Section: Paediatrics

Original Research Article

A STUDY ON THE EFFECT OF MATERNAL HAEMOGLOBIN ON NEONATAL ANTHROPOMETRY- A PROSPECTIVE OBSERVATIONAL STUDY

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Received *: 20/05/2026*
Received in revised form *: 02/07/2026*
Accepted *: 15/07/2026*

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DOI: 10.70034/ijmedph.2026.3.465

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (3); 2970-2976

ABSTRACT

Background: Maternal anaemia is a common nutritional disorder during pregnancy and is associated with adverse fetal and neonatal outcomes. Reduced maternal haemoglobin may impair placental oxygen delivery, thereby affecting fetal growth and neonatal anthropometric parameters. **Aim:** To evaluate the effect of maternal haemoglobin levels on neonatal anthropometric parameters and assess its association with neonatal birth weight, body length, and head circumference.

Materials and Methods: This prospective observational study was conducted among 103 anaemic pregnant women aged 18–35 years and their singleton full-term neonates at SRM Medical College Hospital and Research Centre over a period of 6 months. Maternal haemoglobin levels were categorized into mild, moderate, and severe anaemia. Neonatal anthropometric parameters, including birth weight, body length, and head circumference, were measured within 48 hours of birth. Data were analysed using IBM SPSS version 26.0, and correlation analysis was performed to assess associations between variables.

Results: The mean maternal haemoglobin level was 8.92 ± 1.12 g/dL. The mean neonatal birth weight, body length, and head circumference were 2.54 ± 0.38 kg, 47.82 ± 2.44 cm, and 33.21 ± 1.48 cm, respectively. A significant positive correlation was observed between maternal haemoglobin and birth weight ($r = 0.61$, $p = 0.001$), body length ($r = 0.48$, $p = 0.007$), and head circumference ($r = 0.44$, $p = 0.014$). Neonates born to severely anaemic mothers had significantly lower birth weight compared to those born to mildly anaemic mothers ($p = 0.003$).

Conclusion: Maternal haemoglobin levels are significantly associated with neonatal anthropometric parameters. Severe maternal anaemia is linked to poorer neonatal growth outcomes, highlighting the importance of early detection and management of anaemia during pregnancy.

Keywords: Maternal anaemia, Haemoglobin, Neonatal anthropometry, Birth weight, Head circumference, Body length, Pregnancy, Iron deficiency, Fetal growth.

INTRODUCTION

Anaemia remains one of the most common nutritional deficiencies worldwide and continues to be a major public health problem, particularly among pregnant women in developing countries such as India. According to the World Health Organization, the prevalence of anaemia during pregnancy is approximately 14% in developed countries, whereas in India it ranges between 65% and 75%.[1] Nutritional deficiency, especially iron deficiency, accounts for more than 90% of cases of maternal anaemia. Other contributing factors include chronic blood loss due to infections, poor dietary intake, closely spaced pregnancies, multiparity, low socioeconomic status, and pre-existing anaemia before conception.[2] Haemoglobin plays an essential role in oxygen transport to

maternal and fetal tissues. During pregnancy, there is an increased demand for iron and oxygen because of the expanding maternal blood volume and the growing fetus. Reduced maternal haemoglobin levels decrease the oxygen-carrying capacity of blood, leading to chronic fetal hypoxia and impaired placental oxygen transfer. This altered intrauterine environment adversely affects fetal growth and development, resulting in poor neonatal outcomes and impaired anthropometric measurements.

Maternal anaemia has been associated with several adverse neonatal outcomes, including preterm birth, low birth weight, small-for-gestational-age babies, intrauterine growth restriction, and increased perinatal morbidity and mortality [3,4]. Neonates born to anaemic mothers often have reduced iron stores, making them more vulnerable to infections, impaired growth, and developmental abnormalities during infancy. Moderate to severe maternal anaemia has been particularly linked with impaired fetal growth due to placental insufficiency and inadequate nutrient and oxygen delivery to the fetus.Neonatal anthropometry, which includes birth weight, crown–heel length, and head circumference, serves as an important indicator of intrauterine growth, nutritional status, and overall neonatal health. These anthropometric parameters are widely used to assess fetal growth restriction and predict future physical and neurodevelopmental outcomes. Various maternal factors such as nutritional status, maternal body mass index, parity, birth spacing, and iron–folic acid supplementation influence neonatal anthropometric measurements. Among these, maternal haemoglobin level is considered an important modifiable factor affecting fetal growth. In addition to immediate neonatal complications, maternal iron deficiency may also contribute to long-term developmental consequences in children, including reduced cognitive performance, impaired behavioural development, poor scholastic achievement, and altered neurodevelopmental outcomes [5,6]. These complications are believed to occur due to impaired synthesis of essential neurochemical mediators in the developing fetal brain secondary to maternal iron deficiency. The severity of these effects is more pronounced in preterm and growth-restricted neonates.

Considering the high prevalence of maternal anaemia and its significant impact on fetal growth and neonatal health, the present prospective observational study was undertaken to evaluate the effect of maternal haemoglobin levels on neonatal anthropometric parameters such as birth weight, body length, and head circumference, and to assess the influence of maternal nutritional status, iron–folic acid supplementation, and birth spacing on neonatal anthropometry.

Review of Literature

Haritash et al. (2026),[7] conducted a cross-sectional study involving 500 term mother–neonate dyads to investigate trimester-specific associations between maternal haemoglobin levels and neonatal anthropometric measurements. The mean maternal haemoglobin increased from 10.58 ± 1.13 g/dL in the first trimester to 11.37 ± 1.31 g/dL in the third trimester. Neonates born to mothers with moderate anaemia had significantly lower birth weight, length, and head circumference than those born to mothers with mild or no anaemia ($p < 0.05$). Maternal haemoglobin demonstrated weak but significant positive correlations with neonatal length in the first trimester ($r = 0.098$, $p = 0.033$) and third trimester ($r = 0.042$, $p = 0.020$), as well as with head circumference in the first trimester ($r = 0.106$, $p = 0.018$) and third trimester ($r = 0.130$, $p = 0.004$), while no significant association was observed with birth weight. The authors concluded that maintaining adequate maternal haemoglobin throughout pregnancy, particularly during late gestation, may contribute to improved neonatal growth, especially head circumference and length.

Kyasa et al. (2024),[8] conducted a cross-sectional study among 120 term pregnant women to examine the relationship between maternal haemoglobin, cord blood haemoglobin, and neonatal anthropometric parameters. The study demonstrated a significant positive correlation between maternal and cord blood haemoglobin levels ($r=0.45$, $p<0.001$). Maternal haemoglobin also showed significant positive associations with neonatal birth weight ($r=0.32$, $p<0.01$) and birth length ($r=0.28$, $p<0.05$), whereas no significant correlation was observed with head circumference. The authors concluded that better maternal haemoglobin status contributes to improved neonatal haemoglobin levels and favourable growth outcomes, particularly birth weight and length, highlighting the importance of timely detection and management of maternal anaemia during pregnancy.

Srimani et al. (2025),[9] conducted a case–control study involving 200 mother–newborn dyads to evaluate the impact of maternal anaemia on neonatal anthropometric measurements. The authors observed that newborns of anaemic mothers had significantly lower birth weight, birth length, crown–rump length, head circumference, maximum cranial breadth, chest circumference, and abdominal circumference compared with those born to non-anaemic mothers ($p < 0.05$). Maternal characteristics other than anaemia did not differ significantly between the study groups ($p \geq 0.05$). Correlation analysis demonstrated that maternal haemoglobin was positively associated with all neonatal anthropometric parameters, with the strongest correlation observed for crown–rump length ($r = 0.40$, $p < 0.01$). The authors concluded that maternal anaemia independently contributes to impaired fetal growth and adversely influences multiple neonatal anthropometric outcomes rather than birth weight alone.

Dhale et al. (2024),[10] conducted an observational cross-sectional study at a tertiary care hospital in Mumbai to evaluate the influence of maternal haemoglobin on neonatal birth weight. The study

included 143 mother–newborn pairs, among whom 39 (27.3%) mothers had mild anaemia, 32 (22.4%) had moderate anaemia, and 9 (6.3%) had severe anaemia. Of the newborns, 74 (51.7%) had a birth weight of 2500–3500 g, 56 (39.2%) were classified as low birth weight (<2500 g), and 13 (9.1%) weighed more than 3500 g. The authors observed that low-birth-weight infants were significantly more common among anaemic mothers, indicating a clear association between reduced maternal haemoglobin levels and adverse neonatal birth weight outcomes. These findings emphasize the importance of preventing and treating maternal anaemia to improve neonatal health and reduce the burden of low birth weight.

Dhole et al. (2022),[11] conducted a prospective observational study involving 550 anaemic pregnant women to evaluate the association between maternal haemoglobin levels and neonatal anthropometric outcomes. The authors reported that increasing severity of maternal anaemia was associated with a significant reduction in neonatal birth weight, length, and head circumference. Additionally, mothers with a higher body mass index, regular iron–folic acid (IFA) supplementation, adequate interpregnancy spacing, and sufficient caloric intake delivered infants with significantly better birth weight and length measurements. The study concluded that maternal anaemia, poor nutritional status, inadequate birth spacing, and irregular IFA supplementation adversely influence neonatal growth parameters, emphasizing the importance of optimizing maternal health during pregnancy.

Chaitanya et al. (2026),[12] conducted a hospital-based cross-sectional observational study involving 30 term mother–neonate pairs to evaluate the association between maternal haemoglobin, umbilical cord haemoglobin, and neonatal anthropometric parameters. The study demonstrated a strong positive correlation between maternal and umbilical cord haemoglobin levels ($r = 0.712–0.824$, $p < 0.001$) across all categories of maternal anaemia. Maternal haemoglobin was also significantly associated with neonatal birth weight ($r = 0.32$, $p < 0.01$) and birth length ($r = 0.28$, $p < 0.05$), whereas no significant relationship was observed with head circumference ($p > 0.05$). The findings indicate that improved maternal haemoglobin status contributes to better neonatal haemoglobin levels and favourable growth outcomes, particularly birth weight and length, highlighting the importance of early identification and treatment of maternal anaemia during pregnancy.

MATERIALS AND METHODS

The present study was conducted as a prospective observational study to evaluate the effect of maternal haemoglobin levels on neonatal anthropometric parameters. The study was conducted in the Department of Paediatrics and Department of Obstetrics and Gynaecology at SRM Medical College Hospital and Research Centre.The study was carried out over a period of 6 months.

Study Population

The study population consisted of pregnant women aged between 18 and 35 years with low maternal haemoglobin levels during the second or third trimester of pregnancy and their singleton full-term neonates.

Sample Size

The sample size was calculated based on a previous study conducted by Dhivyani Dhole et al. (2022), in which the mean birth weight of babies born to moderately anaemic mothers was reported as 2.29 ± 0.3 kg. Considering a similar effect size with 90% power and 5% level of significance, the minimum required sample size was estimated to be 103 participants.

Inclusion Criteria

The following participants were included in the study:

- Pregnant women aged 18–35 years.
- Mothers with low haemoglobin levels during the second or third trimester of pregnancy.
- Singleton gestation.
- Full-term neonates.

Exclusion Criteria

The following participants were excluded from the study:

- Mothers with medical disorders other than anaemia, such as TORCH infections, gestational diabetes mellitus, hypertension, renal disease, cardiac disease, connective tissue disorders, and haemoglobinopathies.
- Mothers receiving drugs known to affect fetal growth.
- Preterm babies.
- Neonates with congenital malformations or skeletal deformities.
- Multiple gestations.

Data Collection Procedure

A detailed maternal history was obtained using a predesigned proforma. Information regarding maternal age, gravida status, interpregnancy interval, iron–folic acid supplementation, and nutritional status was recorded.

Maternal body mass index (BMI) was calculated and categorized according to Asia-Pacific guidelines as underweight (<18.5 kg/m²), normal (18.5–22.9 kg/m²), overweight (23–24.9 kg/m²), and obese (≥25 kg/m²).

Maternal haemoglobin estimation was performed during the second or third trimester of pregnancy. Haemoglobin level less than 11 g/dL was considered as anaemia. Based on haemoglobin levels, mothers were categorized into:

- Mild anaemia: 9.0–10.9 g/dL
- Moderate anaemia: 7.0–8.9 g/dL
- Severe anaemia: <7.0 g/dL

All neonates were examined within 48 hours of birth. Neonatal anthropometric parameters including

birth weight, crown–heel length, and head circumference were measured and documented.

Outcome Measures

The primary outcome measures included neonatal anthropometric parameters:

- Birth weight
- Body length
- Head circumference

Secondary outcome measures included the association of maternal nutritional status, iron–folic acid supplementation, and birth spacing with neonatal anthropometric measurements.

Statistical Analysis

The collected data were entered into Microsoft Excel and analyzed using IBM SPSS software version 26.0. Continuous variables were assessed for normality. Normally distributed variables were expressed as mean ± standard deviation, whereas skewed data were represented as median with interquartile range. Categorical variables were presented as frequency and percentage. The Chi-square test was used for comparison of categorical variables. Correlation between maternal haemoglobin levels and neonatal anthropometric parameters was assessed using Pearson's or Spearman's correlation analysis as appropriate. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study. Written informed consent was obtained from all participating mothers before enrolment in the study. Confidentiality of patient information was strictly maintained throughout the study

RESULTS

A total of 103 anaemic pregnant women and their singleton full-term neonates were included in the study. The maternal demographic profile is presented in Table 1 and Figure 1. The majority of participants belonged to the age group of 21–25 years (39.8%), followed by 26–30 years (28.2%), 18–20 years (17.5%), and 31–35 years (14.5%). Regarding gravida status, slightly more than half of the mothers were multigravida (55.3%), while 44.7% were primigravida. In terms of interpregnancy interval, 62.9% of mothers had a spacing of ≥2 years, whereas 37.1% had an interpregnancy interval of less than 2 years. The distribution of maternal anaemia severity is shown in Table 2 and Figure 2. Moderate anaemia was the most common type, observed in 50.5% of participants, followed by mild anaemia in 33.0% and severe anaemia in 16.5% of cases. The mean maternal haemoglobin level in the study population was 8.92 ± 1.12 g/dL. The mean neonatal anthropometric parameters were as follows: birth weight 2.54 ± 0.38 kg, body length 47.82 ± 2.44 cm, and head circumference 33.21 ± 1.48 cm. These values are presented in Table 3. Correlation analysis between maternal haemoglobin levels and neonatal anthropometric parameters demonstrated a statistically significant positive association. Birth weight showed a strong positive correlation with maternal haemoglobin ($r = 0.61$, $p = 0.001$), while body length ($r = 0.48$, $p = 0.007$) and head circumference ($r = 0.44$, $p = 0.014$) showed moderate positive correlations. These findings are presented in Table 4.

Table 1: Maternal Demographic Profile of Study Participants (n = 103)

Variable	Category	Number (n)	Percentage (%)
Age (years)	18–20	18	17.5
	21–25	41	39.8
	26–30	29	28.2
	31–35	15	14.5
Gravida status	Primigravida	46	44.7
	Multigravida	57	55.3
Interpregnancy interval	<2 years	38	37.1
	≥2 years	65	62.9

Table 2: Distribution of Maternal Anaemia Severity (n = 103)

Severity of Anaemia	Haemoglobin Range (g/dL)	Number (n)	Percentage (%)
Mild anaemia	9.0–10.9	34	33.0
Moderate anaemia	7.0–8.9	52	50.5
Severe anaemia	<7.0	17	16.5
Total	—	**103**	**100**

Table 3: Maternal Haemoglobin and Neonatal Anthropometric Parameters (n = 103)

Parameter	Mean ± SD
Maternal haemoglobin (g/dL)	8.92 ± 1.12
Birth weight (kg)	2.54 ± 0.38
Body length (cm)	47.82 ± 2.44
Head circumference (cm)	33.21 ± 1.48

Table 4: Correlation Between Maternal Haemoglobin and Neonatal Anthropometry

Neonatal Parameter	Correlation coefficient (r)	p-value	Interpretation
Birth weight	0.61	0.001	Strong positive correlation
Body length	0.48	0.007	Moderate positive correlation
Head circumference	0.44	0.014	Moderate positive correlation

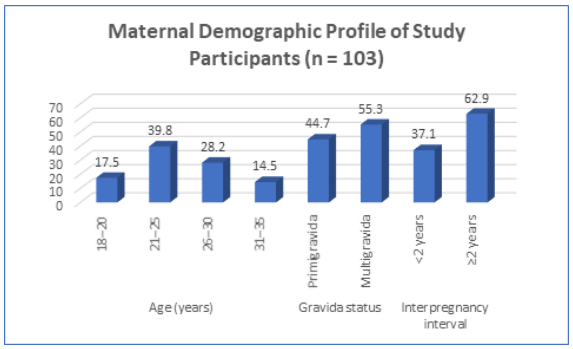

Figure 1: Maternal Demographic Profile of Study Participants (n = 103)

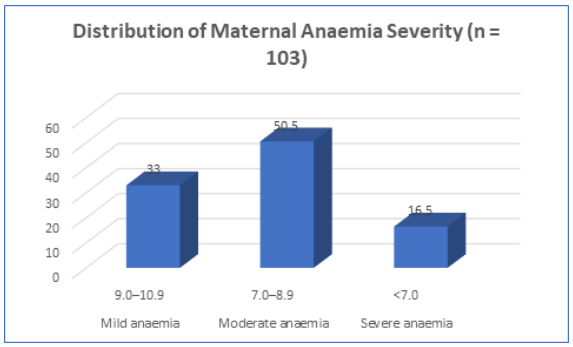

Figure 2: Distribution of Maternal Anaemia Severity (n = 103)

DISCUSSION

The present prospective observational study evaluated the effect of maternal haemoglobin levels on neonatal anthropometric parameters in 103 anaemic pregnant women and their term singleton neonates. In our study, the mean maternal haemoglobin level was 8.92 ± 1.12 g/dL, indicating that most mothers had moderate anaemia. The mean neonatal birth weight, body length, and head circumference were 2.54 ± 0.38 kg, 47.82 ± 2.44 cm, and 33.21 ± 1.48 cm, respectively. These findings indicate overall reduced neonatal anthropometric measurements in anaemic mothers, particularly in those with lower haemoglobin levels.

In the present study, a statistically significant positive correlation was observed between maternal haemoglobin and neonatal birth weight ($r = 0.61$, $p = 0.001$), suggesting that higher maternal haemoglobin levels are associated with improved fetal growth. Similarly, moderate positive correlations were observed with body length ($r = 0.48$, $p = 0.007$) and head circumference ($r = 0.44$, $p = 0.014$), indicating that maternal haemoglobin influences multiple aspects of fetal development. Furthermore, neonates born to severely anaemic mothers had significantly lower birth weights compared to those born to mildly anaemic mothers ($p = 0.003$), highlighting the graded effect of anaemia severity on fetal growth.

The findings of our study are consistent with the study conducted by Gupta et al. (2025),[13] who reported a significant association between maternal haemoglobin levels and neonatal birth weight. In their study, neonates born to anaemic mothers had a significantly lower mean birth weight of 2.55 ± 0.35 kg compared to 3.02 ± 0.38 kg in non-anaemic mothers ($p < 0.001$). This closely aligns with our findings where reduced haemoglobin levels were associated with low birth weight, supporting the hypothesis that maternal anaemia adversely affects fetal growth.

Similarly, Dhole et al. (2022),[14] in their prospective observational study reported that maternal anaemia significantly affects neonatal anthropometric parameters, particularly birth weight and length. Their findings demonstrated that maternal haemoglobin deficiency was associated with reduced neonatal growth indices, which is in agreement with the present study where both birth weight and body length showed significant positive correlation with maternal haemoglobin levels

Another study by Yildiz et al,[15] and Kaur et al,[16] also supports our findings, reporting that increasing severity of maternal anaemia is associated with a higher risk of low birth weight and intrauterine growth restriction. These studies collectively reinforce the graded relationship observed in our study, where severe anaemia showed the most pronounced reduction in neonatal anthropometric outcomes.

In contrast, some studies have reported weaker or non-significant associations between maternal haemoglobin and certain neonatal parameters. For example, Paramahamsa et al. (2019),[17] observed that while birth weight was significantly affected by maternal haemoglobin levels, the association with neonatal length was less consistent across different haemoglobin categories . This partially differs from our findings where both birth weight and length showed statistically significant positive correlations, suggesting that our study population may have had a stronger effect of maternal anaemia on overall fetal growth.

Physiologically, the findings of the present study can be explained by the role of haemoglobin in oxygen transport. Reduced maternal haemoglobin leads to chronic uteroplacental hypoxia, which impairs placental nutrient transfer and fetal oxygen supply. This results in intrauterine growth restriction and reduced deposition of fat and muscle mass, ultimately leading to lower birth weight, shorter body length, and reduced head circumference. The stronger correlation observed with birth weight in

our study (r = 0.61) suggests that birth weight is the most sensitive indicator of maternal anaemia-related fetal growth restriction.

The findings of this study are also supported by recent evidence indicating that maternal haemoglobin is a key determinant of fetal growth and neonatal outcomes. Large observational studies and meta-analyses have consistently demonstrated that maternal anaemia is associated with increased risk of low birth weight, preterm delivery, and small-for-gestational-age infants. These findings reinforce the importance of early detection and correction of anaemia during pregnancy to improve neonatal health outcomes.

CONCLUSION

The present study demonstrated a significant positive association between maternal haemoglobin levels and neonatal anthropometric parameters, including birth weight, body length, and head circumference. Lower maternal haemoglobin levels, particularly severe anaemia, were associated with reduced neonatal growth measurements. Birth weight was found to be the most strongly affected parameter. These findings highlight that maternal anaemia has a direct and measurable impact on fetal growth. Early detection and effective management of anaemia during pregnancy are essential to improve neonatal outcomes.

Limitations

The present study was conducted in a single tertiary care centre with a relatively small sample size, which may limit the generalisability of the findings. The study did not account for all potential confounding factors such as detailed dietary intake, socioeconomic status, and placental parameters. Maternal haemoglobin was assessed only during the second and third trimesters, which may not reflect anaemia status throughout the entire pregnancy. Long-term follow-up of neonatal growth and development was not performed.

Summary

Maternal anaemia remains one of the most common nutritional disorders affecting pregnant women worldwide and is a major public health concern, particularly in developing countries. Reduced maternal haemoglobin levels impair oxygen transport to the placenta and fetus, potentially resulting in adverse neonatal outcomes, including low birth weight and impaired intrauterine growth. The present prospective observational study was conducted to evaluate the effect of maternal haemoglobin levels on neonatal anthropometric parameters, namely birth weight, body length, and head circumference.

The study was carried out over six months at the Departments of Paediatrics and Obstetrics & Gynaecology, SRM Medical College Hospital and Research Centre. A total of 103 anaemic pregnant women aged 18–35 years with singleton full-term pregnancies and their neonates were enrolled. Maternal haemoglobin levels were categorized as mild, moderate, or severe anaemia according to WHO criteria. Neonatal anthropometric measurements were recorded within 48 hours of birth. Statistical analysis was performed using IBM SPSS version 26.0, and correlation analysis was used to evaluate the relationship between maternal haemoglobin and neonatal growth parameters.

The mean maternal haemoglobin level was 8.92 ± 1.12 g/dL. Moderate anaemia was the most prevalent category (50.5%), followed by mild (33.0%) and severe anaemia (16.5%). The mean neonatal birth weight, body length, and head circumference were 2.54 ± 0.38 kg, 47.82 ± 2.44 cm, and 33.21 ± 1.48 cm, respectively. Maternal haemoglobin demonstrated a significant positive correlation with birth weight ($r = 0.61$, $p = 0.001$), body length ($r = 0.48$, $p = 0.007$), and head circumference ($r = 0.44$, $p = 0.014$). Neonates born to mothers with severe anaemia exhibited significantly poorer anthropometric outcomes, particularly lower birth weight, compared with those born to mildly anaemic mothers.

The findings indicate that maternal haemoglobin is an important determinant of fetal growth and neonatal anthropometry. Improving maternal haemoglobin through early antenatal screening, nutritional counselling, and timely iron–folic acid supplementation may enhance fetal growth and reduce the incidence of low birth weight and other adverse neonatal outcomes. These results underscore the importance of strengthening maternal anaemia prevention and management strategies as part of routine antenatal care to improve neonatal health.

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