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Clinical Study

Sex, Conception Interval, Gestational Age, Apgar Score, and Anthropometric Surrogates in relation to Birth Weight of Bangladeshi Newborns: A Cross-Sectional Study

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In developing countries, where about 75% of births occur at home or in the community, logistic problems prevent the weighing of every newborn child. Baby born with a weight less than 2,500 g is considered low birth weight, since below this value birth-specific infant mortality begins to rise rapidly. In Bangladesh, the prevalence of low birth weight is unacceptably high. Infant's sex differences, birth to conception interval, gestational age, and Apgar score are associated with infant birth weight. To screen low-birth-weight babies, simple anthropometric parameters can be used in rural areas where 80–90% of deliveries take place. A sample of 343 newborn singletons, 186 male and 157 female babies, were studied in Southwest region of Bangladesh to examine the birth weight status of newborns and to identify the relationship between birth weight and other anthropometric parameters of newborns. The mean birth weight was 2754.81 ± 465.57 g, and 28.6% were low-birth-weight (<2,500 g) babies. All key anthropometric parameters of the newborns significantly correlated with infant birth weight ($P = 0.05$). Mid upper arm circumference and chest circumference were identified as the optimal surrogate indicators of LBW babies. In the community where weighing of newborns is difficult, these measurements can be used to identify the LBW babies.

1. Introduction

In recent years, there has been a considerable interest in using simple anthropometric measures as a proxy for birth weight. Of the approximately four million global neonatal deaths that occur annually, 98% occur in developing countries, where most newborns die at home while they are being cared for by mothers, relatives, and traditional birth attendants (TBAs) [1]. About 38% of total under-five mortality occurs during the first 28 days of life, and nearly three-quarters of these deaths occur during the first week of life [2]. Globally, about one-sixth of all newborns are low birth weight (LBW, <2500 grams), which is the single most important underlying risk factor for neonatal deaths [1, 3]. Only about half of the newborns are weighed at birth, and for a smaller proportion of them gestational age is known [4]. An estimated 18 million babies are born with LBW and half of them are born in South Asia [5]. Although these LBW babies account for 14% of the children born, they account for 60–80% of neonatal deaths [6]. Moreover, LBW babies who survive the critical neonatal period may suffer impaired physical and mental growth. Therefore, an early identification and prompt referral of LBW newborns is vital in preventing neonatal deaths. Available evidence from resource-poor settings shows that extra essential newborn care for LBW babies can reduce the number of neonatal deaths by 20–40% [7]. Research has also shown that this extra essential newborn care may be delivered by health workers or family members if they are suitably trained [8]. In resource-poor settings, a large proportion of deliveries take place at home and birth weight is most often not recorded. Therefore, there is a need to develop simple, inexpensive, and practical methods to identify LBW newborns soon after birth [9]. One such method may be the use of anthropometric surrogates to identify LBW babies.

Infant's sex differences, birth to conception interval, gestational age, and Apgar scores are associated with infant birth weight. Boys grow faster than girls from an early stage of gestation, even from before implantation [10]. Study in Indonesia, it was seen that mean birth weight for male babies were greater than girls at birth [11]. It was found that birth to conception interval of six months or less was associated with an increased risk of intrauterine growth retardation [12]. Macleod and Kiely [13] also reported a strong association between birth weight and duration of pregnancy. Apgar score is a simple and repeatable method to quickly and summarily assess the health of newborn children immediately after birth [14, 15]. The five-minute Apgar score is positively correlated with birth weight and is higher in small for gestational age (SGA) infants compared with their appropriately grown counterparts [16].

In Bangladesh most delivery cases take place in home and performed by senior experienced relatives or by the TBA locally known as *Dias*. Though many TBAs are trained, they have no weighing scale in their delivery kits. Moreover, in most health complexes, babies are not weighed routinely due to lack of a suitable weighing scale at the centre. However, for this reason a number of alternative anthropometric measurements have been proposed as surrogate for birth weight [17–19]. These include the circumferences of the newborn's head, chest, and mid arm and crown-heel length.

Several researchers have attempted to identify suitable anthropometric surrogates which are simple and reliable to identify LBW babies. Recent hospital-based studies from India, Bangladesh, and other developing countries have suggested different anthropometric surrogates to identify LBW babies and have also recommended various cut-off values for identification of LBW babies [20–29]. Available evidence suggests that there is a lack of consensus about most reliable anthropometric surrogate and a fixed cut-off point.

In this study we tried to find out relationships between sex difference, conception interval, gestational age, and Apgar score on birth weight and tried to correlate and fix anthropometric surrogates to identify low-birth-weight newborns from Southwest region of Bangladesh.

2. Methods and Materials

This cross-sectional study was carried out among the mothers and their newborn babies at the Southwest region of Bangladesh. Almost everywhere in Bangladesh, incidence of low birth weight is unacceptably high. Due to the limitations of time and resources, it is not possible to conduct the study covering the whole country. Therefore, specific areas are chosen by a multistage sampling procedure. Three districts of Khulna division from Southwest region of Bangladesh are our primary study area. Pregnant women attending sadar hospitals and maternal clinics for delivery purpose and their newborn babies during the study period (January 2010 to December 2010) were regarded as the study subjects. A multistage sampling procedure was adopted in selecting the ultimate sampling unit for the present study. In the first stage, three districts of Khulna division: Jessore, Kushtia, and Jhenaidah were randomly selected as primary sampling units. In the second stage, twelve upazilas out of twenty of the aforesaid districts were randomly selected as secondary sampling units. In the third stage, thirty-eight hospitals and clinics were randomly selected taking at least three from each of the upazilas. In this stage nine mothers and their newborns from each hospital and clinic were targeted to collect data. However, in case of Jessore Sadar Hospital ten mothers and their newborns were targeted. To have a representative sample of population of the study districts, it was decided to collect data from five upazilas from Jessore, four upazilas from Kushtia, and three upazilas from Jhenaidah district. Women with normal vaginal delivery and live singleton birth were included in this study. Women with multiple pregnancies, caesarian section and stillbirth were excluded from study. The subjects were informed about the nature of the study, and verbal consent was taken from them before data collection. A total of 343 mothers with singleton babies were enrolled in this study. Data of sociodemographic factors, obstetrical history, morbidities, and anthropometric parameters of the mother and newborn baby subsections were collected in a questionnaire form. Anthropometric parameters of the newborns were recorded by the investigator within 18 hours of birth by standard techniques [30]. All the newborns were weighed naked on a spring electronic balance with a maximum paucity of 15 kg and a minimum of 125 g and 5 g subdivisions. The weighing machine was checked daily by known standard weight before weighing.

The mid upper arm circumference (MUAC) was measured using a nonelastic measuring tape to the nearest of 1.0 cm. The MUAC was obtained from the left arm, at the midpoint between the acromion and olecranon, with the newborn in dorsal decubitus with the arm lying laterally to the trunk. The midpoint was located by measuring the distance between the acromion and olecranon extremities, with the elbow flexed at an angle of 90°. A small mark was made at the identified point. A total of three consecutive measurements were taken for each newborn, and the mean value (rounded to the nearest 0.1 cm) was considered for analysis. Crown-heel length (CHL) of newborns was measured to the nearest of 0.1 cm on an infantometer. The baby was placed in the board with legs completely stretched by applying moderate pressure on the knees. Head was touching the fixed board; then the length was measured. Head circumference (HC) of newborns was measured 24 hours of delivery with the help of nonelastic measuring tape. The HC was measured with the newborn in dorsal decubitus. The measuring tape was placed along the occipital-frontal circumference, just over the eyebrows and the occiput, in order to obtain the largest measurement. The maximum value of three consecutive measurements was considered, rounded to the nearest 0.1 cm. Maximum circumference was recorded. Chest circumference (CC) was measured at the level of nipple at the end phase of expiration.

Table 1: Relationship between birth weight and sex of newborns.

Variable	<2500		2500–2999		3000+		χ^2	Mean	SD	F	Total no. of cases
	n	%	n	%	n	%					
Sex of newborn											
Male	33	21.0	61	38.9	63	40.1		2859.87	476.480		186
Female	65	34.9	77	41.4	44	23.7	13.321 (0.5)	2666.13	438.157	15.363 (0.5)	157
Both	98	28.6	138	40.2	107	31.2		2754.81	465.568		343

Birth weight (g)

Table 2: Relationship between birth weight and birth to conception interval.

Variable	<2500		2500–2999		3000+		χ^2 (P)	Mean	SD	F (P)
	n	%	n	%	n	%				
Birth to conception interval (month)										
No prior	40	28.2	59	41.5	43	30.3		2705.00	461.354	
Up to 12	4	30.8	5	38.5	4	30.8		2754.93	454.013	
13–24	15	27.8	22	40.7	17	31.5		2724.07	414.790	
25–36	19	28.8	25	37.9	22	33.3	2.244 (0.5)	2777.27	514.944	0.440 (0.5)
37–48	13	32.5	16	40.0	11	27.5		2707.69	504.086	
49–59	4	20.0	9	45.0	7	35.0		2890.00	515.956	
60+	3	37.5	2	25.0	3	37.5		2762.50	385.218	
Total	98	28.6	138	40.2	107	31.2		2754.81	465.568	

Birth weight (g)

Data were analyzed using standard statistical methods, which include correlation coefficient, analysis of variance, simple and multiple regressions, and sensitivity and specificity analyses for different cut-offs of the newborns (CHL, HC, CC, MUAC) using SigmaStat (version 3.1; Systat Software Inc., Point Richmond, CA, USA) and SPSS for Windows (release 17; SPSS Inc., Chicago, ILL, USA) with P value of 0.05 considered statistically significant.

3. Results

3.1. Relationship between Birth Weight and Sex of Newborns. Table 1 shows the percentage of distribution of birth weight by sex. Result shows that LBW was higher in female infant than in male infant. Adequate birth weight was almost twice in male babies than female babies. And the relation was significant ($X2 = 13.32$, $P = 0.05$). Variance analysis also shows that the mean difference of birth weight between male and female newborns was 193.74 g, but the difference was insignificant ($F = 15.36$, $P = 0.5$).

3.2. Relationship between Birth Weights with Birth to Conception Interval. Effects of conception interval on birth weight are presented in the Table 2. Highest LBW was found when the interval was 60 or more months. On the other hand, incidence of adequate birth weight was also the highest observed for interval of 60 or more months. There were no significant differences in mean birth weights among different birth to conception interval groups ($F = 0.440$, $P = 0.5$).

3.3. Relationship between Birth Weight and Gestational Age. The effect of gestational age on birth weight is shown in Table 1 and Figure 1. Mean birth weight gradually increased as gestational age increased. The result was highly significant ($F = 2.625$, $P = 0.05$). Figure 1 shows the increased trend mean birth weight from 31 weeks onwards. But at 37 weeks birth weight drooped slowly, and then after 38 weeks weight increased sharply.

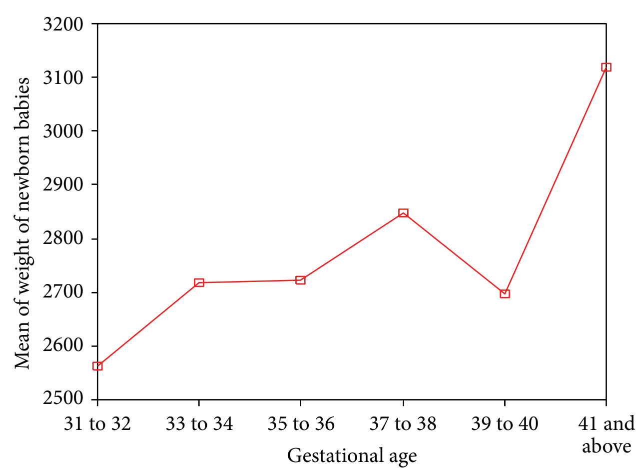

Figure 1: Relationship between mean birth weight and gestational age.

3.4. Relationship between Birth Weight and Apgar Score. Apgar score was recorded at birth and according to the scoring birth weight was categorized. The incidence of LBW was 28.1% for Apgar score 7 and 25.0% for Apgar score 8

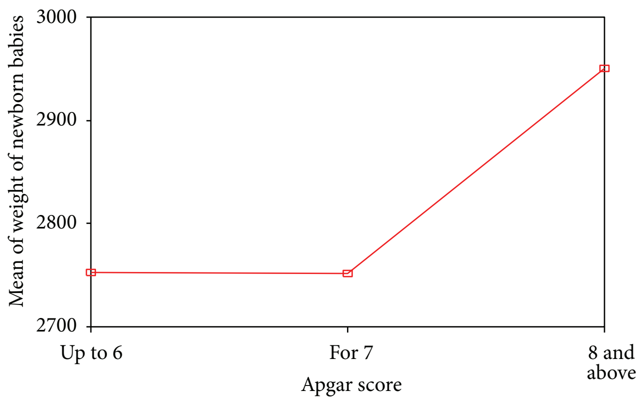

Figure 2: Relationship between mean birth weight and Apgar score.

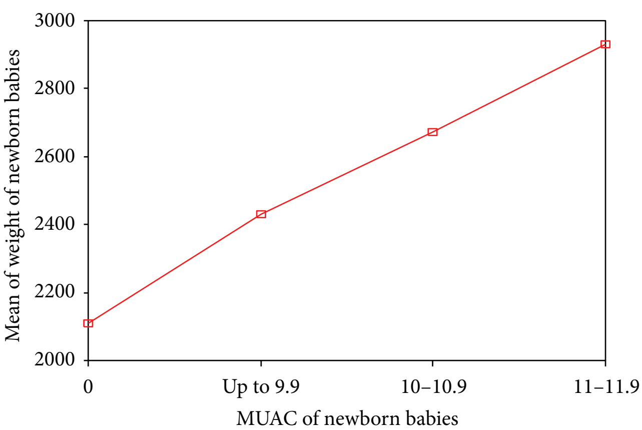

Figure 3: Relationship between mean birth weight and newborn's MUAC.

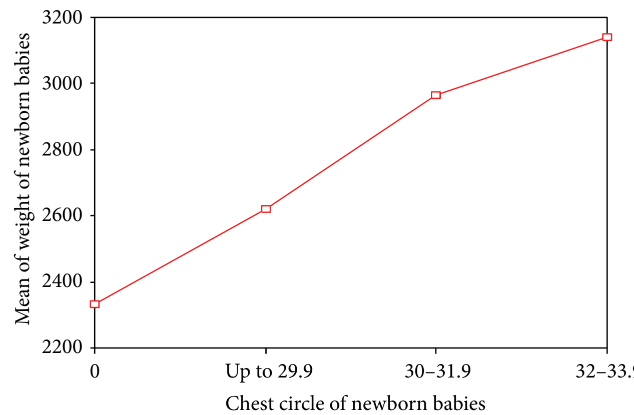

Figure 4: Relationship between mean birth weight and CC.

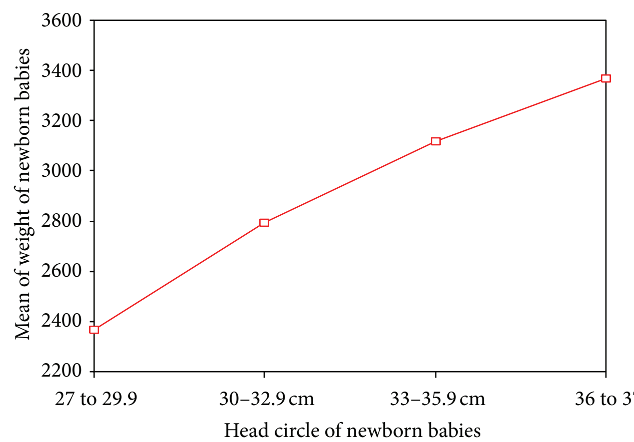

Figure 5: Relationship between mean birth weight and newborn's HC.

or more. Incidence of adequate birth weight was the highest (50.0%) for Apgar score 8 or more 8. 33.3% for 7 and only 30.7% for up to 6. Mean birth weight difference from the highest to lowest Apgar score was 197.39 g ($F = 0.354$, $P = 0.05$) which is statistically significant. Figure 2 shows the relationship between mean birth weight and Apgar score.

3.5. Birth Weight and Surrogate Markers

3.5.1. Mid Upper Arm Circumference (MUAC) of Newborns. The mean birth weight was found progressively higher with increasing MUAC. The difference in mean birth weight from the highest (12 cm or more) to the lowest (7.0–9.9 cm) MUAC was 524.67 g, which is statistically significant ($F = 37.141$, $P = 0.05$). Figure 3 shows the relationship between mean birth weight and MUAC.

3.5.2. Chest Circumference (CC) of Newborns. Result shows that the mean birth weight had a significant correlation with the CC. The highest mean birth weight was 3141.46 g when CC was between 32 to 33.9 cm and lowest mean birth weight was 2619.44 g for the lowest range (up to 29.9 cm) of CC. The difference of mean birth weight was 522.02 g between the highest and lowest CC group of newborns, which is statistically significant ($F = 37.281$, $P = 0.05$). Figure 4 shows the relationship between mean birth weight and CC.

3.5.3. Head Circumference (HC) of Newborns. The birth weight was positively co-related with HC. Mean birth weight was 2365.85 g for HC ranging from 27.0 to 29.9 cm and 3366.67 g for HC 36 cm or more. The difference was 1000.82 g, which is statistically significant ($F = 52.382$, $P = 0.05$). Figure 5 shows the relationship between mean birth weight and HC.

3.5.4. Crown-Heel Length (CHL) of Newborns. The result shows that the mean birth weight was progressively higher with increasing newborn's CHL. For crown-heel length, mean birth weight was found 2359.26 g when it ranges from 40.0 to 44.9 cm and 3282.61 g when CHL was 51.0 cm or more. The difference in mean birth weight between the highest and lowest CHL group of newborns was 923.35 g, which is statistically significant ($F = 65.285$, $P = 0.05$). Figure 6 shows the relationship between mean birth weight and CHL.

Table 3: Relationship between birth weight and gestational age.

Variable	Birth weight (g) <2500 n	%	2500–2999 n	%	3000+ n	%	χ^2 (P)	Mean	SD	F (P)
Gestational age (weeks)										
31-32	9	42.9	9	42.9	3	14.3	14.795 (0.05)	2561.90	390.482	2.625 (0.5)
33-34	12	27.3	21	47.7	11	25.0		2718.18	407.644	
35-36	37	34.6	40	37.4	30	28.0		2723.36	479.894	
37-38	22	19.8	47	42.3	42	37.8		2848.65	474.986	
39-40	18	32.7	19	34.5	18	32.7		3120.00	456.624	
40+	0	0	2	40.0	3	60.0		2696.36	408.656	
Total	98	28.6	138	40.2	107	31.2		2754.81	465.568	

Table 4: Matrix of zero order co-relation coefficients between birth weight and anthropometric parameters of newborns.

	BW	MUAC	CC	HC	CHL
Birth weight (BW)	1.000	0.250**	0.447**	0.554**	0.569**
MUAC		1.000	0.151**	0.191**	0.190**
CC			1.000	0.240**	0.339**
HC				1.000	0.281**
CHL					1.000

**Correlation is significant at the 0.01 level (2-tailed).

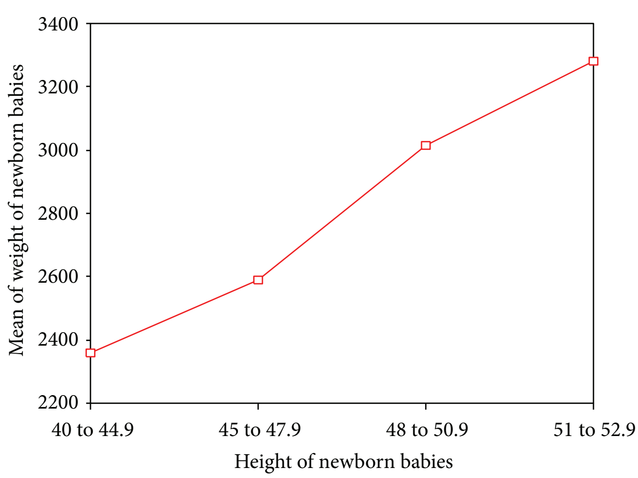

Figure 6: Relationship between mean birth weight and newborn's CHL.

3.6. Matrix of Zero Order Co-Relation Coefficients between Birth Weight and Anthropometric Parameters of Newborns. Table 4 shows matrix of zero order correlation coefficients between birth weight and other anthropometric parameters of newborns at birth. All parameters were significantly correlated to each other ($P = 0.01$). The highest correlation was observed between birth weight and crown heel length ($r = 0.56$), followed by between birth weight and head circumference ($r = 0.55$).

3.7. Simple Regression Equations for Estimating Birth Weight. Table 5 shows that for each cm increase of MUAC, CC, HC and CHL weight of newborn increased by 224 g, 139 g, 125 g and 113 g respectively. In simple regression it is also seen that highest variation 40.9% of birth weight was explained by CHL followed by MUAC 36.5%, HC 30.9% and CC 25.3%.

3.8. Multiple Regression Equations for Estimating Birth Weight. Multiple regression equation was also undertaken to observe which individual variable or combination of variables explain the variation of birth weight maximally. From Table 6 it is revealed that in stepwise regression, CC alone explains the variation by 25.3%. In the equation no two MUAC entered with CC and together explains the variation by 47.1%. When HC is added in the equation, together these three variables explained the variation of birth weight by 56.7%.

4. Discussion

The sex of the fetus is probably the easiest of the factors to evaluate [31]. A meta-analysis report cited that among 19 studies in developing countries (including two studies of poor urban Blacks in the USA), the difference of birth weight between male and female infants was found to be 93.1 g and the difference was found to be 126.4 g in developed countries shown in 15 studies. In another study in Indonesia, it was seen that mean birth weight for male babies was found to be 3047 g and that for female babies was found to be 2900 g [11]. In our study there were no significant differences in birth weight and anthropometric measurements between male and female newborns. Therefore we analyzed the combined data for both sexes. In the present study LBW was found to be 21.0% and 34.9% respectively for male and female babies. Mean birth weight was found to be 2859.87 g and 2666.13 g respectively for male and female babies (Table 1). We found relatively healthy baby because all newborn babies are born in hospitals and not at home, possibly leading to a higher average health condition and higher birth weight. The finding is consistent with many other studies [32, 33].

Many studies have demonstrated elevated risks of mortality for infants born at short birth intervals [34–37]. Infants born after birth intervals of 12 months or less are 30 percent more likely to be small for gestational age (SGA) than infants born 18–59 months after the previous birth, even when the effects of maternal age and parity are controlled [34].

Table 5: Simple regression equations for estimating birth weight.

Anthropometric parameters	Regression equations	F (P)	Adjusted R square
Mid upper arm circumference (cm)	$Y = 148.910 + 224.156$ MUAC	197.511 (0.05)	0.365
Chest circumference (cm)	$Y = -1612.834 + 139.203$ CC	116.873 (0.05)	0.253
Head circumference (cm)	$Y = -1096.313 + 124.734$ HC	154.198 (0.05)	0.309
Crown heel length (cm)	$Y = -2559.43 + 113.336$ CHL	237.588 (0.05)	0.409

Table 6: Multiple regression equations for estimating birth weight.

Multiple regression equations	Adjusted R square
$Y = -1612.834 + 139.203$ CC	0.253
$Y = -2358.755 + 95.236$ CC $+ 182.826$ MUAC	0.471
$Y = -3804.727 + 81.839$ CC $+ 141.262$ MUAC $+ 76.099$ HC	0.567

In another study, also it was found that, birth to conception interval of six months or less were associated with an increased risk of intrauterine growth retardation [38], and this may in part account for the increased risk of neonatal mortality with short birth intervals observed in other studies [37, 39].

The present study reveals the fact that birth to conception interval <12 months or >60 months leads to high incidence of LBW (Table 2). The highest and lowest mean birth weight was found 2890.00 g and 2705.00 g for 49–59 and less than 12 months groups of mothers, respectively. The possible explanation for higher incidence of LBW with <12 months interval is that women with closely spaced births have insufficient time to restore their nutritional reserves prior to conception and therefore have poor nutritional status. However, one study showed no increased risk of LBW for short pregnancy intervals after adequate multivariate control for confounding [40]. The higher incidence of LBW associated with the longest birth interval may be the result of maternal reproductive problems.

Birth weight and gestational age each have an important effect on fetal and neonatal mortality [41–43]. Gestational age is the most important factor affecting the birth weight. Wharton [44] in his study showed that an extra week of gestation was associated with a 150 g increase in birth weight. Das et al. [45] reported a significant positive correlation between birth weight and gestational age. Relationship between mean birth weight and gestational age was shown in the present study. We found that birth weight increase with gestational age (Table 3). Highest mean birth weight (3120.00 g) was observed in 41 or more weeks of gestation. This result is in consistence with other studies [46–48].

Apgar score of the newborn is an independent observer after delivery as an indicator of immediate newborn condition. In the present study, relationship between birth weight of newborn and their Apgar score was examined. There is significant difference mean birth weight (l97.39 g) was found among the highest Apgar score (8+) and the lowest Apgar score (up to 6) group of infants.

Study from Bangladesh it was found that MUAC had cut off value of <8.8 cm in identifying infants weighing <2500 g, correlation coefficient of birth weight and mid arm circumference was 0.9224 [49]. Sharma et al. [46] in their study found that at 6.0–7.9 cm MUAC the mean birth weight was 1823 ± 312.13 g and at >10 cm the mean birth weight was 3023 ± 349.21 g. In a Brazilian study, it was found that an average arm circumference below 9 cm indicated low birth weight with a sensitivity of 84.5% and a specificity of 94.9% [50]. We found there is a significant relationship between MUAC and infant birth weight. When MUAC was 7.0–9.9 the mean birth weight was <2500 g and mean birth weight was >2500 g when MUAC was ≥10.0, respectively. Our finding is very much similar of previous studies.

Study conducted by Sharma et al. [46] found that chest circumference ranging from 21 to 23.9 cm give rise to mean birth weight of 1739±321.37 g and ranging from 30 to 32.9 cm give rise to 2789 ± 402.34 g, respectively. Other Indian studies also had similar results [51–53]. An Egyptian study showed that infant's chest circumference is an excellent predictor of birth weight in Egypt [54]. We found that when CC ≥ 29.9 cm the mean birth weight was 2619.44 gm, which shows agreement with those studies.

Sharma et al. [46] found that, birth weight was 1347 ± 189.17 g when HC ranges from 24 to 26.9 cm and 2803 ± 370.84 g when it ranges from 33 to 35.9 cm, respectively. In our study, mean birth weight was found 2365.85 gm when HC was 27.0–29.9 cm. That states that mean birth weight increases as the HC increases.

In one Indian study, it was found that mean birth weight increased progressively with increasing crown heel length [46]. Lowest mean birth weight (1347 ± 185.49 g) was found when CHL was 36 to 41.9 cm and highest mean birth weight (2739±399.92 g) when CHL was 47 to 50.9 cm. We also found significant relation between CHL to infant birth weight.

In the present study we assess the relationship between birth weight and anthropometric surrogates (MUAC, CC, HC, and CHL) of newborns. Such indices are important tools in the identification of LBW babies in areas where scales are not widely available. We found that the mean birth weight increased progressively with increasing MUAC, CC, HC, and CHL of the newborns. This finding is similar to the findings of other studies [34]. Dhar et al. [25] found and proposed CC significantly related to infant birth weight and that alone can be used as a surrogate marker. But in our study we found that both MUAC and CC are significantly related to infant birth weight, and we suggest the measurement of both.

5. Conclusion

It is estimated that, in Bangladesh, about 80–90% of deliveries take place either at home or in the community till today. The results of the present study showed that MUAC, CC, HC, and CHL can be used for identifying low-birth-weight babies at the community level, where weighing scales are not easily available. Since low birth weight is highly predictive of neonatal mortality, and MUAC, CC, HC, and CHL can identify infants with low birth weight with a fair degree of accuracy, it would be logical to assume that these substitute measurements would be useful in predicting neonatal outcome. Furthermore, in the community, where taboos exist regarding weighing of newborns, these measurements can be used without any obstruction from the community to identify low birth-weight babies. However, further studies with larger populations are needed in the field to cross-validate our results.

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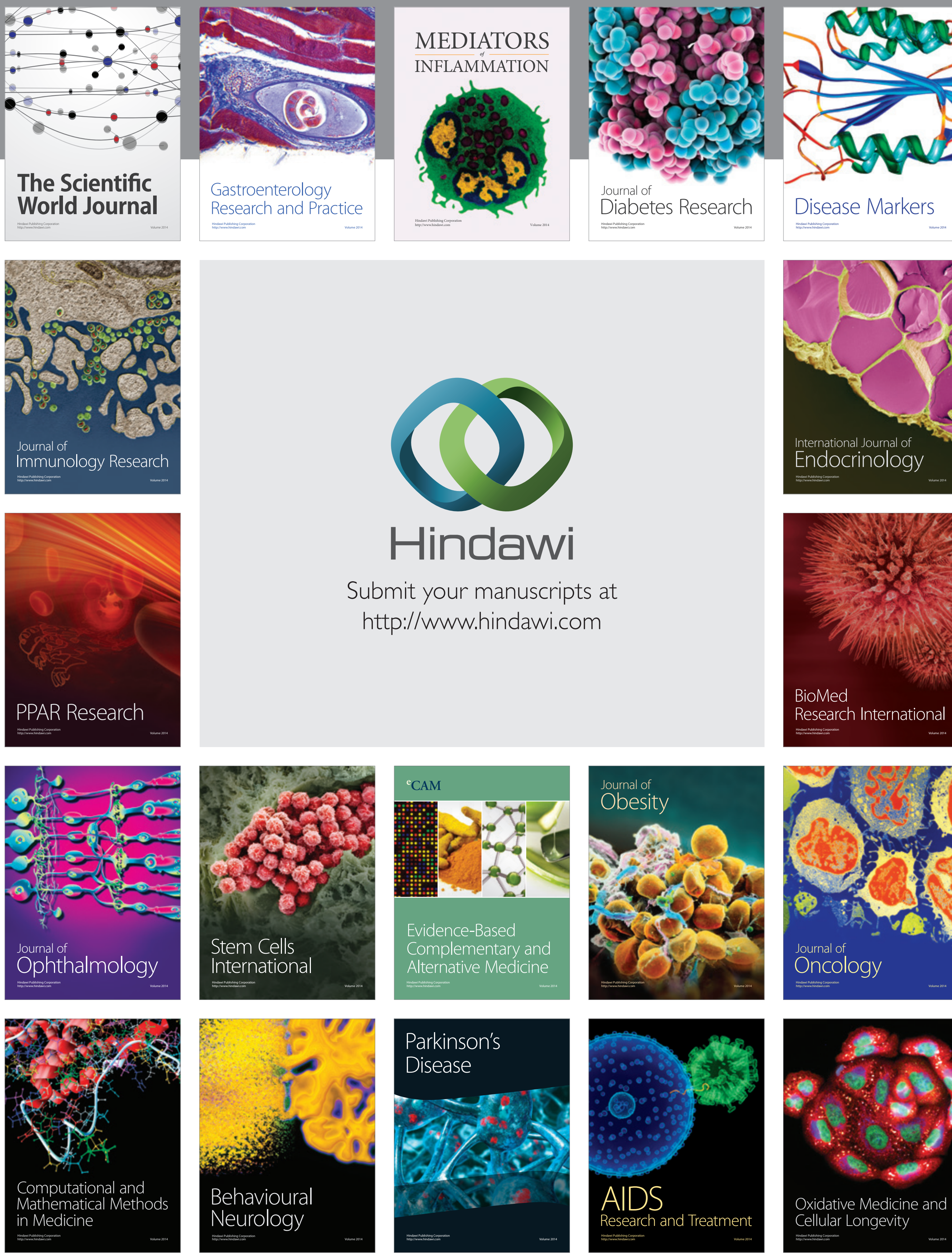
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