

Original Research Article

MATERNAL MID UPPER ARM CIRCUMFERENCE AND ITS CORRELATION WITH BIRTH WEIGHT OF NEONATE

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ABSTRACT

Background: Low birth weight (LBW) remains a major public health concern and is one of the leading causes of neonatal morbidity and mortality, particularly in developing countries. Maternal anthropometric measurements are simple, inexpensive, and practical indicators of maternal nutritional status and may help identify women at risk of delivering low birth weight infants. This study was undertaken to evaluate the association between maternal anthropometric parameters and neonatal birth weight. **Objectives:** To assess the relationship between maternal anthropometric measurements, including maternal height, weight, body mass index (BMI), mid-upper arm circumference (MUAC), and gestational weight gain, and neonatal birth weight among term singleton pregnancies.

Materials and Methods: A hospital-based cross-sectional observational study was conducted in the Department of Obstetrics and Gynaecology. A total of 181 healthy mother-neonate pairs were enrolled. Maternal demographic, socioeconomic, obstetric, and anthropometric data were collected using a pre-tested semi-structured questionnaire, clinical examination, and hospital records. Neonatal birth weight was measured within 24 hours of delivery. Data were analysed using IBM SPSS software. Chi-square test and Pearson's correlation analysis were performed, and a p-value <0.05 was considered statistically significant.

Results: Among the 181 neonates, 39 (21.5%) had low birth weight (<2.5 kg), while 142 (78.5%) had normal birth weight (≥2.5 kg). Maternal gestational weight gain (p=0.006), maternal weight (p=0.032), BMI (p=0.014), MUAC (p=0.005), and iron-folic acid (IFA) supplementation (p=0.007) were significantly associated with neonatal birth weight. Maternal weight and BMI also showed significant positive associations with MUAC (p<0.001). In contrast maternal age, residence, socioeconomic status, educational level, booking status, gravidity, mode of delivery, maternal height, planned pregnancy, birth interval, age at marriage, type of family, religion, number of antenatal care visits, and neonatal sex were not significantly associated with neonatal birth weight (p>0.05).

Conclusion: Maternal nutritional status as reflected by gestational weight gain, maternal weight, BMI, MUAC, and IFA supplementation was significantly associated with neonatal birth weight. Among these parameters, MUAC emerged as a simple, reliable, and cost-effective screening tool for identifying women at risk of delivering low birth weight infants. Routine assessment of maternal anthropometric parameters during antenatal care may facilitate early nutritional intervention and contribute to improved neonatal outcomes, particularly in resource-limited settings.

Keywords: Low birth weight; Maternal anthropometry; Mid-upper arm circumference; Body mass index; Gestational weight gain; Maternal nutrition; Neonatal outcome.

INTRODUCTION

Maternal nutrition plays a major role in development of foetus and mother. Pregnancy outcomes related to maternal nutritional status have been measured by anthropometry (weight, height, pre pregnancy weight, gestational weight gain & maternal mid upper arm circumference). Screening with maternal anthropometry that require only one contact with a woman are useful particularly in developing countries due to limitation in available prenatal care. Maternal MUAC reflects both past and present nutritional status and is less responsive than bodyweight to short term changes in health & nutritional status (WHO, 1995).^[1] The usefulness of MUAC for screening women at risk of poor pregnancy outcome reflects maternal fat/lean tissue stores and it is independent of gestational age. Various studies have shown that mid upper arm circumference can be used as an indicator of progress of pregnancy and its outcome.^[2] MUAC requires minimal training and equipment compared with weight, height and BMI measurements. If maternal MUAC can be established as a surrogate marker for neonatal anthropometric parameter, it helps to plan timely intervention for improvement of health of pregnant women. Assessment of maternal MUAC in adults living in resource -poor countries offers the advantage of being simple measure that can be carried out in both community and facility based setting.^[3]

World Health Organisation (WHO) has defined low birth weight (LBW) as birth weight less than 2500 grams. An infant birth weight has been identified as the best marker of optimal foetal growth, development and strongest determinant of infant morbidity and mortality. In India the incidence of LBW is 25-30% & infant mortality rate is 29.9%. Low birth weight is considered to be indicator not only of the health and nutrition status of pregnant women but also social development of a population. A number of factors have been identified to be associated with low birth weight in various studies but a baby's low birth weight at birth is dependent on two major factors are Premature birth, IUGR; Intra uterine growth retardation-implies that the foetus has not attained the potential growth. While a globally accepted cut-off for low MUAC (<11.5 cm) has been established by the WHO for children 6-60 months of age, no such cut-off exists for low MUAC in adult. There are difference between developed and developing countries in determining the most appropriate cut-off points for anthropometric measurements. The government through the ministry of health has put in place intervention to ensure improved pregnancy outcome such as introducing refocused ANC with recommends a minimum of four ANC visits by pregnant mother.^[4]

The purpose of this study was to determine whether MUAC cut off could be recommended to assess malnutrition in pregnant women and consequently

identify those at risk of delivering an LBW infant. The physical maturity of the new born infant can be judged by its dimension at birth or its gestational age. The parameters vary from one population to another due to racial, genetic, socio economic nutritional and environmental factors.

MATERIALS AND METHODS

Study Setting: The study was conducted in the Department of Obstetrics and Gynaecology.

Study Period: The study was carried out over a period of 23 months, from November 2023 to September 2025.

Study Design: A hospital-based cross-sectional observational study was conducted.

Study Population: The study population comprised healthy pregnant women who received antenatal care and delivered at Nalgonda during the study period. Eligible mothers who fulfilled the inclusion criteria and provided written informed consent were recruited.

Sample Size: A total of 181 mother–neonate pairs were included in the study.

Study Materials: The following instruments were used for anthropometric measurements:

- Infant weighing scale
- Adult weighing machine
- Stadiometer
- Flexible non-stretchable measuring tape (graduated in centimetres)

Participant Recruitment and Data Collection: Eligible mothers fulfilling the inclusion and exclusion criteria were enrolled after obtaining informed written consent. Data were collected using a pre-tested semi-structured questionnaire, personal interviews, review of medical records, anthropometric measurements, and routine laboratory investigations.

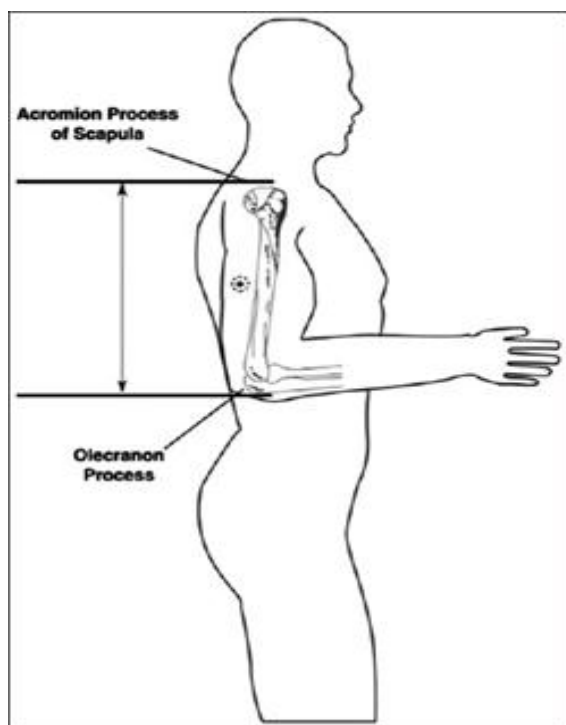
The following maternal variables were recorded as Maternal age, Height, Weight, Body Mass Index (BMI), Mid Upper Arm Circumference (MUAC), Gestational weight gain, Gestational age, Age at marriage, Interpregnancy interval, Religion, Educational status, Occupation, Socioeconomic status, Type of family, Number of antenatal care (ANC) visits and iron and folic acid (IFA) supplementation

Routine laboratory investigations performed at the time of delivery included Haemoglobin (Hb), Total leukocyte count (TLC), Differential leukocyte count (DLC), Blood grouping and Rh typing, HIV screening, Hepatitis B surface antigen (HBsAg), Hepatitis C virus (HCV) screening and Sick cell screening

Anthropometric Measurements

Measurement of MUAC: MUAC is measured in left upper arm at the midpoint between the tip of shoulder and the tip of elbow (olecranon & acromion). MUAC measured to nearest millimetres using non –

stretchable tape. Measurement was taken to the nearest 0.1 cm



Step1: Bend the arm so it is at a right angle and place the string on the tip of the shoulder, to the elbow.

Step2: Fold the string over in half to find the middle of the arm

Step3: Mark the middle of the arm with a pen

Step4: Straighten the arm, insert the tape at the midpoint and measure the MUAC

Step5: Make sure the tape is not too tight

Step6: Make sure the tape is not too loose

Maternal Measurements: Maternal weight was measured using a calibrated weighing machine, while height was measured using a stadiometer. Mid Upper Arm Circumference (MUAC) was measured using a flexible non-stretchable measuring tape.

Maternal Body Mass Index (BMI) was calculated using the following formula:

$$\text{BMI (kg/m}^2\text{)} = \text{Weight (kg)} \div \text{Height (m}^2\text{)}$$

Measurement of Maternal Height

Height was measured according to standard anthropometric procedures:

1. The participant stood barefoot on a flat surface with heels together and back straight against the stadiometer.
2. The headpiece was lowered until it touched the vertex of the head.
3. Height was recorded to the nearest 0.1 cm.

Measurement of Neonatal Birth Weight: Birth weight was measured within 24 hours of birth to minimize the effect of physiological postnatal weight loss.

The procedure included

1. Placing the weighing scale on a flat, firm, and level surface and ensuring zero calibration before each measurement.
2. Weighing the newborn naked or with minimal clothing.
3. Positioning the baby at the centre of the weighing pan.
4. Recording the weight to the nearest appropriate unit as recommended by the manufacturer.

Assessment of Gestational Age: Gestational age was determined based on the first day of the Last Menstrual Period (LMP). Whenever the discrepancy between the LMP-based gestational age and the first-trimester ultrasonography exceeded 5 days, the ultrasound estimate was used for dating.

Neonatal Examination: Each neonate underwent a complete clinical examination within 24 hours of delivery to assess general health status and identify any congenital anomalies before inclusion in the study.

Inclusion Criteria

Pregnant Women

- Healthy pregnant women receiving antenatal care.
- Singleton term pregnancy.
- Free from medical or surgical disorders that could influence fetal growth or birth weight.
- Willing to participate and provide informed consent.

Neonates

- Healthy singleton term neonates.
- Examined within 24 hours of birth.
- No congenital malformations.

Exclusion Criteria

Pregnant Women: Women with any of the following conditions were excluded as Gestational diabetes mellitus (GDM), Pregnancy-induced hypertension (PIH), Antepartum haemorrhage (APH), HIV infection, Tuberculosis, Multiple pregnancy, Sickle cell disease, Hypothyroidism, Chronic medical or surgical illness and History of smoking or alcohol consumption

Neonates: Neonates with the following conditions were excluded as Preterm birth, Congenital malformations, Hydrops fetalis, Birth injuries, Cephalohaematoma, Macrosomia and any condition likely to affect accurate birth weight measurement

Statistical Analysis: Data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) software. Continuous variables were expressed as mean $\pm$ standard deviation (SD), while categorical variables were presented as frequency and percentage.

Statistical analyses included Pearson's correlation coefficient to determine the correlation between continuous variables. Chi-square test to assess the association between categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Distribution of Birth Weight According to demographic details

Maternal Age (years)	Birth Weight <2.5 kg n (%)	Birth Weight ≥2.5 kg n (%)	Total n (%)	P Value
≤21	9 (5.0)	19 (10.5)	28 (15.5)	P value = 0.145
22–30	30 (16.6)	116 (64.1)	146 (80.7)	
≥30	0 (0.0)	7 (3.9)	7 (3.9)	
Residence				
Rural	35 (19.3)	110 (60.8)	145 (80.1)	P value = 0.089
Urban	4 (2.2)	32 (17.7)	36 (19.9)	
Socioeconomic Status				
Lower Middle	24 (13.3)	68 (37.6)	92 (50.8)	P value = 0.206
Lower	13 (7.2)	55 (30.4)	68 (37.6)	
Middle	2 (1.1)	19 (10.5)	21 (11.6)	
Educational Status				
Illiterate	2 (1.1)	8 (4.4)	10 (5.5)	P value = 0.936
≤10th Class	31 (17.1)	109 (60.2)	140 (77.3)	
>10th Class	6 (3.3)	25 (13.8)	31 (17.1)	
Booking Status				
Booked	30 (16.6)	110 (60.8)	140 (77.3)	P value = 0.943
Unbooked	9 (5.0)	32 (17.7)	41 (22.7)	
Gravid Status				
Primigravida (1)	20 (11.0)	66 (36.5)	86 (47.5)	P value = 0.595
Multigravida (≥2)	19 (10.5)	76 (42.0)	95 (52.5)	
Mode of Delivery				
Normal Vaginal Delivery (NVD)	20 (11.0)	67 (37.0)	87 (48.1)	P value = 0.650
Lower Segment Caesarean Section (LSCS)	19 (10.5)	75 (41.4)	94 (51.9)	
Gestational Weight Gain (kg)				
5	3 (1.7)	3 (1.7)	6 (3.3)	P value = 0.006
6	19 (10.5)	36 (19.9)	55 (30.4)	
7	14 (7.7)	63 (34.8)	77 (42.5)	
8	3 (1.7)	34 (18.8)	37 (20.4)	
9	0 (0.0)	6 (3.3)	6 (3.3)	

Maternal age, residence, socioeconomic status, education, booking status, gravidity, mode of delivery and Maternal Height showed no statistically significant association with neonatal birth weight ($p > 0.05$). In gestational weight gain was significantly

associated with neonatal birth weight ($p = 0.006$), with mothers gaining 7 kg during pregnancy having the highest proportion (34.8%) of neonates weighing ≥2.5 kg.

Table 2: Distribution of Maternal MUAC According to Gestational Weight Gain

Gestational Weight Gain (kg)	MUAC <23 cm	MUAC 24–26 cm	MUAC 27–29 cm	MUAC 30–32 cm	Total n (%)
5	4 (2.2)	1 (0.6)	1 (0.6)	0 (0.0)	6 (3.3)
6	15 (8.3)	28 (15.5)	12 (6.6)	0 (0.0)	55 (30.4)
7	13 (7.2)	41 (22.7)	16 (8.8)	7 (3.9)	77 (42.5)
8	5 (2.8)	15 (8.3)	15 (8.3)	2 (1.1)	37 (20.4)
9	3 (1.7)	1 (0.6)	2 (1.1)	0 (0.0)	6 (3.3)
Total	40 (22.1)	86 (47.5)	46 (25.4)	9 (5.0)	181 (100.0)

P value = 0.018

The largest proportion of mothers (22.7%) had a MUAC of 24–26 cm with a gestational weight gain

of 7 kg. Maternal MUAC showed a statistically significant association with gestational weight gain ($p = 0.018$).

Table-3: Distribution of Maternal Height and weight According to MUAC

Maternal Height	MUAC <23 cm	MUAC 24–26 cm	MUAC 27–29 cm	MUAC 30–32 cm	Total n (%)	P value
<1.52 m	9 (5.0)	29 (16.0)	12 (6.6)	5 (2.8)	55 (30.4)	0.193
≥1.53 m	31 (17.1)	57 (31.5)	34 (18.8)	4 (2.2)	126 (69.6)	
Maternal Weight (kg)						
≤55	26 (14.4)	30 (16.6)	6 (3.3)	0 (0.0)	62 (34.3)	< 0.001
≥56	14 (7.7)	56 (30.9)	40 (22.1)	9 (5.0)	119 (65.7)	
BMI (kg/m ²)						
<24.9	35 (19.3)	54 (29.8)	12 (6.6)	0 (0.0)	101 (55.8)	< 0.001
25–29.9	5 (2.8)	28 (15.5)	33 (18.2)	8 (4.4)	74 (40.9)	
≥30	0 (0.0)	4 (2.2)	1 (0.6)	1 (0.6)	6 (3.3)	

Maternal Height showed no statistically significant association with neonatal birth weight . In Maternal

weight and BMI was significantly associated with neonatal birth weight

Table-4: Comparison of Maternal Characteristics According to Neonatal Birth Weight.

Maternal Height (in meters)	Birth Weight <2.5 kg n (%)	Birth Weight ≥2.5 kg n (%)	Total n (%)	P- Value
1.52 m	39 (21.5)	138 (76.2)	177 (97.8)	0.289
≥1.53 m	0 (0.0)	4 (2.2)	4 (2.2)	
Maternal Weight (kg)				
≤55	19 (10.5)	43 (23.8)	62 (34.3)	
≥56	20 (11.0)	99 (54.7)	119 (65.7)	0.032
BMI (kg/m ²)				
<24.9	29 (16.0)	72 (39.8)	101 (55.8)	
25–29.9	8 (4.4)	66 (36.5)	74 (40.9)	0.014
≥30	2 (1.1)	4 (2.2)	6 (3.3)	
Planned Pregnancy				
No	4 (2.2)	21 (11.5)	25 (13.8)	
Yes	35 (19.3)	121 (66.9)	156 (86.2)	0.467
Last Pregnancy Interval				
≤3 years	14 (17.3)	44 (54.3)	58 (71.6)	0.269
>3 years	3 (3.7)	20 (24.7)	23 (28.4)	
Age at Marriage (years)				
≤21	19 (10.5)	58 (32.0)	77 (42.5)	
22–30	20 (11.0)	84 (46.4)	104 (57.5)	0.378
Type of Family				
Extended	20 (11.0)	55 (30.4)	75 (41.4)	
Nuclear	19 (10.5)	87 (48.1)	106 (58.6)	0.159
Religion				
Hindu	36 (19.9)	126 (69.6)	162 (89.5)	0.519
Muslim	3 (1.7)	16 (8.8)	19 (10.5)	
Number of ANC Visits				
≤4	4 (2.2)	12 (6.6)	16 (8.8)	
>4	35 (19.3)	130 (71.8)	165 (91.2)	0.725

Maternal weight and BMI showed a highly significant association with MUAC (p < 0.05). Planning of pregnancy, Last Pregnancy Interval, Age

at Marriage, Type of Family, religion, Number of ANC Visits was not significantly associated with neonatal birth weight

Table-5: Association Between Selected Maternal and Neonatal Characteristics and Birth Weight

Number of ANC Visits	Birth Weight <2.5 kg n (%)	Birth Weight ≥2.5 kg n (%)	Total n (%)	P- Value
≤4	4 (2.2)	12 (6.6)	16 (8.8)	
>4	35 (19.3)	130 (71.8)	165 (91.2)	0.725
IFA Intake				
Yes	7 (3.9)	7 (3.9)	14 (7.7)	
No	32 (17.7)	135 (74.6)	167 (92.3)	0.007
Sex of Baby				
Female Child (FCH)	20 (11.0)	73 (40.3)	93 (51.4)	
Male Child (MCH)	19 (10.5)	69 (38.1)	88 (48.6)	0.989
Maternal MUAC (cm)				
<23	16 (8.8)	24 (13.3)	40 (22.1)	
24–26	17 (9.4)	69 (38.1)	86 (47.5)	
27–29	6 (3.3)	40 (22.1)	46 (25.4)	0.005
30–32	0 (0.0)	9 (5.0)	9 (5.0)	

Overall, maternal nutritional indicators (MUAC and IFA intake) were significantly associated with

neonatal birth weight, whereas ANC visits and neonatal sex were not.

Table-6: Distribution of Maternal MUAC According to Sex of the Neonate

Maternal MUAC Category	Female Child n (%)	Male Child n (%)	Total n (%)
<23 cm	21 (11.6)	19 (10.5)	40 (22.1)
24–26 cm	43 (23.8)	43 (23.8)	86 (47.5)
27–29 cm	23 (12.7)	23 (12.7)	46 (25.4)
30–32 cm	6 (3.3)	3 (1.7)	9 (5.0)
Total	93 (51.4)	88 (48.6)	181 (100.0)

P value = 0.810

The highest proportion of mothers (47.5%) had a MUAC of 24–26 cm, with an equal distribution of female and male neonates (23.8% each). Maternal

MUAC was not significantly associated with the sex of the neonate (p = 0.810).

DISCUSSION

The present study evaluated the association between maternal anthropometric, demographic, socioeconomic, and obstetric characteristics and neonatal birth weight among 181 mother–neonate pairs. Maternal nutritional indicators, including gestational weight gain, maternal weight, body mass index (BMI), mid-upper arm circumference (MUAC), and iron–folic acid (IFA) supplementation, demonstrated significant associations with neonatal birth weight. In contrast, maternal age, place of residence, educational status, socioeconomic status, booking status, gravidity, mode of delivery, maternal height, planned pregnancy, inter-pregnancy interval, age at marriage, type of family, religion, number of antenatal care visits, and neonatal sex were not significantly associated with birth weight. These findings suggest that maternal nutritional status plays a more influential role in determining neonatal birth weight than demographic or obstetric characteristics in the study population.

Maternal age was not significantly associated with neonatal birth weight, which is consistent with the findings of Alice Goisis et al.,^[5] Deshpande Jayant D et al.,^[6] Mavalankar et al.,^[7] Fikree et al.,^[8] and Anand and Garg,^[9] all of whom reported that maternal age alone was not an independent predictor of low birth weight. Similarly, maternal residence, educational status, socioeconomic status, booking status, gravidity, and mode of delivery were not significantly associated with birth weight in the present study, corroborating observations by Matin et al.,^[10] Deshpande et al.,^[6] Nyamasege et al.,^[11] However, these findings differ from those of Ghimire et al.,^[12] Nagargoje et al.,^[13] and Shamsudeen Mohammed et al.,^[14] who identified several socio-demographic and obstetric variables as significant determinants of low birth weight.

Among the maternal anthropometric variables, gestational weight gain exhibited a significant positive association with neonatal birth weight. Mothers with a gestational weight gain of 7 kg had the highest proportion of neonates weighing ≥ 2.5 kg. This finding supports reports by Vijay Kishanrao Dimple et al.,^[15] Sengupta et al.,^[16] and Sutan et al.,^[17] who demonstrated that inadequate gestational weight gain increases the risk of low birth weight. Although Wen-Pen Wang et al.,^[18] reported a higher optimal gestational weight gain than observed in the present study, both studies consistently demonstrated a positive relationship between gestational weight gain and neonatal birth weight.

Maternal weight and BMI were also significantly associated with neonatal birth weight. Mothers weighing ≥ 56 kg and those with higher BMI categories were more likely to deliver neonates weighing ≥ 2.5 kg. These findings are in agreement with Donugama Vasundhara,^[19] who demonstrated a positive correlation between maternal weight and neonatal birth weight. Likewise, the significant

correlation between BMI and MUAC observed in the present study is consistent with reports by Khadivzadeh,^[20] Das et al.,^[21] Lopez et al.,^[21] Cooley et al.,^[24] and Sultana et al.,^[24] indicating that MUAC is a reliable surrogate marker of maternal nutritional status.

Maternal height was not significantly associated with neonatal birth weight, consistent with the findings of Matin et al.,^[10] Sengupta et al.,^[16] and Sutan et al.,^[17] although some investigators have reported short maternal stature as a risk factor for low birth weight. Similarly, planned pregnancy, inter-pregnancy interval, age at marriage, type of family, religion, and antenatal care visits were not significantly associated with neonatal birth weight in the present study. These observations agree with several previous studies, including those by Deshpande et al.,^[6] Rizvi et al.,^[25] Ganesh Kumar et al.,^[26] and Nagargoje et al.,^[13] although contrasting findings have been reported by Sengupta et al.,^[16] Sutan et al.,^[17] and Vijay Kishanrao Dimple et al.,^[27]

Maternal MUAC demonstrated a significant association with neonatal birth weight, with mothers having a MUAC of 24–26 cm showing the highest proportion of neonates weighing ≥ 2.5 kg. This finding supports recommendations by the World Health Organization regarding the use of MUAC as a practical screening tool for identifying maternal undernutrition in resource-limited settings. Similar positive associations between MUAC and birth weight have been reported by Katz et al.,^[28] and other investigators. Furthermore, IFA supplementation showed a significant association with neonatal birth weight, corroborating findings by Matin et al.,^[10] and Rizvi et al.,^[25] who demonstrated that adequate iron supplementation during pregnancy reduces the risk of low birth weight.

Overall, the findings of the present study emphasize that maternal nutritional status, reflected by gestational weight gain, maternal weight, BMI, MUAC, and IFA supplementation, is a more important determinant of neonatal birth weight than maternal demographic or obstetric characteristics. These results highlight the importance of improving maternal nutrition through adequate antenatal nutritional assessment, regular monitoring of gestational weight gain and MUAC, and appropriate micronutrient supplementation to reduce the burden of low birth weight in resource-constrained settings.

CONCLUSION

Among the anthropometric parameters, maternal MUAC emerged as a simple, inexpensive, and reliable indicator of maternal nutritional status and was significantly associated with neonatal birth weight. Given its ease of measurement, MUAC can serve as a practical screening tool for identifying pregnant women at risk of delivering low birth weight infants, particularly in resource-limited

settings where accurate assessment of gestational weight or BMI may not be feasible.

The findings underscore the importance of routine nutritional assessment during antenatal care, with emphasis on monitoring maternal weight gain, BMI, and MUAC, along with ensuring adequate iron-folic acid supplementation throughout pregnancy. Strengthening maternal nutrition interventions and promoting appropriate gestational weight gain may contribute substantially to reducing the incidence of low birth weight and improving neonatal outcomes. Further multicentre prospective studies with larger sample sizes are recommended to validate these findings and establish population-specific MUAC cut-off values for predicting low birth weight in Indian women.

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