Research Article

Body mass index values for term newborns and its correlation with other anthropometric surrogates

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ABSTRACT

Background: Body mass index is a better tool as it relates two anthropometric measures - Weight and Length. This study aims at identifying the mean BMI in term new-borns in Asian population and also the correlation between BMI and other anthropometric surrogates for birth weight.

Methods: Cross Sectional study was conducted in a tertiary care hospital by taking anthropometric measurements for 339 consecutive term newborns, born in the institution. Mean BMI was 11.784 ± 1.7 . Moderate Positive correlation was observed between BMI and Mid Arm Circumference ($r = +0.401$; $P = 0.000$).

Results: The cut off value for BMI to identify LBW was 13. Mid Arm Circumference, Chest circumference and Head circumference correlated well with BMI.

Conclusions: By trial and error method of analysis we recommend BMI value of 13 as a cut off for identifying low birth weight infants. BMI is seen to be better than Birth weight in assessing body proportion of a new born.

Keywords: Body mass index, Birth weight, Anthropometric surrogates

INTRODUCTION

Incidence of low birth weight in developing countries (16.5%) is more than double the level in developed regions i.e. 7%.¹ Forty percent of all LBW babies in the developing world are born in India.² It is associated with increased morbidity and mortality.

Birth weight is the basic criteria by which nutrition is assessed in a newborn till date. BMI which is derived from the two anthropometric measurements is probably considered to be better assessment criteria.³ The Body mass index (BMI), which is a measure of adiposity in

children and adults, is used as a measure of nutrition also. The same can be applied to the neonates also.

There are various studies done earlier, which looked into the correlation between birth weight and other anthropometric surrogates. These studies showed that the Mid Arm circumference, Chest circumference and head circumference correlated well with birth weight.⁴⁻¹⁴

A study done by Brock RS, charted BMI for newborns according to the gestational age and the mean BMI in term neonates were found to be 13.25 ± 1.11 .¹⁵ It also validated BMI as a good tool for accessing nutrition. This study was done in Caucasian population and hence the

BMI value may be slightly high when compared to Asian population. Mean BMI observed in another study done in South India was 12.86 kg/m^2 close to the expected value of 13.⁸ In addition, this study showed good correlation with BMI and Mid Arm Circumference.

In these circumstances, the purpose of the present study was to determine the mean BMI for South Asian population and to recommend a cut off value for BMI for identifying LBW. In addition, the study determines the correlation of various anthropometric surrogates with BMI. The present study was conducted with the written informed consent from the parents after clearance from the Institutional Research and Ethics Committee.

METHODS

All full-term, singleton, live born babies born of consecutive deliveries ($n=339$) that took place from June 2012 to Feb 2013 were included in this study. One of the investigators examined all the neonates, assessed gestational age and measured anthropometric measurements within 24 hours of birth. Only those who are greater than 37 weeks of gestational age were enrolled in the study. The neonates with congenital anomalies/dysmorphic features were excluded.

Anthropometric measurements taken were birth weight (BW), Length, Mid Arm Circumference (MAC), Chest circumference (CC) and Head circumference (HC).

All the neonates were weighed on a spring type of weighing scale to the nearest 50 grams. Standardizations of the weighing machine were done daily. The length, in centimetres, was obtained with the newborn in the supine position, on a rigid surface, using an Infantometer, with the aid of another person to hold the infant. Other measurements were made with a non-stretch plastic measuring tape. Mid-upper Arm circumference (MAC) was measured at the midpoint between the tip of Acromion process and Olecranon process of the left upper arm. Chest Circumference (CHC) was measured at the level of nipple at the end phase of expiration. Head Circumference (HC) was measured between Glabella and the most prominent point of Occiput posteriorly.

RESULTS

In the present study of 339 newborns, 178 (52.5%) were males and 161 (47.5%) females. Mean Birth weight was found to be $2.9 \pm 0.02 \text{ kg}$ (birth weight was ranging from 1.5kg to 3.9kg). The percentage of LBW infants was 11.8%; Head circumference ranges from 30 to 37 cm with Mean $\pm$ SE as 33.0 ± 0.07 ; Chest circumference from 27 to 37cm with mean 31.8 ± 0.09 ; Mid Arm circumference from 8cm to 13cm with mean 9.92 ± 0.05 .

The mean BMI was $11.7 \pm 1.7 \text{ kg/m}^2$. The mean BMI for males was $11.8 \pm 1.6 \text{ kg/m}^2$ and that for females was

$11.7 \pm 1.8 \text{ kg/m}^2$. This difference was statistically insignificant with a $P = 0.36$

We also observed a positive correlation of ' $r = +0.56 (P=0.000)$ ' for MAC with Birth weight and ' $r = +0.556 (P=0.000)$ ' for MAC with CC. A significant mild positive correlation was seen among HC with CC and BW, CC with BW respectively.

Student-t-test in Table 1 shows a statistically significant difference in the BMI values between the groups in HC, CC and MAC. Since Length and Birth Weight were used to estimate BMI, we calculated Karl Pearson's Bivariate Coefficient of Correlation between HC, CC, MAC and BMI.

Table 1: Student -t-test of BMI for anthropometric measures.

Measures (cm)	N	Mean $\pm$ SE (Mean)	t-value (P-value)
HC $\leq$ 32.5	117	11.2 ± 0.14	3.945
HC $>$ 32.5	220	12.0 ± 0.12	(0.000)*
CC $\leq$ 30.5	52	11.3 ± 0.25	1.998
CC $>$ 30.5	287	11.8 ± 0.10	(0.047)*
MAC $\leq$ 9	98	11.1 ± 0.18	4.401
MAC $>$ 9	241	12.0 ± 0.10	(0.000)*

*Significant; HC-Head circumference; CC-chest circumference; MAC-Mid arm circumference.

Figure 1 shows the Scatter plot and there existed a Statistically Significant positive High Correlation of these measures with BMI ($P=0.000$).

Figure 1: Scatter plot of anthropometric measures with BMI.

Table 2 presents the sensitivity, specificity for three anthropometric measures at different BMI levels i.e. 11, 12 and 13 by trial and error method. ROC curves from Figure 2 highlights a good coordinates for these measures which is similar to the other studies of BMI 13. Hence, as per Kapoor SK et al, Naik DB et al and Brock RS et al, we have grouped the BMI at 13, we observed 257 (75.8)

with BMI $\leq$ 13, 82(24.2) with BMI $\geq$ 13. Among them 148 (43.7) males and 109 (32.2) females had BMI $\leq$ 13; 30(8.8) males and 52(15.3) females had BMI $\geq$ 13.¹³⁻¹⁵

Figure 3 Shows Error Bars for HC, CC and MAC. There was Statistically Significant Association between the BMI 13 group with HC [$\chi^2=24.07(P=0.000)$] and MAC [$\chi^2=14.7(P=0.000)$] contributing to 3.7 times chance of identifying the LBW babies [odds ratio=3.7(1.8 to 7.6)] and an insignificant association was observed with CC.

The main findings of our study: BMI correlates well with HC, CC, MAC and it is better than Birth weight in assessing the newborn nutrition. BMI 13 is the ideal cutoff point in identifying the LBW newborns.

Table 2: Cut off points of anthropometric measures for different BMI.

BMI	Measures (cm)	Sensitivity (%)	1 -Specificity (%)
11	HC - 29.75	99.1	100
	CC - 26.00	97.7	99.2
	MAC - 8.25	94.8	91.3
12	HC - 29.75	97.1	99.0
	CC - 27.5	97.8	98.5
	MAC - 8.55	93.4	91.6
13	HC - 30.5	95.1	95.3
	CC - 28.5	97.6	91.4
	MAC - 8.80	90.0	89.1

Figure 2A: ROC curve for BMI 11.

Figure 2B: ROC curve for BMI 12.

Figure 2C: ROC curve for BMI 13.

Figure 3: Anthropometric measures for BMI 13.

DISCUSSION

Our study showed mean birth weight of the newborns as 2.9 ± 0.02 kg which is comparable with WHO criteria for this region. But the WHO standard for average birth weight in the world is 3.229 kg.¹ The average BMI of 11.87 kg/m² for term neonate was close to the value of 12.86 kg/m² arrived in the previous study done in South India⁸ but less when compared with Brazil study.¹⁵ The comprehensive study done in a large population in Brazil has shown a value of 13.25 ± 1.11 kg/m² at 37 weeks and 14.10 ± 1.01 at 40 weeks. Our study had only 24.2% of babies with BMI $\leq$ 13. This may be due to the fact that our hospital caters to lower middle class population and when compared to western standards the mean Birth weight was low. Moreover, this variation can be explained by the difference in the population studies as Caucasians are proved to have a better BMI due to the genetic variation. Another contributing factor may be the significantly higher percentage of Low Birth Weight babies in our population.

The BMI showed no significant statistical difference between males and females in our study which is in

agreement with study done in Brazil where no difference was noted in almost all the gestational ages.¹⁵

BMI was analyzed for correlation with three parameters i.e. MAC, HC and CC which will give us an indirect way to assess whether BMI alone is sufficient to assess the neonatal nutrition. On the other hand it will also give us an idea which of the parameters can be used as a surrogate for BMI in the community. This has got prime importance as in the community there are some logistic deficits which leads to not weighing the newborn at birth. In these situations surrogates can come to use to identify low birth weight babies who need special care.

BMI has shown better correlation with all surrogates taken. High Significant Correlation was seen with MAC, but others like CC, HC was also moderately significant. This fact was already suggested in a study where correlation with MAC and BMI was established.⁸ Much more studies are to be conducted to find out the correlation with BMI and these surrogates mentioned above. Studies are lacking in this particular area even though many studies are there showing correlation with birth weight.⁴⁻¹⁴

We trialed the BMI cutoff points at 11, 12, 13 for the anthropometric surrogates and compared their efficacy as provided in Table 2. This was done with proof from other studies, where their mean BMI ranged from 11 to 13.

Our own previous studies have shown a cut off value of 8.55 cm for MAC in low birth weight babies who had a sensitivity of 90% and specificity of 95.3% which is a good criteria for a screening tool in identifying low birth weight babies. Cutoff given for mid arm circumference by other studies ranges from 8.44 cm to 9 cm. This study also gives a cut off value 8.25 and 8.55 for BMI 11 and 12. Head circumference did not show much difference with various BMI, which can be due to the sparing of growth retardation of head in cases of IUGR babies.

In our study the cut off for LBW in terms of BMI was 13 with sensitivity 90% and Specificity 95%. This low cut off is good enough for the community where the study was done as the nutrition of new born is low when compared to western standards. This low cut off aids in maximal referral and special care being given to all babies who require the same. In other words, it reduces the false negatives.

To our surprise chest circumference showed a satisfactory significant correlation with birth weight. It is suggested as best surrogate by other studies.^{5,12,13}

CONCLUSION

BMI is a better tool to assess neonatal nutrition .The Effective cut off for identifying Low Birth Weight babies is 13 kg/m². Average BMI at neonatal period for South Indian population can be suggested as -13. Assessment of

nutrition at newborn period itself helps to provide a baseline value for further follow up and also reflects intra uterine growth. To present BMI as a good tool, further studies with large sample size should be conducted in the developing countries and also in the same ethnic group.

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