Section: Pediatrics

Original Research Article

ANTHROPOMETRIC SURROGATE PARAMETERS FOR EARLY DETECTION OF LOW BIRTH WEIGHT NEWBORN BABIES WHERE THERE IS NO STANDARDIZED WEIGHING SCALE

Chinthi Reddy Sanjana Reddy[1], Harshika Patel[2], Yalamanchili Sai Sree[3]

[1]*Assistant Professor, Department of Pediatrics, Malla Reddy Institute of Medical Sciences, Malla Reddy Vishwavidyapeeth (Deemed to be University), Suraram, Hyderabad 500055, Telangana, India.*
[2]*Consultant, Department of Pediatrics, Radhika childrens Hospital, Mancherial, Telangana, 504208, Telangana, India.*
[3]*Assistant Professor, Department of Pediatrics, Malla Reddy Institute of Medical Sciences, Malla Reddy Vishwavidyapeeth (Deemed to be University), Suraram, Hyderabad 500055, Telangana, India.*

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Corresponding Author:
Dr. Chinthi Reddy Sanjana Reddy, Assistant Professor, Department of Pediatrics, Malla Reddy Institute of Medical Sciences, Malla Reddy Vishwavidyapeeth (Deemed to be University), Suraram, Hyderabad 500055, Telangana, India.
Email: dr.sanjanareddych@gmail.com

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ABSTRACT

Background: Low birth weight (LBW), defined as birth weight <2500 g, is a major contributor to neonatal morbidity and mortality, particularly in resource-limited settings where standardized weighing scales may not be readily available. Simple anthropometric measurements can serve as reliable surrogate markers for early identification of LBW newborns, enabling timely referral and intervention.

Aim & objectives

1. To identify which anthropometric surrogate parameters of birth weight which can be used to detect low birth weight new born babies where standardized weighing scales are not available for weighing newborn babies.
2. To detect early nutritional status of the baby and prevent the mortality and morbidity.

Materials and Methods: A hospital based cross sectional study. The study population will consist of newborns admitted between 34 and 42 weeks of gestational age, born between May 2025 and April 2026 at Department of Pediatrics, Malla Reddy Institute of Medical Sciences, Malla Reddy Vishwavidyapeeth. It is a teaching hospital and tertiary care centre. The patient population comprises, mainly of low income group from surrounding rural areas, urban slums, referred patients from surrounding rural areas, private clinics and adjacent private hospitals, and some middle and high income group of patients from surrounding Malla Reddy Institute of Medical Sciences.
Results: In this cross-sectional study done in Department of Pediatrics, Malla Reddy Institute of Medical Sciences, 53.28% were male and 46.72% were female. 53.28% were LSCS delivery and followed by 46.72% were normal delivery. In our study we found that chest circumference followed by head circumference were best parameters to assess low birth weight babies. In our present study, we found that statistical correlation was strong positive in chest circumference (r=0.71) followed by head circumference (r=0.68). Medium positive correlation was found in mid arm circumference (r=0.48), abdominal girth (r=0.45), calf circumference (r=0.43), SFT of supra-scapular (r=0.56), SFT of quadriceps (r=0.51), SFT of flanks ($r = 0.51$). Weak positive correlation was found in upper limb length (r=0.48), thigh circumference (r=0.39), lower limb length (r=0.27), SFT of triceps (r=0.24). Very weak positive correlation was found in foot length (r=0.03), crown heel length (r=0.01), crown rump length (r=0.05) and anterior fontanelle size (r=0.05).

Conclusion: In our study it is concluded that, chest circumference followed by head circumference is a simple, cheap, cost-effective and culturally acceptable surrogate anthropometric parameter of birth weight for screening and earliest detection of high risk neonates by health workers with immediate referral to appropriate health facility especially at the community level where there are no facilities for weighing babies.
Keywords: Surrogate Anthropometric Measurments, Low birth weight, Nutritional status, Mortality, Neonatal Screening.

INTRODUCTION

Anthropometry is derived from Greek word (Anthropos - man, metron - measurement). Anthropometry is expedient of substantial measurements of the human body at various age groups. Anthropometric estimations evaluate development longitudinally or cross-sectionally. When determining intra-uterine development, the anthropometrical measurements in newborn baby is considered significant. These measurements were compared with standard values which provides a simple and reliable method for identifying infants at risk groups. Growth charts for different populations of country can be made by determining the birth indices at various levels.[1-5]

Anthropometry is an efficient screening method to assess child nutrition and health status. The data collection value depends on reliability, accuracy and the way it is recorded and interpreted. Geographic locations play an important role on fetal growth indicated by birth weight. Numerous studies proclaimed that female babies are smaller than male babies.

World health organization in the year 2012, executed a strategy on maternal, infant and young child nutrition, which stated six global nutrition goals for 2025. The target is: "30% reduction of low birth weight". The objective of this policy is to increase awareness, venture in, and take adequate measures for cost-efficacious interventions and principles that resort in curtailing rates of low birth weight.

In a comprehensive data collected by World health Organisation, it is predicted that 15% to 20% of all births globally are low birth weight, which illustrates more than 20 million births per year. Preterm birth is one of the major cause of infant mortality rate in developing countries. Annually, 1.1 million babies succumb from the complications associated with preterm birth. In the poverty-stricken countries, on an average, 12% of babies are born prematurely in comparison with 9% in higher-income countries.[1,2] Hence multiple researches have been done to detect new methods for developing simple inexpensive practical method to identify the birth weight such as anthropometric surrogate parameters to identify LBW babies at primary health care level in under-developed countries like India, where significant number of births are conducted at home and the birth weight measurement is very intricate due to paucity of standard weighing scale.

2. Objectives

3. To identify which anthropometric surrogate parameters of birth weight which can be used to detect low birth weight new born babies where standardized weighing scales are not available for weighing newborn babies.
4. To detect early nutritional status of the baby and prevent the mortality and morbidity.

MATERIALS AND METHODS

Study setting

The study population will consist of newborns admitted between 34 and 42 weeks of gestational age, born between May 2025 and April 2026 at Department of Pediatrics, Malla Reddy Institute of Medical Sciences, Malla Reddy Vishwavidyapeeth. It is a teaching hospital and also tertiary care centre. The patient population comprises, mainly of low income group from surrounding rural areas, urban slums, referred patients from surrounding rural areas, private clinics and adjacent private hospitals, and some middle and high income group of patients from surrounding Department of Pediatrics, Malla Reddy Institute of Medical Sciences, Malla Reddy Vishwavidyapeeth.

Study design

A hospital based cross sectional study

Study population.

During present study total 333 study subjects were reviewed in Pediatric department, among 257 (78.24%) patients were enrolled into the study according present study inclusion criteria and 71 (21.75%) patients were excluded according exclusion criteria, in study area.

Inclusion criteria

- All consecutive singleton, live born babies born during the study period.
- Newborns aged less than 24 hours.
- Newborns more than 34 weeks of gestation.

Exclusion criteria

1. Babies with major congenital malformations.
2. Parents not willing to give informed consent.
3. Newborns with birth injuries such as scalp swellings and limb fractures.
4. Newborn less than 1000 grams.
5. Babies whose anthropometric measurements were not recorded due to unavoidable reasons.

Study period

May 2025 and April 2026

Sampling method

Simple random sampling.

Method of collection of data

Data collection was started after obtaining clearance from ethical committee, respective authorities, from in patients meeting the inclusion criteria in Department of Pediatrics, Malla Reddy Institute of Medical Sciences,. Informed consent was obtained from the patients/guardians/parents.

The new-borns fulfilling the inclusion criteria was enrolled for the study after obtaining the informed consent. The present study was done with an aim to find an alternate, cheap and reliable predictor of LBW babies that can be used by a trained or Here is the extracted text from the image:

untrained person. It also aims to study the relationship between birth weight and the other anthropometric parameters, so that, a parameter that correlates best with the birth weight can be identified. All the anthropometric measurements was carried out by a single observer within 24 hours of birth and was taken with the new born lying down.

Anthropometric Parameters (To the nearest 0.1 centimetre)

- Head circumference (HC)
- Chest circumference (CHC)
- Mid arm circumference (MAC)
- Upper limb length (ULL)
- Lower limb length (LLL)
- Calf circumference (CFC)
- Thigh Circumference (TC)
- Foot Length (FC)
- Crown Heel length (CHL)
- Crown Rump length (CRL)
- Abdominal Girth (AG)
- Skin Fold Thickness (SFT)
- Anterior fontanelle size(AFS)

Naked birth weight in grams (to the nearest 50 grams)Equipment's used during the study was a flexible, non-stretchable measuring tape, an infantometer, and digital weighing machine (ESSAE BS-250 Digital Weighing Scale, Essae - TeraokaPvt. Ltd, Bangalore, India).

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Head Circumference (HC): The head circumference was measured by placing a flexible non-stretchable tape anteriorly at the glabella, posteriorly along the most prominent points.

Chest Circumference (CC): The chest circumference was measured at the level of xiphoid cartilage (at the level of nipples).

Mid-Arm Circumference (MAC): The mid-arm circumference was measured in the left arm at the point midway between tip of the acromion process and the olecranon process of ulna.

Upper limb length (ULL): The most upper edge of the posterior border of the acromion process of the posterior surface of the arm to the middle finger.

Lower limb length (LLL): was measured from the greater trochanter to the lateral malleolus, with the limb maintained in complete extension.

Calf Circumference (CC): The calf circumference was measured at the most prominent point in semi flexed position of the leg.

Thigh Circumference (TC): The thigh circumference was measured in supine position, at the level of lowest furrow in the gluteal region; the tape was placed perpendicular to the long axis of lower limb.

Foot length (FL): Foot measured from the heel to the tip of hallux (big) toe using a stiff transparent plastic metric ruler.

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Crown Heel Length (CHL): The baby's supine crown-heel length was recorded by placing the baby in an infantometer, with knees fully extended and soles of feet held firmly against the foot board.

Crown Rump Length (CRL): Crown-rump length is recorded from the crown of the head to the prominence of the buttocks. With regard to low birth weight babies, their crown rump length is usually less than 47 centimeters.

Abdominal Circumference (AC): According to our methodological protocol, 30 minutes afterbirth during the physical examination abdominal circumference at the umbilical level will be measured.

Skin fold thickness measurements (SFT): A caliper will be used to measure the thickness of a fold of the baby's skin with its underlying layer of fat (the subcutaneous fat). The measurements was taken from the following body sites: triceps (upper arm), sub scapular (shoulder blade area), quadriceps (thigh area) and flank (at the back between rib and hip).

Triceps: The measurement of the triceps skin fold is taken halfway between the top of the shoulder and the elbow (halfway along the upper arm).

Sub-scapular: The measurement of the sub scapular skin fold is taken at the bottom right corner of the left shoulder blade.

Quadriceps: The measurement of the quadriceps (thigh) skin fold is taken halfway along the top of the upper leg.

RESULTS

During present study total 333 study subjects were reviewed in pediatric department, among 257 (78.24%) patients were enrolled into the study according present study inclusion criteria and 71 (21.75%) patients were excluded (16 babies had major congenital malformations, 32 parents not willing to give informed consent, 9 babies had birth injuries such as limb fractures, 14 newborns were less than 1000 grams) according exclusion criteria.

Table 1: Subjects were distributed according sex

Sex	Frequency	Percentage
Male	136	53.28
Female	121	46.72
Total	257	100

136 (53.28%) were male and followed by 121 (46.72%) were female

Table 2: Subjects were distributed according type of Delivery

Type of Delivery	Frequency	Percentage
LSCS	137	53.28
NVD	120	46.72
Total	257	100

Among 257 Babies, 137 (53.28%) were LSCS delivery and followed by 120 (46.72%).

Table 3: Correlation between Body weight and HC

Body weight	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.68	<0.0001
HC	33.47+/-175		

Weight=205.6 X HC-3967

Strong positive correlation between Head circumference (HC) and Body weight was observed (r=0.68). Mean head circumferences in measurements of investigator was 33.47 ± 1.75cm. Independent sample linear regression equation showed that Head circumferences of a newborn has a Strong positive correlation with birth weight (R2=0.47).
Specific formula for estimation of normal Head circumference was developed as a result of this study: Weight = 205.6 × HC-3967.

Table 4: Correlation between Body weight and CC

Body weight	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.71	<0.0001
CC	31.50+/-1.87		

Weight = 198.9 X CC-3353

Strong positive correlation between Chest circumference (CC) and Body weight was observed (r=0.71). Mean Chest circumference in measurements of investigator was 31.50 ± 1.87cm. Independent sample linear regression equation showed that chest circumference of a newborn has a Strong positive correlation with birth weight (R2-0.50).
Specific formula for estimation of normal Head circumference was developed as a result of this study: Weight = 198.9 X CC-3353.

Table 5: Correlation between body weight and MAC

Body weight/ MAC	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.48	<0.0001
MAC	9.47+/-1.20		

Weight = 213.7 X MAC+831.8

Medium positive correlation between mid arm circumference (MAC) and Body weight was observed (r-0.48).Mean Mid arm circumference in measurements of investigatorwas 9.47 ± 1.20cm. Independent sample linear regression equation showed that mid arm circumference of a newbornhas a medium positive correlation with birth weight (R2-0.23).
Specific formula for estimation of normal mid arm circumference was developed as a result of this study: Weight = 213.7 X MAC±831.8.

Table 6: Correlation between Body weight and ULL

Body weight/ ULL	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.24	<0.0001
ULL	20.84+/-1.68		

Weight = 77.19 X ULL+1306

Weak positive correlation between Upper limb length (ULL) and Body weight was observed (r=0.48). mean Upper limb length in measurements of investigator was 20.84 ± 1.68 cm. Independent

sample linear regression equation showed that Upper limb length of a new born has a weak positive correlation with birth weight (R2-0.06).

Specific formula for estimation of normal Upper limb length was developed as a result of this study: Weight = 77.19 X ULL ± 1306.

Table 7: Correlation between Body weight and LLL

Body weight/ LLL	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.27	<0.0001
LLL	21.73+/-1.75		

Weight = 83.29 X LLL+1105

Weak positive correlation between Lower limb length (LLL) and Body weight was observed (r-0.27). Mean lower limb length in measurement of investigator was 21.73 ± 1.75 cm. independent sample linear regression equation showed that lower limb length of a new born has a weak positive correlation with birth weight (R2=0.07).

Specific formula for estimation of normal lower limb length was developed as a result of this study. Weight = 83.29 X LLL ± 1105.

Table 8: Correlation between Body weight and CFC

Body weight/ CFC	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.24	<0.0001
CFC	9.49+/-1.44		

Weight = 1585.5 X CFC+1338

Medium positive correlation between calf circumference (CFC) and Body weight was observed (r=0.43). Mean Calf circumference in measurements of investigator was 21.73 ± 1.75cm. Independent sample linear regression equation showed that Calf circumference of a newborn has a medium positive correlation with birth weight (R2=0.18)

Specific formula for estimation of normal Calf circumference was developed as a result of this study: Weight = 158.5 X CFC + 1338.

Table 9: Correlation between Body weight and TC

Body weight/ TC	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.39	<0.0001
TC	13.63+/-1.78		

Weak positive correlation between Thigh Circumference (TC) and Body weight was observed (r=0.39).Mean Thigh circumference in measurements of investigator was 13.63 ± 1.78cm. Independent sample linear regression equation showed that Thigh circumference of a newborn has a weak positive correlation with birth weight (R2=0.15).

Specific formula for estimation of normal Thigh circumference was developed as a result of this study: Weight = 117.7 X TC + 1318.

Table 10: Correlation between Body weight and FL

Body weight/ FC	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.03	<0.56
FC	8.47 +/-1.78		

Weight = 7.154 X FC+2854

Very weak positive between Foot Length (FL) and Body weight was observed (r=0.03). Mean Foot Length in measurements of investigator was 8.47 ± 1.78 cm. Independent sample linear regression equation showed that Foot Length of a newborn has a very weak positive correlaiton with birth weight (R2=0.0001).

Specific formula for estimation of normal Foor Length was developed as a result of this study: Weight = 7.154 X FL + 2854.

Table 11: Correlation between Body weight and CHL

Body weight/ ULL	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.1	<0.09
CHL	48.63+/-6.15		

Weight = 8.8894X CHL+2482

Very weak positive correlation between Crown Heel length (CHL)and Body weight was observed (r=0.01). Mean crown heel length in measurements of investigator was 48.63 ± 6.15 cm. Independent sample linear regression equation showed that crown heel length of a newborn has a very weak positive correlation with birth weight (R2=0.01) (fig.11).
Specific formula for estimation of normal crown heel length was developed as a result of this study: Weight = 8.894 X CHL+2482.

Table 12: Correlation between Body weight and CRL

Body weight/ ULL	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.05	<0.56
CRL	4.61+/-5.66		

Weight = 4.901 X CRL+2849

Very weak positive correlation between Crown Heel length (CHL)and Body weight was observed (r=0.01). Mean crown heel length in measurements of investigator was 48.63 ± 6.15 cm. Independent sample linear regression equation showed that crown heel length of a newborn has a very weak positive correlation with birth weight (R2=0.01) (fig.11).
Specific formula for estimation of normal crown heel length was developed as a result of this study: Weight = 8.894 X CHL+2482.

Table 13: Correlation between Body weight and AG

Body weight/ ULL	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.45	<0.0001
AG	28.24+/-2.35		

Weight = 100.3 X +81.37

Medium positive correlation between abdominal girth (AG) and Body weight was observed (r=0.45). Mean abdominal girth in measurements of investigator was 28.24 ± 2.35 cm. Independent sample linear regression equation showed that abdominal girth of a newborn has a medium positive correlation with birth weight (R2=0.202) (fig.13).
Specific formula for estimation of normal abdominal girth length was developed as a result of this study: Weight = 100.3 X AG+81.37.

Table 14: Correlation between Body weight and SFT-Triceps

Body weight/ SFT-Triceps	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.24	<0.0001
SFT-Triceps	4.44+/-2.04		

Weight = 65.05 X SFT-Triceps+2626

Weak positive correlation between SFT-Triceps and Body weight was observed (r=0.24). Mean SFT-Triceps in measurements of investigator was 4.44 ± 2.04 cm. Independent sample linear regression equation showed that SFT-Triceps of a newborn has a weak positive correlation with birth weight (R2=0.06) (fig.14).
Specific formula for estimation of normal SFT-Triceps was developed as a result of this study: Weight = 65.05 X SFT-Triceps+2626.

Table 15: Correlation between Body weight and SFTSS

Bodyweight/ SFTSS	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.56	<0.0001
SFTSS	4.38+/-0.96		

Weight = 356.7X SFTSS+1373

Medium positive correlation between SFTSS and Body weight was observed (r=0.56). Mean SFTSS in measurements of investigator was 4.32 ± 0.83 cm. Independent sample linear regression equation showed that SFTSS of a newborn has a medium positive correlation with birth weight (R2=0.317) (fig.14).
Specific formula for estimation of normal SFTSS was developed as a result of this study: Weight = 356.7 X SFTSS+1373.

Table 16: Correlation between Body weight and SFTFLa

Bodyweight/ SFTFLa	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.48	<0.0001
SFTFLa	4.38+/-0.96		

Weight = 262.0 X SFTSS+1373SFTFLa+1765

Medium positive correlation between SFTFLa and Body weight was observed (r=0.48). Mean SFTFLa in measurements of investigator was 4.38 ± 0.96 cm. Independent sample linear regression equation showed that SFTFLa of a newborn has a medium positive correlation with birth weight (R2=0.232) (fig.16).

Specific formula for estimation of normal SFTFLa was developed as a result of this study: Weight = 262.0 X SFTFLa+1765.

Table 17: Correlation between Body weight and SFTQua

Bodyweight/ SFTQua	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.510	<0.0001
SFTQua	7.27 +/- 1.71		

Weight = 1.56.8 X SFTQua+1774

Medium positive correlation between SFTQua and Body weight was observed (r=0.51). Mean SFTQua in measurements of investigator was 7.27 ± 1.71 cm. Independent sample linear regression equation showed that SFTQua of a newborn has a medium positive correlation with birth weight (R2=0.260) (fig.17).

Specific formula for estimation of normal SFTQua was developed as a result of this study: Weight = 156.8 X SFTQua+1774.

Table 18: Correlation between body weight and AFS

Bodyweight/ AF	Mean SD	Pearson Correlation Coeffiecients	P-value
Bodyweight	291.500 +/-525.3	0.05	<0.0001
AFS	18.60 +/- 8.27		

Weight = 3.691 XAFS+2846

Very weak positive correlation between Anterior fontanelle size(AFS)and Body weight was observed (r=0.05). Mean Anterior fontanelle size in measurements of investigator was 18.60 ± 8.27 cm. Independent sample linear regression equation showed that Anterior fontanelle size of a newborn has a very weak positive correlation with birth weight (R2=0.003) (fig.18).Specific formula for estimation of normal abdominal girth length was developed as a result of this study: Weight = 3.691 X AFS+2846.

DISCUSSION

Since the time of Hippocrates, mortality of low birth weight babies has been reported in medical bible. Biologists all over the world appreciated the importance of normal birth weight and effect of maternal factor on progeny, even before Charaka Samhita dedicated a entire chapter to the role of healthy progenitors and care of pregnant women for a healthy parturition. There is still no accord of an ideal constant surrogate and the research in this field is still on. Several anthropometric indices have been recommended such as head circumference, mid arm circumference, chest circumference, thigh circumference and calf circumference. The present study was conducted to find the best alternative surrogate parameters, which can be used at community level by health workers in rural areas to identify low birth weight babies and prompt referral to higher tertiary centers. Such an surrogate indicator must have a good correlation with birth weight.

This study was conducted in an urban area of Hyderabad with the objective of comparing various anthropometric measurements as a screening tool for LBW neonates. Many hospital-based studies have reported the utility of anthropometric measurements to screen for LBW neonates. Different studies have identified various anthropometric measurements such as MUAC and CC as the most useful predictors of LBW. There exists a paucity of community based studies that use these indices as a screening tool for LBW in field settings especially for home-based deliveries. Most of previously conducted studies are hospital based and thus enables the researcher to measure birth weight and other anthropometric indices in a standardized time interval soon after birth.

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In our study we found that chest circumference and head circumference were best parameters to assess low birth weight babies in neonates.

In this study total 257 subjects were enrolled into study, among them 53.28% were male and 46.72% were female. 53.28% were LSCS delivery and followed by 46.72% were normal delivery.

Statistically Strong positive correlation with body weight Vs parameter

Head circumference (HC)

In present study, a Strong positive correlation between Head circumference (HC) and Body weight was observed (r=0.68).Similar observation were found in previous studies like Das NK et al,[6]Pomeroy et al,[7]NairBetal,[3]MinhajuddinA,[8]et al, Bably Sabina Azhar et al,[9]was 0.95, 0.77,0.82, 0.63 and 0.55respectively.

Specific formula for estimation of normal Head circumference was developed as a result of this study: Weight = 205.6 X HC-3967. Similar formula made Minhajuddin A et al,[53] and Bably Sabina Azhar et al,[54]

Chest circumference (CC):

In present study, Strong positive correlation between Chest circumference (CC) and Body weight was observed (r=0.71). Similar observation were found in previous studies like Das NK et al,[6] Pomeroy et al,[7]Nair Be et al,[3]Minhajuddin et al,[8]Bably Sabina Azhar et al,[9]was 0.86, 0.75, 0.73, 0.71 and 0.44 respectively.

Specific formula for estimation of normal chest circumference was developed as a result of this study: Weight = 198.9 X CC-3353. Similar formula was made by Minhajuddin A et al,[8] and Bably Sabina Azhar et al.[9]

Medium positive correlation

Medium positive correlation between mid arm circumference (MAC) and Body weight was observed (r=0.48). But other study observation that strong correlation were found in previous studies like B, Suneetha F et al,[10] and Minhajuddin et al,[8]0.57 and 0.59 respectively. Specific formula for estimation of normal mid arm circumference was developed as a result of this study: Weight = 213.7 X MAC+831.8.

CONCLUSION

In our study it is concluded that, chest circumference followed by head circumference is a simple, cheap, cost-effective and culturally acceptable surrogate anthropometric parameter of birth weight for screening and earliest detection of high risk neonates by health workers with immediate referral to appropriate health facility especially at the community level where there are no facilities for weighing babies.

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