh circumference, some categories of health workers especially the traditional birth attendants (TBAs) encounter difficulty in identifying the midpoint between the anterior superior iliac spine of the femur and the medial condyle of the knee which are the stipulated landmarks.^{19, 23}

In view of the foregoing, this study was undertaken to evaluate the utility of the neonatal maximum thigh circumference as an alternative indicator of low birth weight, and to propose the design of a tri-coloured Maximum Thigh Circumference Tape. This should enable health workers to identify easily, the high risk LBW neonates for appropriate intervention, in order to reduce neonatal mortality rate and postnatal developmental retardation.

Materials and Methods

The subjects for this prospective study consisted of all consecutive, live born neonates delivered at the Lagos University Teaching Hospital (LUTH) and Ikeja General Hospital (Ayinke House), Lagos from February 1997 to July 1997. These two hospitals render maternal and child health services to all ethnic, religious and socio-economic populations of Nigerians within and outside Lagos. The neonates were included in the study within 24 hours of delivery after informed parental consent was obtained. Babies with congenital anomalies, oedema or asymmetry of the extremities from whatever cause, were excluded. Gestational age at birth was determined from the first day of the mother's last menstrual period (LMP) where this was

known, and the period had been regular. Obstetrical ultrasonographic measurements during the antenatal period were also utilized whenever available. The appropriateness of the infant's weight for gestational age was determined using the Olowe's standards of intrauterine growth chart for an African population at sea level.²⁴

The anthropometric measurements viz: weight, length, maximum thigh circumference, occipitofrontal circumference and the mid upper arm circumference were carried out using standard methods.^{5-8,15-17} In supine infants, the maximum thigh circumference was measured by placing a non stretchable tape on the inguinal fold anteriorly, 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 limb.^{15-18, 23} The corresponding author, assisted by two neonatal unit resident doctors, carried out all anthropometric measurements. The assistants were trained and closely supervised. A group of 15 healthy newborn infants, not included in the study, were assessed independently by the corresponding author and the two assistants, to determine the validity of the method used for maximum thigh circumference measurement. The interobserver and intraobserver errors were evaluated, and the differences were not statistically significant, with p values of 0.847 and 0.765, respectively.

Table I

<i>Mean Maximum Thigh Circumference (MTC) of Subjects by Birthweight</i>			
<i>Birth weight(g)</i>	<i>Frequency (N=788)</i>	<i>Mean MTC(cm)</i>	<i>SD</i>
<1000	5	9.40	0.87
1000-1499	14	11.86	0.72
1500-1999	35	14.06	0.65
2000-2499	82	14.93	0.61
2500-2999	167	16.80	0.75
3000-3499	274	18.18	0.63
3500-3999	172	19.27	0.99
4000-4499	34	21.22	0.85
³ 4500	5	22.28	0.48

F-statistics=80.66

P value <0.0001

Table II*Mean MTC of Subjects by Gestational Age*

<i>Gestational Age (completed wks)</i>	<i>Frequency (N=788)</i>	<i>Mean MTC (cm)</i>	<i>SD</i>
<28	1	8.50	0.00
28-31	12	11.94	1.77
32-36	112	14.99	1.63
37-41	637	18.12	1.62
≥42	26	18.87	1.42

F-statistics = 136.73

P value <0.001

Correlation and regression analyses were used to examine linear relationships between maximum thigh circumference (MTC) and other anthropometric variables. To ascertain the utility of the MTC in detecting low birth weight neonates, both sensitivity and specificity of the measures were determined on the same population using different cut-off points.

Sensitivity was computed as the percentage of low birth weight infants that were correctly classified by the MTC, while specificity was taken as the percentage of truly normal birth weight infants that were so identified by the MTC. Intra and inter observer errors were evaluated by the paired t-test. The analysis of variance (ANOVA) was used for the comparison of means and interpreted based on the F-statistics.

Results

Seven hundred and eighty-eight neonates were studied, of which 136 (17.3 percent) were of low birth weight. Table I shows that as the birth weight of the neonates increased from ≤1000g to ≥4500g, the mean MTC also increased from 9.40cm ± 0.87 to 22.28cm ± 0.48, respectively (F-statistics=80.66; p<0.0001). Table II indicates that as the gestational age (in completed weeks) of the subjects increased from <28 weeks to ≥42 weeks, the mean MTC also increased from 8.50cm ± 0.00 to 18.87cm ± 1.42. The rate of increase of MTC was greater during the period of rapid growth (<28 weeks to 36 weeks) and became smaller as the neonate reached term and beyond (37 weeks to ≥42 weeks)(F-statistics=136.73; p<0.001).

As shown in Table III, MTC was significantly correlated with all the other anthropometric variables (P < 0.001). The highest degree of correlation was, however, between MTC and birth weight (r=0.95) while

Table III*Degree of Correlation with 95% Confidence Interval Between MTC and Other Anthropometric Variables*

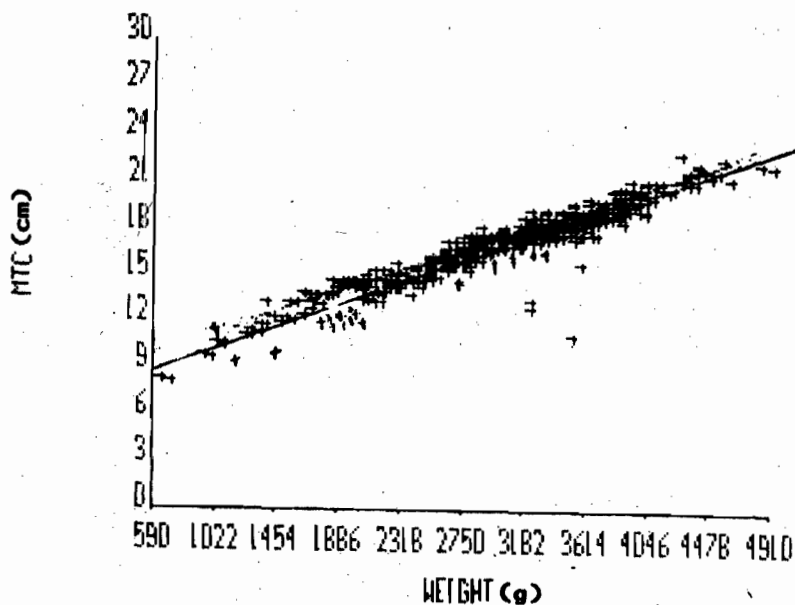
<i>Variables</i>	<i>Correlation Coefficient (r)</i>	<i>95% CI</i>	<i>β</i>	<i>P Value</i>
Birth weight (g)	0.95	0.94, 0.96	0.003	<0.001
MAC (cm)	0.86	0.84, 0.88	1.465	<0.001
Length (cm)	0.85	0.83, 0.87	0.589	<0.001
Gestational age (wks)	0.66	0.62, 0.70	0.596	<0.001
OFC (cm)	0.64	0.60, 0.68	0.519	<0.001

r = correlation coefficient

95% CI = 95% confidence intervals

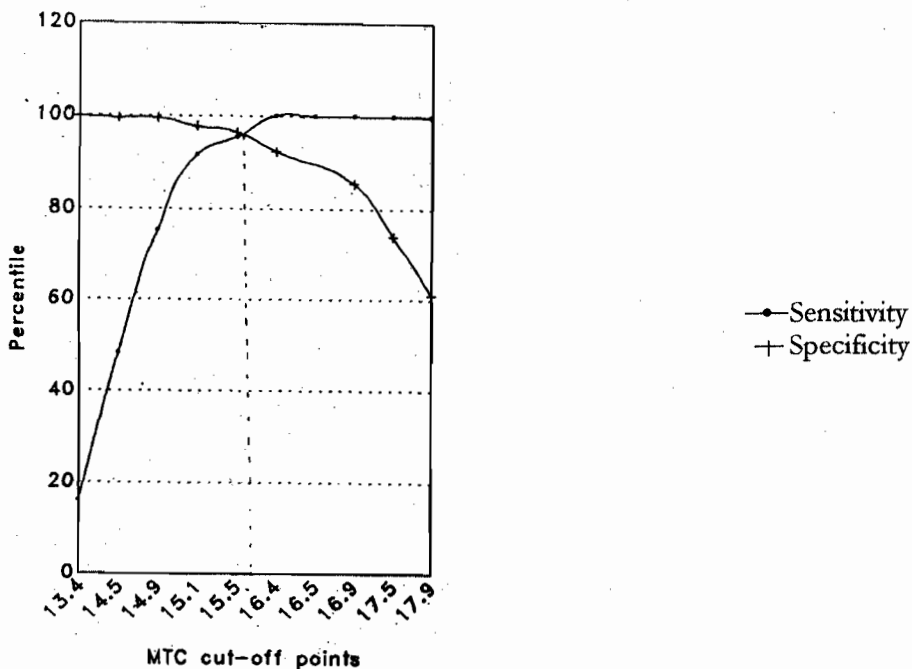
β = regression coefficient

OFC = Occipito-frontal circumference



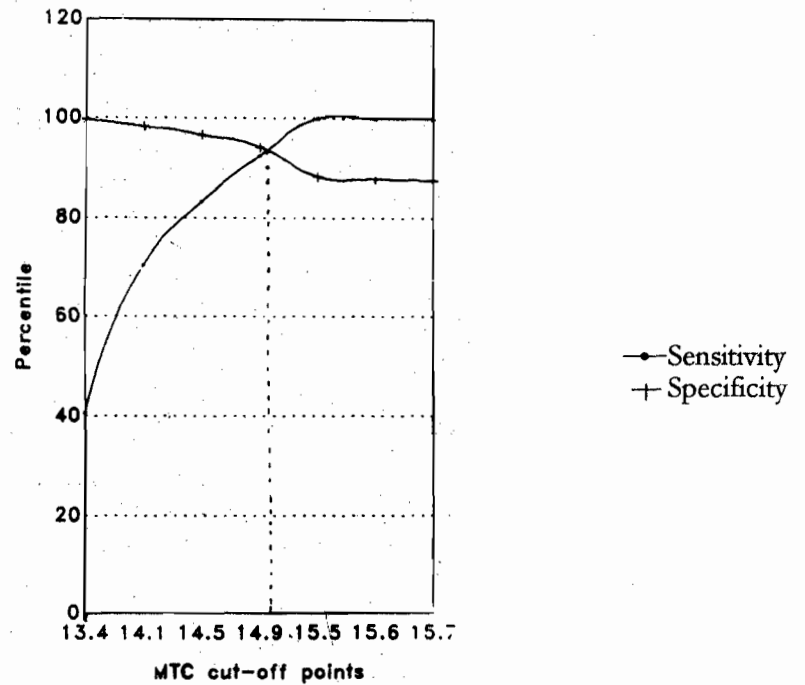
n = 788
 y = 8.25 + 0.003x
 Slope = 0.003

Fig. 1 Regression line of MTC on birth weight of subjects



Sensitivity = ability of the cut-off point to correctly identify children weighing less than <2500g
 Specificity = ability to identify children \geq 2500g.

Fig. 2 Percentile plot of sensitivity and specificity values for various cut-off points of maximum thigh circumference for <2500g neonates



Sensitivity = ability of the cut-off point to **correctly** identify children weighing less than 2000g
 Specificity = ability to identify children ≥ 2000 g

Fig. 3 Percentile plot of sensitivity and specificity values for various cut-off points of maximum thigh circumference for <2000g neonates.

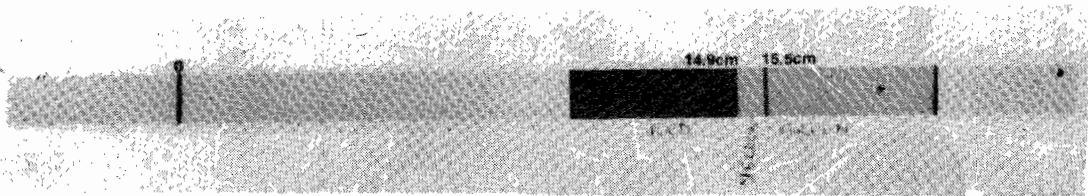


Fig. 4 Sample of a Thigh Circumference Strip

the least was between MTC and OFC ($r=0.64$) ($P<0.001$).

Fig. 1 shows the regression line of MTC on birth weight of subjects with a regression equation of $y=8.25 + 0.003x$. MTC cut-off values of $\leq 15.5\text{cm}$ and $\leq 14.9\text{cm}$ had the best combination of sensitivity and specificity for identifying neonates with birth weight of $<2500\text{g}$ (Fig. 2) and $<2000\text{g}$ (Fig. 3), respectively. A prototype of the proposed tri-coloured MTC Tape using these cut-off points is shown in Fig. 4.

Discussion

Birth weight is an important index for a continuing re-appraisal of a nation's health care delivery and neonatal viability. However, in countries and poor population groups, where the proportion of LBW is highest and action is most needed, data on birth weight are few, due to unavailability of suitable weighing scales. Health care workers such as TBAs and non-specialized village health workers need to identify these LBW babies by appropriate means, in order to improve their care in the critical first weeks of life and beyond.

The observation that the mean MTC increased with the birth weight of the neonates corroborated the findings of others.^{8,15-17} Furthermore, Ojofeitimi *et al*, in Ile-Ife, assessed 700 children aged seven months to 36 months and found MTC to be a sex independent, potential indicator of occult malnutrition before it became overt in as early as seven month old toddlers.²² In the same study, MTC was also reported to be even more sensitive in identifying malnourished children than the mid-arm circumference.²² The significant correlation between MTC and the other variables viz: birthweight, length, gestational age, occipitofrontal circumference and mid-arm circumference is in keeping with the observations by various workers.¹⁵⁻²⁰ Sharma *et al*,¹⁵ Ramji *et al*,¹⁶ and Shahidullah¹⁷ reported correlations, r of 0.920, 0.918 and 0.845, respectively.

The finding in the present study that MTC cut-off values of $\leq 15.5\text{cm}$ and $\leq 14.9\text{cm}$ had the best combination of sensitivity, specificity and predictive value for identifying neonates weighing $<2500\text{g}$ and $<2000\text{g}$ respectively, is in keeping with the results of others.¹⁵⁻¹⁷ However, these cited studies reported lower MTC cut-off figures of $\leq 14.5\text{cm}$ and $\leq 13.5\text{cm}$,¹⁵ $\leq 14.7\text{cm}$ and $\leq 13.9\text{cm}$,¹⁶ and $\leq 14.9\text{cm}$ and $\leq 14.0\text{cm}$ ¹⁷ for identifying infants $\leq 2500\text{g}$ and $\leq 2000\text{g}$, respectively. These lower MTC values could be related to the lower mean birth weight of babies in India.²⁵ Therefore, the WHO⁵ and some other workers^{4,10} have recommended that each country should derive her own specific cut-off points. Furthermore, Lawoyin^{13,14} in Nigeria and Landicho *et al*¹² in Central America, reported mid-thigh circumference cutoff values of $\leq 13.9\text{cm}$ and $\leq 14.5\text{cm}$

respectively, for identifying LBW neonates ($<2500\text{g}$). These values are relatively lower than the cutoff value of $\leq 15.5\text{cm}$ obtained in the present study for neonates weighing $<2500\text{g}$. This difference could be due to the fact that the mid-thigh circumference, which has a smaller diameter than the maximum thigh circumference, was utilized in the cited studies.

Based on the MTC cut-off values of $\leq 15.5\text{cm}$ for $<2500\text{g}$ neonates, and $\leq 14.9\text{cm}$ for $<2000\text{g}$ neonates, the newborns in the present study can be categorized into three "risk" groups.^{5,17} The term "risk" here refers to the morbidity and mortality pattern based on the birth weight. The groups are:

- Those neonates with MTC of $\leq 14.9\text{cm}$ denoting a birth weight of $<2000\text{g}$ can be categorized as "highly at risk".
- Those with MTC of $>14.9\text{cm} - 15.5\text{cm}$ denoting a birth weight of $2000\text{g}-2500\text{g}$ can be categorized as "moderate risk".
- While those neonates with MTC value of $>15.5\text{cm}$ denoting a birth weight of $>2500\text{g}$ can be grouped as "low risk" neonates.

In this context, a Maximum Thigh Circumference Tape can be designed for use whenever adequate facilities to weigh newborns are not available. The calibrations and contrast colouring of the tape should be such that when applied over the maximum circumference of the thigh, the colour zones superimposed on the cut-off values would be as follows (Fig. 4):

- The "highly at risk" newborns (with birth weight of $<2000\text{g}$ and MTC of $\leq 14.9\text{cm}$) fall within the "danger" red zone.
- The "moderate risk" neonates (with birth weight between $2000\text{g} - 2500\text{g}$, and MTC between $>14.9\text{cm}-15.5\text{cm}$) fall within the "borderline" yellow zone.
- Whereas the "low risk" newborns (with birth weight $>2500\text{g}$ and MTC $>15.5\text{cm}$) fall within the "normal" green zone.

Health workers, especially TBAs and community health workers should be trained to recognize that the neonates who fall within the danger "red" zone on application of the MTC Tape at birth, should be referred immediately to the nearest, better equipped, secondary or tertiary institution for further evaluation and specialized care. However, neonates who fall within the borderline "yellow" zone ($2000\text{g}-2500\text{g}$) who have no obvious clinical complication, should be monitored closely at the place of delivery, and subsequently discharged home or referred if the clinical condition deteriorates. TBAs and mothers should be counselled by health workers on the provision of extra warmth,

exclusive breast feeding and safe hygienic practices. The "Kangaroo" technique,²⁶ used in the absence of incubators to keep preterm babies warm and in constant contact with their mothers, could be implemented. Thus, in the absence of appropriate weighing scales, the maximum thigh circumference measurement seems to be a reliable, practical and cost-effective alternative indicator of low birth weight infants in the community. This will help to significantly reduce neonatal mortality rate and post neonatal neuromotor retardation. However, further studies on the use of the MTC should be carried out on a wider scale, across all ethnic and socioeconomic groups of the Nigerian population. Furthermore, as with any other field indicator, appropriate supervision, validation and standardization are essential for its usefulness.

References

- McCormick MC. The contribution of low birth weight to infant mortality and childhood morbidity. *N Eng J Med* 1985; **312**: 82-90.
- Kramer MS. Birth weight and infant mortality: perceptions and pitfalls. *Paediatr Perinatal Epidemiol* 1990; **4**: 381-90.
- World Health Organization. Traditional Birth Attendants: A joint WHO/UNFPA/UNICEF Statement, Geneva 1992.
- Ngowi JA, Lallinger RR, Hirji KF. An assessment of the use of anthropometric measures for predicting low birth weight. *J Trop Pediatr* 1993; **39**: 356-60.
- WHO. Use of a simple anthropometric measurement to predict birth weight: WHO Collaborative Study of Birth Weight Surrogates. *Bull WHO* 1993; **71**: 157-63.
- Arisoy AE, Sarman G. Chest and mid-arm circumferences: identification of low birth weight newborns in Turkey. *J Trop Pediatr* 1995; **41**:34-7.
- Eregie CO. Assessment of gestational age: the value of a maturity scoring system for head circumference and mid arm circumference. *J Trop Pediatr* 1991; **37**: 182-4.
- Vaquera MVD, Townsend JW, Arroyo JJ, Lechtig A. The relationship between arm circumference at birth and early mortality. *J Trop Pediatr* 1983; **29**: 167-74.
- Shakir A. Arm circumference in the surveillance of protein calorie malnutrition in Baghdad. *Am J Clin Nutr* 1975; **28**: 661-5.
- Singh M, Paul VK, Dearari AD, Anadalakhmi PN, Sundaram KR. Simple tricoloured measuring tapes for identification of low birth weight babies by community health workers. *Ann Trop Paediatr* 1988; **8**: 87-91.
- Gohil JR, Sosi M, Vani SN, Desai AB. Foot length measurement in the neonate. *Ind J Pediatr* 1991; **58**: 675-7.
- Landicho B, Lechtig A, Klein E. Anthropometric indicators of low birth weight. *J Trop Pediatr* 1985; **31**: 301-5.
- Lawoyin TO. Validation and use of a simple device to identify low birth weight babies at birth. *Afr J Med Med Sci* 1998; **27**: 143-5.
- Lawoyin TO. Introducing the law strip: a simple device to screen for, and improve documentation of low birthweight babies in Nigeria. *J Trop Pediatr* 1999; **45**: 121-2.
- Sharma JN, Saxena S, Sharma U. Thigh circumference at birth as the best predictor of low birth weight babies. *Ind Pediatr* 1989; **26**: 19-21.
- Ramji S, Marmah J, Satyanarayana L, Kapani V, Mohan M. Neonatal thigh circumference as an alternative indicator of low birth weight. *Ind J Med Res* 1986; **83**: 653-4.
- Shahidullah MD. Birth weight: relationship with other anthropometric parameters. *Ind Pediatr* 1989; **21**: 830-8.
- Zeitlin MF, Inciong MB, Lacuna R, Opena M. The advantages of using a Thigh Circumference Tape analogous to the Shakir Strip for detection of malnutrition in preschool children. *J Trop Pediatr* 1981; **27**: 267-70.
- Zeitlin MF, Pyle DF, Austin JE, Sempore G, Gouba E. Circumference growth charts for community level workers with little or no formal schooling. *J Trop Pediatr* 1982; **28**: 62-8.
- Zeitlin MF. Comparison of malnourished children selected by weight for age, mid upper arm circumference, and maximum thigh circumference. *J Trop Pediatr* 1986; **32**: 190-5.
- World Health Organization. The use and interpretation of anthropometry. Technical Report Series, Geneva 1995; **854**: 121-60.
- Ojofeitimi EO, Afolabi OA, Owolabi SP, Oguntade JO. Maximum thigh circumference in the surveillance of protein energy malnutrition among young children. *Nig J Paediatr* 1985; **12**: 87-90.
- Zeitlin MF. The derivation of a reference standard for maximum thigh circumference of preschool children aged 0-5years. *Human Biol* 1979; **51**: 11-21.
- Olowe SA. Standards of intrauterine growth for an African population at sea level. *J Pediatr* 1981; **99** : 498-95.
- World Health Organization. The incidence of low birth weight: A critical review of available information. *Wld Hlth Stat Q* 1980; **33**: 197-204.
- WHO. Coverage of Maternity Care: A listing of available information. Maternal and Newborn Health/Safe Motherhood, Geneva, Switzerland.WHO/RHT/MSM 1997; **96**: 28.