UK Journal of Pharmaceutical and Biosciences Vol. 5(3), 35-40, 2017 RESEARCH ARTICLE

UK Journal of Pharmaceutical and Biosciences

Available at www.ukjpb.com

ISSN: 2347-9442

Detection of Low Birth Weight Newborns by Foot Length as Prox-measure for Birth Weight

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Article Information
Received 27 January 2017
Received in revised form 25 June 2017
Accepted 26 June 2017

Keywords:
Newborn,
Weight,
Foot-length,
Babies,
Measurement

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Abstract

The majority of births in rural communities in Nigeria take place at home, and lack of weighing facilities makes early and reliable identification of low birth weight babies difficult. One thousand live newborns of gestational ages 28-44 weeks were studied at the Federal Medical Centre,Owerri Imo State Nigeria to find out the correlation between birth weight and foot length and to detect low birth weight newborns by using foot length measurement as a proxy measure of birth weight. Further the foot length of newborns was noted within 24 hours of birth. Foot length findings demonstrated that correlation coefficients between foot length and birth weight showed the highest correlation (r=0.93). The birth weight of these 1000 newborns ranges from 850g to 4500g. Results showed that the mean birth weight of newborns was 2931^{+}-464g. The incidence of low birth weight babies was 12.6%. Male births were slightly more preponderant (52.4%) over female (47.6%). Furthermore demonstrated a sensitivity of 70.6%, specificity of 98.5% and positive predictive value of 89.7% for identifying low birth weight newborns. For very low birth weight newborns, the sensitivety, specificity and positive predictive value, all were 100%. Foot length may be considered an alternate parameter to birth weight to detect low birth weight babies, especially in remote areas and pre-terms nursed in incubators. Thus, if implemented on a large scale this simple, low cost technology of foot length measurement can significantly enhance the yield of identification of low birth weight babies born at home and the babies can be managed thereafter accordingly.

1 Introduction

By definition low birth weight is weight at birth below 2500 gram[1]. The developing countries namely Nigeria facing major problems on the neonatal services due to lack of resources available for health care delivery and family financing. The developing countries of Africa, Asia and Latin America bear the bruit of the clinical problems[2].

UNICEF/WHO 2004 reported that 15.5 percent of all births or more than twenty million[3]. It has been reported that the level of low birth weight in developing countries (15.5%) are double than the level in a developed countries (7.0%).

The birth weight reflects the health of the community of particular country. It is accepted that foot length of foetal and neonatal indicates the health of foetal and neonatal. Birth weight, in particular, is strongly associated with foetal, neotatal and post-neotatal mortality and with infant and child morbidity[4].

Size at birth reflects two factors: duration of gestation and rate of foetal growth. Hence it must take care about gestational age during development of foetal, otherwise the increase in size that occurs with age will lead to severe confounding of growth and maturity[5].

During foetal life, serial measurements are feasible only with assessing foetal growth as ultrasound setimation of foetal weight has a high coefficient of variation. Moreover, ultrasound measurements are not truly anthropometric.

Body size is obviously proportional to age, not only in the foetus but throughout childhood until the time of skeletal fusion. Consequently, size of infant at birth reflects the average growth rate for that infant from conception to birth. It is not necessarily a steady stage, because there may have been periods of rapid and slow growth. Problems arise when the distribution of size at birth of different infants born at different gestation ages is used to make inferences about 'normal' foetal growth[6].

The standards derived from anthropometric measurements for newborn infants are not accurate for first 20-24 weeks of gestion, when elective, induced abortions are achieved for indications unrelated to foetal growth (i.e. for reasons other than chromosomal or other genetic abnormalities of the foetus). The situation changes, however, when all foetuses are induced, since a large number of births during weeks 20 to 24 are spontaneous and probably related to factors that do effect foetal growth. Form week 24 onwards, however, it should be kept in mind that foetal growth curves based on anthropometric ages may not be valid, particularly pre-post-term and term newborns[7].

The paediterican always showed interest towards the development of foetal growth, and the developed parameters are differ from the etiological determinants of gestational duration. It has been noted that the maternal stature, pre-pregnancy weight and energy intake during gestation impact on the rate of foetal growth. Genetic (including racial) and inter-generational effect also bears primarily on foetal growth. Cigarette smoking effects both foetal growth and gestational duration, but the effect is considerably greater on the former. Only a few other determinants such as infections, maternal cocaine use, and pre-pregnancy and gestational hypertension (particularly severe pre-eclampsia), also affect both outcomes.

Impairments in foetal growth can have adverse consequences in infancy and childhood in terms of mortality, morbidity, growth and performance. It has even been suggested that restriction of foetal growth may increase the risk of ischemic heart disease, hypertension, obstructive lung disease, and diabetes in adulthood.

Accordingly, the birth weight of an infant broadly reflects the quality of its intra-uterine development. It is an important parameter which could be indicative of: (i) the immediate viability of the neonate; and (ii) the state of maternal health/nutrition during pregnancy. From the public health point of view, the mean birth weight in a community may provide a broad indication of the quality of maternal health/nutrition care that is available to it. Birth weights could be a useful criterion in monitoring trends with respect to improvements in the quality of ante-natal care.

The gestational age weight at birth is often to classify an individual infant as having experienced normal, subnormal (small for gestational age - SGA, or intrauterine growth retardation - IUGR), or supra-normal growth in utero. The classification most frequently used is:

i. Small-for-gestational age (SGA or IUGR)

ii Appropriate-for-gestational age (AGA) and

iii Large-for-gestational age (LGA)

However, strictly speaking SGA and IUGR is not synonymous[8]. Some SGA infants (e.g. those born to short mothers) may merely represent the lower third of the “normal” foetal growth distribution, while other infants who have been exposed to one or more growth-inhibiting factors may actually meet the criteria for AGA (e.g. those born tall, well nourished cigarette-smokers). In individual cases, however, it is usually very difficult to determine whether or not the observed birth weight is the result of true in - utero growth restriction, and classification of an infant as IUGR is therefore based on the established cut-off for SGA as a result of IUGR.

Various criteria (i.e. cut-off points) have been used as the dividing lines between these three categories. Those most commonly used are based on the percentile of a distribution of birth weight-for-gestational age derived from an accepted reference population; the 10^{th} percentile is used most frequently as the cut-off between SGA and AGA, and the 90^{th} percentile between AGA and LGA. These criteria have been applied in this study.

Other definitions, such as <-2 or >+2 standard deviations (z-scores) from the reference mean, have also been applied[9].

Regardless of which definition is used, the classification of a newborn as either SGA or LGA has implications for diagnosis, prognosis, surveillance and treatment. SGA infants are more likely to have congenital anomalies, and the observation that an infant is growth-retarded often prompts a more careful physical examination or even laboratory tests such as karyotyping.

Laboratory cultures of biological samples and serological tests of the mother and infant may occasssionally reveal a previously unsuspected intra-uterine infection. The diagnosis of SGA may also prompt closer examination of the plencenta and reveal evidence of infection, single umbilical artery, velamentous insertion of the cord, decreased placenta weight, or previously unsuspected disease in the mother.

Regardless of the cause of the growth retardation, a severely growth-retarded foetus or infant is at markedly increased risk of death, hypoglycemia, hypocalcaemia, polycythaemia, and neurocognitive complications of pre-and intra-partum hypoxia (i.e. in-utero malnutrition is associated with in-utero deprivation of oxygen. Close monitoring of blood glucose, calcium, haematocrit, and circulatory adequacy in the neonatal period will allow timely intervention and should reduce the risk of adverse secondary sequelae. Diagnosis of SGA should prompt actions to support brest-feeding and in affluent populations where weaning food are hygienically safe may indicate the need for instituting a high energy diet to maximize potential for catch-up growth in the first few post-natal months. Over the long term, growth-retarded infants may exhibit permanent mild deficits in growth and neuro-cognitive development[10].

The diagnosis of LGA can also be important for the individual infants. Large infants are at increased risk of birth trauma (including clavicular fracture and brachial plexus injury), and of asphyxia secondary to obstructed labour. The most common concern is maternal diabetes, which may or may not have been diagnosed before or during pregnancy; so monitoring (especially for the development of hypoglycaemia) is important to permit an institution of glucose therapy and thus prevent adverse sequelae[11].

Anthropometric assessment of newborns is an important research tool for studying the determinants and consequences of impaired (or excessive) foetal growth. Sometimes, specific local factors may play an important aetiological role such as maternal tobacco-chewing, exposure to indoor smoke, malaria or other tropical diseases, and HIV infection.

Similarly, although the immediate, life threatening sequelae of severe IUGR are properly similar in all populations, the long-term consequences for child growth, development and performance may differ across populations because of interaction with adverse post-natal influences in disadvantaged populations, including socio-economic, nutritional factors, as well as the level of medical care available. So, investigation of such environmental factors and of interventions that reduce adverse health sequelae should receive high priority in developing countries where the sequelae of SGA is high.

Anthropometric assessment of neonates can also be important in the context of nutritional surveillence. Periodic assessment of population overtime may show changes in the prevalence of SGA (or LBW as a proxy) that could signal adverse environmental circumstances.

In a developing country like ours, where approximately (60-80)% of births occur outside orthodox health care facilities (Nigerian Demographic and health Survey[12, 13]; most deliveries take place in private homes, and rural maternities and are attended to by relatives, neighbours or unskilled attendants. It is essential to find out an alternative method for estimation of birth weight. Various anthropometric measurements mentioned above have been identified as proxy measure for birth weight during first week of life, but they still require a health worker for proper measurement. Identification of LBW babies delivered at home can be enhanced if the tool used is simple enough to be used by the mother/caretaker. Use of foot-length as proxy measure of birth weight is simple, cheap, easy to perform, rapid, requiring less handling and disturbance to newborns.

Even foot length measurement can be used to estimate birth weight, length and surface area, which is especially valuable in pre-term babies nursed in incubators. This study was done to evaluate the usefulness of foot length as a proxy measure for birth weight so that it can be used as a simple screening tool for LBW.

2 Materials and Methods

One thousand live born babies at Maternity Ward of FMC Owerri, were selected according to the above stated criteria. Mother's obstetric history was taken in detail. The gestational age was calculated by inquiring into the first day of the mothers last menstrual period and was confirmed by Dubowitz's Physical and Neurological clinical criteria.

2.1 Anthropometric measurements

(1) Birth weight (BW): Babies were weighed naked on weighing machine (BRAUN company) nearest to 50g in the delivery room at FMC Owerri within 24 hours of birth.

(2) Foot length (FL): The foot lenth of each foot was measured by a measuring tape to the nearest of 0.05cm thrice by the and the average was recorded. The measurement was taken by fixing the tip of heel to the zero mark of the tape and after straightening the foot and toes, the foot length measurement was recorded, the other end being the tip of the great or second toe (whichever was the longer toe). The mean of values of foot lengths of right and left feet was recorded.

All the measurements were recorded within 24 hours after birth.

2.2 Statistical analysis

Standard statistical methods used for data analysis included correlation coefficient, simple regression equation, sensitivity, specificity, positive predictive value, negative predictive value, mean, standard deviation and P value. All these were done with the help of EPI-INFO programme on computer.

3 Results

In this study, the birth weight of 1000 newborns born live at FMC Owerri ranges from 850 to 4500g, with a mean of 2931g and a standard deviation of 464g. Male was slightly preponderant (52.4%) over female (47.6%). Mean birth weight was higher in males (2959g) than in females (2901g).

The incidence of low birth weight babies was 12.6%. This included 0.4% of VLBW babies and 0.2% of ELBW babies. Out of 126 LBW babies, 50 (39.7%) were preterms and 76(60.3%) were term babies. LBW babies comprised of 72(57.1%) SGA and 54(42.9%) AGA babies (Table 1).

Table 1: **Incidence of neonates by different birth-weight groups**

Birth-weight groups(g)	Male (n)	Female (n)	Total (n)	Incidence (%)
Less than 1000	2	0	2	0.2
10000-1500	1	1	2	0.2
1500-2000	11	7	18	1.8
2000-2500	55	49	104	10.4
2500-3000	170	204	374	37.4
3000-3500	196	159	355	35.5
3500-4000	78	55	133	13.3
4000-4500	11	1	12	12.0
Total	524	476	1000	100.0
Mean (g)	2959	2901	2931	-
SD	0.49	0.43	0.46	-

Sensitivity, specificity and positive predictive value for foot length less than 7.5cm were 72.5%, 97% and 79.4%, respectively (Table 2).

Table 2: **Sensitivities, specificities and predictive values for foot less than 7.55cm and 7.6cm for predictions of birth weight below 2500g**

Parameter (%)	Foot length		
	>7.5cm	**<7.5cm**	**<7.55cm**
Sensitivity	72.51 (CI=64.1-79.6)	70.6 (CI=62.8-77.4)	64.8 (CI=51.2-71.7)
Specificity	97.0 (CI=95.5-98.0)	98.5 (ci=97.3-99.1)	98.5 (ci=97.4-99.2)
+ ve predictive value	79.4 (CI=71-85.8)	89.7 (CI=82.7.94.2)	90.5 (CI=83.6-94.8)
- ve predictive value	95.7 (CI=94-96.9)	94.6 (CI=92.9-96.0)	92.9 (CI=90.9-94.5)

For foot length less than 7.55cm, sensitivity was lower but specificity and positive predictive value were higher. The positive predictive value was highest at the cut-off point of 7.6cm.

Relationship of gestational age with birth rate and foot length

At 27-28 weeks, the means of birth weight and foot length were 100.3±0.25 g and 5.51±0.50cm respectively. The means of birth weight and foot were 3054.7±0.62g and 8.01±0.32gcm at 39-40 weeks. But at 43-44 weeks, the means of birth weight and foot length were 2900.9±0.72 g and 7.83±0.15 cm respectively (Table 3).

Table 3: Statistically significant relationship of gestational age with birth weight and foot length (p<0.001).

Gestation (weeks)	Birth weight (g) (mean ± SD)	Foot length (cm) (mean ± SD)
28-30	900.2±0.71	5.15±O.50
27-28 (1)	100.3±0.25	5.51±0.50
29-30 (1)	1700.5±0.82	6.52±0.27
31-32 (4)	1888.6±0.29	6.93±0.29
33-34 (18)	2121.5±0.47	7.12±0.21
35-36 (41)	2332.4±0.75	7.79±0.41
37-38 (269)	2801.3±0.47	7.79±0.35
39-40 (570)	3054.7±0.62	8.01±0.32
41-42 (91)	3101.2±0.34	8.04±0.32
43-44 (3)	2900.9±0.72	7.83±0.15
p value	p<0.001	P<0.001

The data in table 4 depict statistically significant relationship of foot length with birht weight (<p0.001). Babies with foot length oof 6-6.99cm had the mean birth weight of 1865.1±0.32g, whereas those with foot length of 8-8.99cm had the mean birth weight 0f 3279.2±0.31g.

Table 4: Birth weight in relation to various subgroups of foot length

Foot length (cm)	Birth weight (g) (mean ± SD)
4-5.99 (3)	933.4±0.76
6-6.99 (13)	1865.1±0.32
7-7.99 (491)	2623.7±0.28
8.8.99 (492)	3279.2±0.31
9 (1)	3350.4±0.45

Likewise, table 5 shows the relationship of birth weight with foot length. Babies with birth weight 1500-2000g had the mean foot length of 6.93±0.30 cm whereas those with birth weight of 3000-3500g had the mean foot length of 8.17±0.19cm.

Table 5: Foot length in relation to various subgroups of birth weight

Birth weight groups (g)	Foot length (cm) (mean ± SD)
Up to 1000 (2)	5.15±0.50
1000-1500 (2)	5.80±0.42
1500-2000(18)	6.93±0.30
2000-2500 (104)	7.33±0.22
2500-3000 (374)	7.74±0.19
3000-3500 (355)	8.17±0.19
3500-4000 (133)	8.36±0.21
4000-4500 (12)	8.73±0.19

4 Discussions

In this study of 1000 newborns delivered at FMC Owerri, the birth weight ranged from 850 to 4500grams with a mena of 2931±0.46g.

The mean birth weight of 2.931±0.464g recorded in this study is similar to the 3.046+0.656kg reported[14, 15] in Lagos, and some other authors for Nigeraia neonates. However, this figure is higher than the mean birth weight ranges reported for Indian Subcontinent (2.493±0.477) kg and 2694+689g reported by Gozal et al, (1991) in carmeroon but lower than the mean birth weight recorded for British (3650g) and American (3300g) infants[16]. 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 that area. Goldenber et al, (1991) showed that in America, intrinsic and extrinsic black babies and for much of the racial differences in birth weight[17].

There is slight preponderance of males over females in this study comprising 52.4.% males and 47.6% females

Among 1000 babies 132 were SGA (13.2%), 848 AGA (84.8%) and 20 LGA (2%). Out of the SGA babies 125(94.7%) were term babies and 7(5.3%) preterm. Among the preterm 7(10.4%) were SGA and 60(89.6%) were AGA. The findings of preterm are in conformity with the study done by Pokhrel[18] (1991).

Out of 126 LBW babies, 50(39.7%) were preterm and 76(60.3%) were term babies. So, a term LBW was more than the preterm LBW babies in this study.

The mean foot length was 7.92±0.45 and 7.87±0.36cm in males and females respectively. There was no statistically difference between males and females (p=0.07). The mean foot length of right and left feet both were 7.69+41.cm. so, there is no difference in the values obtained from left and right side.

Significant relationship between foot length and other body parameters was observed in the different groups of newborns (p<0.001). the highest correlation in term small gestational age (TSGA) and term birth weight (r=0.86 and 0.64 respectively) indicating that foot length and birth weight are effected in a similar fashion in term babies. However, in preterm the foot length correlated well with all the indices. The outcomes of preterm exhibited that the correlation co-efficient (r) was higher compared to TAGA or TSGA babies. Consequently, the findings demonstrated that an increase in gestational age, there was increase in birth weight and foot length. The relationship between birth weight and foot length was statistically significant (p<0.001). The above statement is justify with the study of Sharma et al, (1988)[19]. The means for birth weight increased progressively with increasing foot length of the newborns. The means for foot length increased progressively with increasing weight of newborns[20, 21].

Conclusion

Foot length is an alternative anthropometrical parameter to birth weight and can be useful especially in remote areas with no facility of baby weighing machines and in conditions where baby would not liked to be exposed like in winter and disturbed in sickness. The digital calipers used to measure foot length are less costly, easy to carry and operate in the absence of baby weighing machines.

5 Conflict of interests

Authors have declared that no competing interests

6 Author's contributions

ADA and UGC carried out literature review and experimental. ABC was responsible for statistical work and calculations in addition to manuscript proofing. AEA collected the data and gained patient approval. All authors read and approved the final manuscript.

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