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Effect of Maternal Anemia on Neonatal Anthropometry

[1]Dr. C M Usman Manal, MBBS, MD, Department of Paediatrics, Kempegowda Institute of Medical Sciences and Research Centre, Bangalore

[2]Dr. Mohan Kumar N, Professor, Department of Paediatrics, Kempegowda Institute of Medical Sciences and Research Centre, Bangalore

[3]Dr. Smitha K, Professor, Department of Obstetrics and Gynecology, Kempegowda Institute of Medical Sciences and Research Centre, Bangalore

Corresponding Author: Dr. C M Usman Manal, MBBS, MD, Department of Paediatrics, Kempegowda Institute of Medical Sciences and Research Centre, Bangalore.

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Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Introduction: Maternal anemia remains a significant public health concern globally, particularly in low– and middle–income countries like India, where over half of pregnant women are affected. It is associated with adverse pregnancy outcomes, including intrauterine growth restriction and low birth weight. However, comprehensive evaluation of neonatal anthropometric parameters beyond birth weight is essential to fully understand the impact of maternal anemia severity on fetal growth.

Aims and Objectives:

Aim:

- To evaluate the effect of maternal anemia on neonatal anthropometric parameters among term neonates.

Primary Objective

- To assess neonatal birth weight, head circumference and crown–heel length.

Secondary Objective

- To correlate the severity of maternal anemia in the third trimester with neonatal anthropometric parameters.

Material and Method:

Study Design: The study was designed as a Prospective observational study.

Study Place: The study was carried out the Department of Pediatrics and Department of Obstetrics and Gynecology at Kempegowda Institute of Medical Science& Research Centre, Bengaluru.

Study Period: The study was conducted over 18 a period of months.

Study Participants: The study included postnatal mothers diagnosed with anemia during the third trimester of pregnancy and their corresponding term neonates delivered at the study hospital.

Sample Size: A total sample size were 100 anemic mothers and their term neonates.

Result: Among 100 mothers, 44% had mild anemia, 45% moderate anemia and 11% severe anemia, with mean hemoglobin of 9.15 ± 1.46 g/dL. The mean neonatal birth weight was 2.86 ± 0.36 kg, with 17% low birth weight.

Conclusion: Severe maternal anemia in the third trimester is significantly associated with reduced neonatal head circumference, while birth weight and length show non-significant decreasing trends. Head circumference appears to be a more sensitive indicator of intrauterine growth restriction related to maternal anemia. Early detection and severity-based management of anemia during pregnancy are essential to mitigate adverse effects on fetal growth.

Keywords: Maternal Anemia, Neonatal Anthropometry, Birth Weight, Head Circumference, Hemoglobin

Introduction

Anemia remains one of the most common and preventable public health problems worldwide, with the greatest burden observed in low– and middle–income countries.[1,2] Maternal anemia still affects a significant percentage of pregnant women, particularly those in India, despite improvements in prenatal care and nutritional supplementation programs.[3,4] A hemoglobin content of less than 11 g/dL is considered anemia in pregnancy, according to the World Health Organization. Anemia is categorized as mild (10.0–10.9 g/dL), moderate (7.0–9.9 g/dL) and severe (<7.0 g/dL) according to hemoglobin levels.[1] During pregnancy, haemoglobin concentrations decline partly due to physiological changes; however, inadequate iron stores may result in true pathological anaemia associated with adverse maternal and neonatal outcomes.[5,6] Iron deficiency is the most common cause of anemia and results from inadequate intake, increased requirements, or impaired absorption.[8] According to the National Family Health Survey-5 (2019–2021), 52.2% of pregnant women aged 15-49 years in India are anaemic.[4] Iron deficiency anemia is the most common etiology, resulting from increased iron requirements during pregnancy for expansion of maternal red cell mass, placental development and fetal growth, combined with inadequate dietary intake and poor iron bioavailability.[11]

Deficiencies of folate and vitamin B12 also contribute significantly to maternal anemia. Folate deficiency may result in megaloblastic anemia and is associated with adverse fetal outcomes, while vitamin B12 deficiency common in populations consuming predominantly vegetarian diets may adversely affect fetal neurodevelopment.[13,14]

As gestational age increases, anemia becomes more common, especially in the third trimester when fetal growth accelerates and maternal iron requirements reach their peak.[18.] Multiple studies have consistently demonstrated that neonates born to anemic mothers have significantly lower birth weight, reduced length and smaller head circumference compared to those born to non–anemic mothers. A clear dose–response relationship has been observed, with moderate and severe maternal anemia associated with progressively poorer neonatal anthropometric outcomes.[21,25,26,27]

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Inclusion Criteria

- Postnatal mothers diagnosed with anemia (Hemoglobin<11 g/dL) during the third trimester.
- Mothers delivering term neonates (37–40 weeks gestation).
- Singleton pregnancies.
- Mothers willing to provide informed consent.

Exclusion Criteria

- History of TORCH (T)Toxoplasmosis, (O)thers, (R)ubella, (C)ytomegalovirus, (H)erpes Simplex infections
- History of smoking tobacco or alcohol consumption
- Any chronic illnesses like Hypertension, Diabetes Mellitus, renal, liver or heart disease during / before pregnancy
- Known Haemoglobinopathies (e.g. Thalassemia)
- Babies born with congenital deformities and genetic disorders

Statistical Analysis

Data entry: The collected study data were entered in Microsoft Office Excel 2013 and analyzed using SPSS 26 software.

Data cleaning: Before analyzing the data, each variable was acquired to check for missing values, blank values and typing errors. The corresponding case numbers were used to trace the questionnaires and the information was rechecked and entered.

Descriptive statistics: Continuous variables such as maternal age, gestational age, maternal hemoglobin level, neonatal birth weight, crown–heel length and head circumference were expressed as mean ± standard deviation (SD). Categorical variables such as severity of maternal anemia (mild, moderate, severe), parity, mode of delivery, gender of the newborn and distribution of anthropometric categories were expressed as frequencies and percentages.

Inferential Statistics: One-way Analysis of Variance (ANOVA) was used to compare mean birth weight, head circumference and neonatal length across different severity groups of maternal anemia. Tukey's post–hoc test was applied for multiple comparisons where ANOVA showed statistical significance. Pearson's

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correlation test was used to assess the relationship between maternal hemoglobin levels and neonatal anthropometric parameters. All statistical tests were two–tailed and a p-value of <0.05 was considered statistically significant.

Sample Size Calculation:

The sample size was calculated using the formula for estimation of a single proportion:

$$N = \frac{Z^2(1-\alpha/2) \times P \times (1-P)}{d^c}$$

Where:

- N= Required sample size
- $Z(1-\alpha/2)$ = Standard normal variate at 95% confidence level = 1.96
- P= Prevalence of anemia in pregnancy (52.2% = 0.52), based on NFHS-5 (2019–2021) data
- 1-P= Complement of prevalence = 0.48
- d= Absolute precision (margin of error) = 10% (0.10)

Substituting the values:

$$N = \frac{(1.96)^2 \times 0.52 \times 0.48}{(0.10)^2}$$

$$N = \frac{3.8416 \times 0.2496}{0.01}$$

$$N = \frac{0.958}{0.01} - 95.8$$

Thus, the calculated sample size was 95.8, which was rounded off to 100 participants. Therefore, the present study included 100 anemic mothers and their term neonates.

Result

The present study included 100 postnatal mothers and their newborns to assess the relationship between maternal anemia and neonatal anthropometric outcomes. The findings are presented below.

Table 1: Age distribution among postnatal mothers

Age category	Number	Percentage
> 18 to 30 Years	75	75%
> 30 to 40 Years	25	25%
Mean ± SD	27.96 ± 3.99	
Minimum Age in years	19	
Maximum Age in Years	38	
Total	100	100.0 %

The mean age of the study participants was 27.96 ± 3.99 years. The minimum age observed was 19 years and the maximum age observed was 38 years. Majority 75% of the postnatal mother belongs to age category between more than 18 to 30 years, indicating that most mothers were in the optimal reproductive age group.

Figure 1: Box whisker diagram shows age distribution among study participants

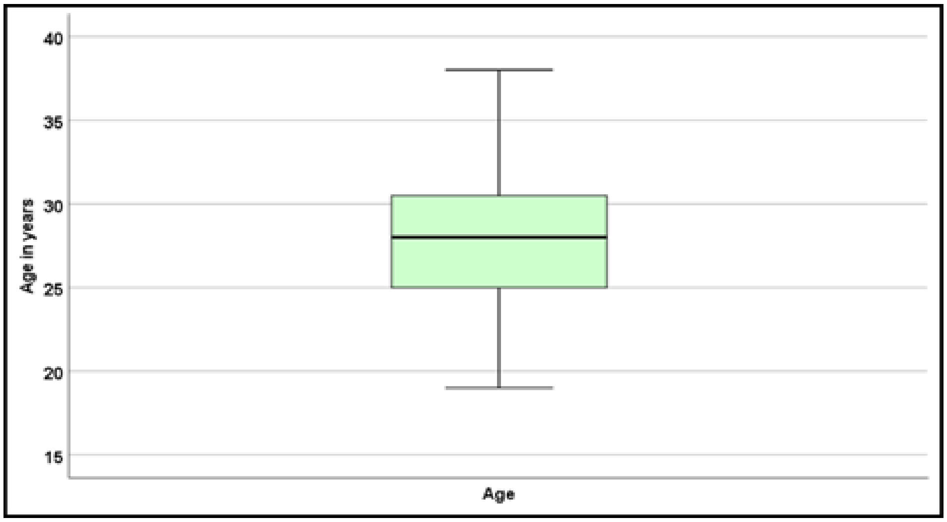

Table 2: Obstetrics score distribution among postnatal mothers

Obstetrics code	Frequency	Percentage
Para		
P1	32	32.0 %
P2	50	50.0 %
P3	17	17.0 %
P4	1	1.0 %
Living children		
1	32	32.0 %
2	51	51.0 %
3	16	16.0 %
4	1	1.0 %
Abortions		
0	66	66.0 %
1	21	21.0 %
2	13	13.0 %
Total	100	100.0 %

Out of 100 postnatal mothers, the majority were para two (50%), followed by para one (32%), while smaller proportions were para three (17%) and para four (1%). With respect to living children, most participants had two children (51%), whereas 32% had one child, 16% had three children and only 1% had four. Regarding abortions, two–thirds of the women reported none (66%), while 21% had experienced one abortion and 13% had two**,** suggesting a predominantly low–risk obstetric population.

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Table 3: Hemoglobin and anemia severity distribution among postnatal mothers

Hemoglobin (mg/dl)	Number	Percentage
Mild anemia	44	44.0 %
Moderate anemia	45	45.0 %
Severe anemia	11	11.0 %
Mean ± SD	9.15 ± 1.46	
Median (IQR)	9.60 (7.80 – 10.50)	
Minimum Age in years	5.80	
Maximum Age in Years	10.90	
Total	100	100.0 %

The mean hemoglobin distribution among the post–natal mothers was 9.15 ± 1.46 g/dL. The minimum hemoglobin observed was 5.80 g/dL and the maximum observed was 10.90 g/dL. Among 100 post–natal mothers,

- Mild anemia: 44%
- Moderate anemia: 45%
- Severe anemia: 11%

Thus, moderate anemia was the most prevalent, highlighting the high burden of anemia among postnatal mothers.

Figure 2: Pie diagram shows anemia severity among postnatal mothers

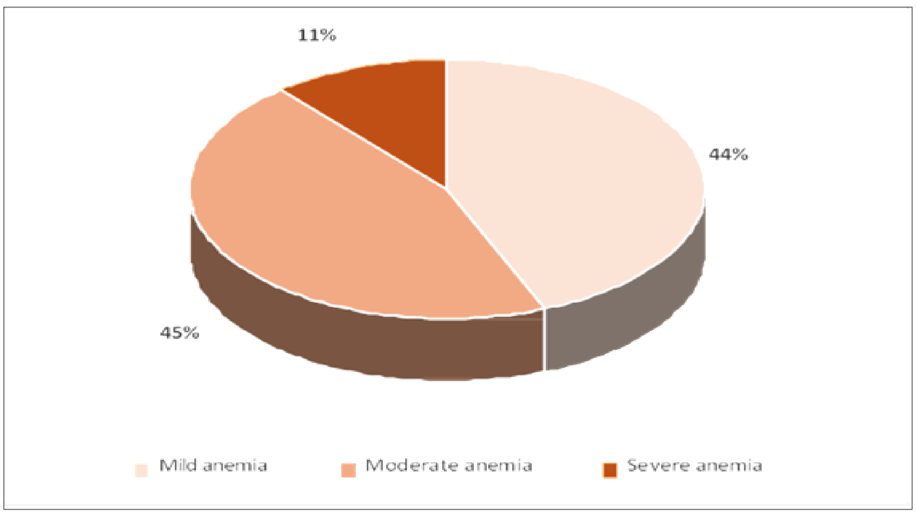

Table 4: Maternal anemia severity in relation to birth weight of newborns

Birth weight	Anemia Severity			p value
	Mild	Moderate	Severe	
Low Birth Weight	5 (11.4%)	8 (17.8%)	4 (36.4%)	
Normal	39 (88.6%)	37 (82.2%)	7 (63.6%)	
Mean ± SD (Kgs)	2.88 ± 0.37	2.88 ± 0.35	2.75 ± 0.35	
Total	44 (100%)	45 (100%)	11 (100%)	0.561

Note: p value based on one way ANOVA

In the mild anemia group, 5 (11.4%) newborns had low birth weight while 39 (88.6%) had normal birth weight, with a mean ± SD of 2.88 ± 0.37 kg. In the moderate anemia group, 8 (17.8%) newborns were of low birth weight and 37 (82.2%) were of normal birth weight, with a mean ± SD of 2.88 ± 0.35 kg. In the severe anemia group, 4 (36.4%) newborns had low birth weight compared to 7 (63.6%) with normal birth weight, with a mean ± SD of 2.75 ± 0.35 kg. Statistical analysis using one–way ANOVA revealed a p value of 0.561, indicating no significant difference in birth weight across the three anemia severity groups.

Figure 3: Error bar diagram shows maternal anemia severity in relation to mean birth weight of newborns

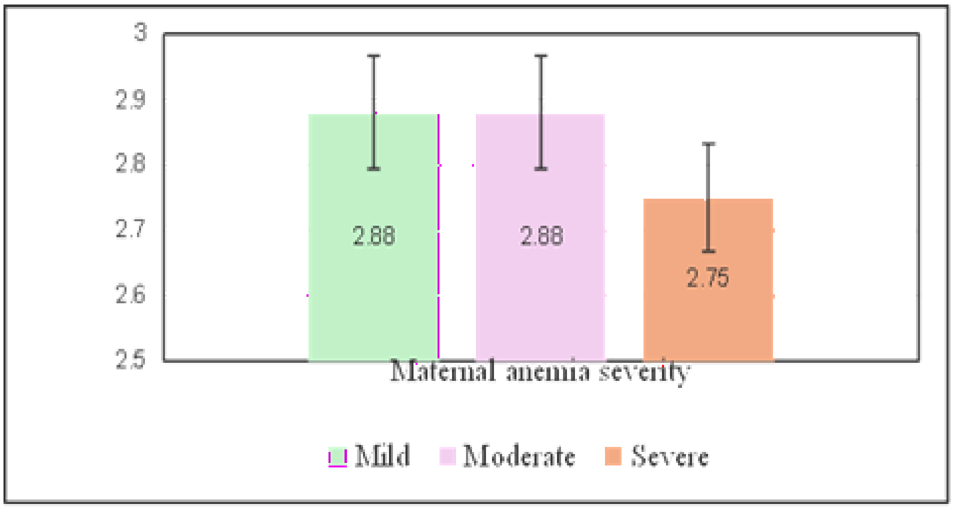

Table 5: Multiple comparison between maternal anemia severity with head circumference of newborn

(I) Anemia severity	(J) Anemia severity	Mean Difference (I-J)	p value	95% Confidence Interval	
				Lower Bound	Upper Bound
Mild	Moderate	0.1449	0.901	-0.643	0.933
	severe	1.4318*	0.021	0.178	2.685
Moderate	Mild	-0.1449	0.901	-0.933	0.643
	severe	1.2869*	0.042	0.036	2.537
Severe	Mild	-1.4318*	0.021	-2.685	-0.178
	Moderate	-1.2869*	0.042	-2.537	-0.036

The multiple comparison analysis between maternal anemia severity and neonatal head circumference revealed that there was no significant difference between mild and moderate anemia groups, with a mean difference of 0.1449 (p = 0.901; 95% CI: –0.643 to 0.933). However, a significant difference was observed between mild and severe anemia, with a mean difference of 1.4318 (p = 0.021; 95% CI: 0.178 to 2.685). Similarly, the comparison between moderate and severe anemia also showed a significant difference, with a mean difference of 1.2869 (p = 0.042; 95% CI: 0.036 to 2.537). These findings indicate that severe maternal anemia is significantly associated with reduced neonatal head circumference when compared to both mild and moderate anemia groups.

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Table 6: Maternal anemia severity in relation to length of newborns

Length	Anemia Severity			p value
	Mild	Moderate	Severe	
Appropriate for age	18 (40.9%)	13 (28.9%)	3 (27.3%)	0.077
Reduced length (Cm)	26 (59.1%)	32 (71.1%)	8 (72.7%)	
Mean ± SD	48.55 ± 2.21	47.44 ± 3.12	46.91 ± 2.66	
Total	44 (100%)	45 (100%)	11 (100%)	

Note: p value based on one way ANOVA

Among 44 mothers with mild anemia, 18 (40.9%) newborns had length appropriate for age, while 26 (59.1%) showed reduced length, with a mean ± SD of 48.55 ± 2.21 cm. In the moderate anemia group, 13 (28.9%) newborns had appropriate length and 32 (71.1%) had reduced length, with a mean ± SD of 47.44 ± 3.12 cm. In the severe anemia group, only 3 (27.3%) newborns had appropriate length, whereas 8 (72.7%) had reduced length, with a mean ± SD of 46.91 ± 2.66 cm. Statistical analysis revealed a p value of 0.077, indicating that the observed differences in neonatal length across anemia severity groups were not statistically significant

Figure 4: Error bar diagram shows maternal anemia severity in relation to mean length of newborns

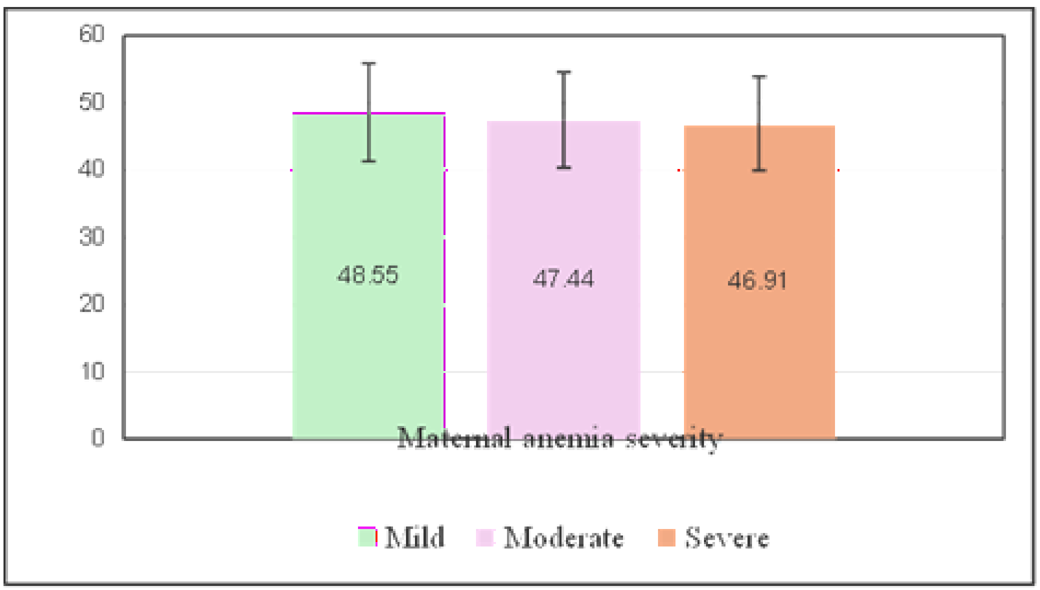

Table 7: Correlation between maternal hemoglobin with neonatal birth weight, head circumference and length (n= 100)

Neonatal Anthropometric measurements	Maternal hemoglobin	
	Correlation Coefficient	p value
Birth Weight (in kg)	0.090	0.371
Head circumference (in cm)	0.246*	0.014
Baby Length (in cm)	0.237*	0.018
Total	100	

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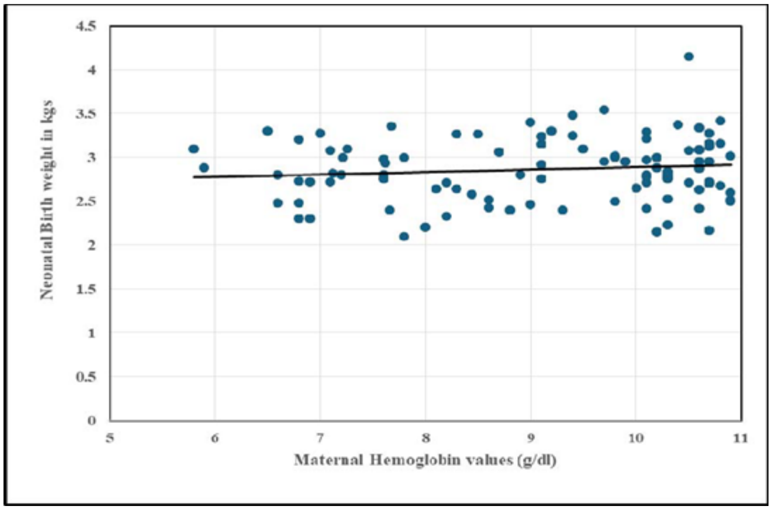
*. Correlation is significant at the 0.05 level (2-tailed).

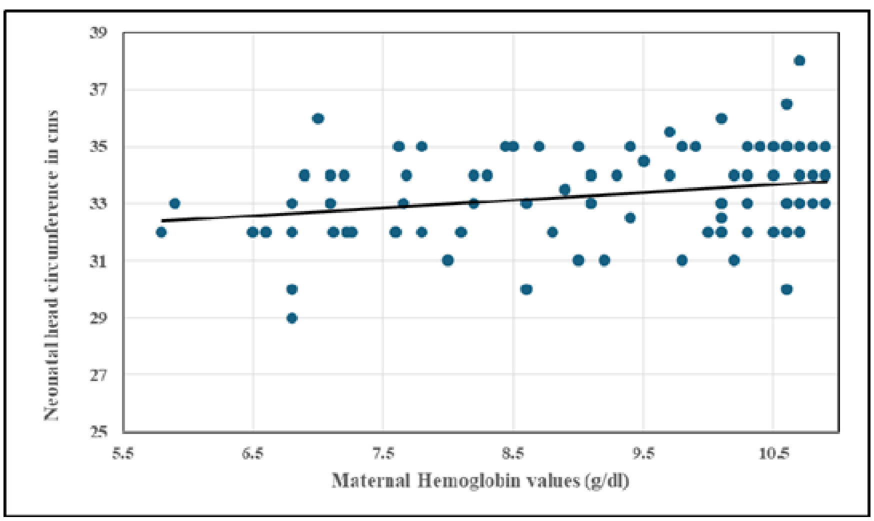
Birth weight showed a weak positive correlation with maternal hemoglobin (r= 0.090, p = 0.371), which was not statistically significant. In contrast, head circumference demonstrated a significant positive correlation (r = 0.246, p = 0.014), and baby length also showed a significant positive correlation (r = 0.237, p = 0.018). These findings indicate that higher maternal hemoglobin levels are significantly associated with larger neonatal head circumference and length, while no significant relationship was observed with birth weight.

Figure 5: Scatter plot diagram shows correlation between maternal hemoglobin values with neonatal birth weight



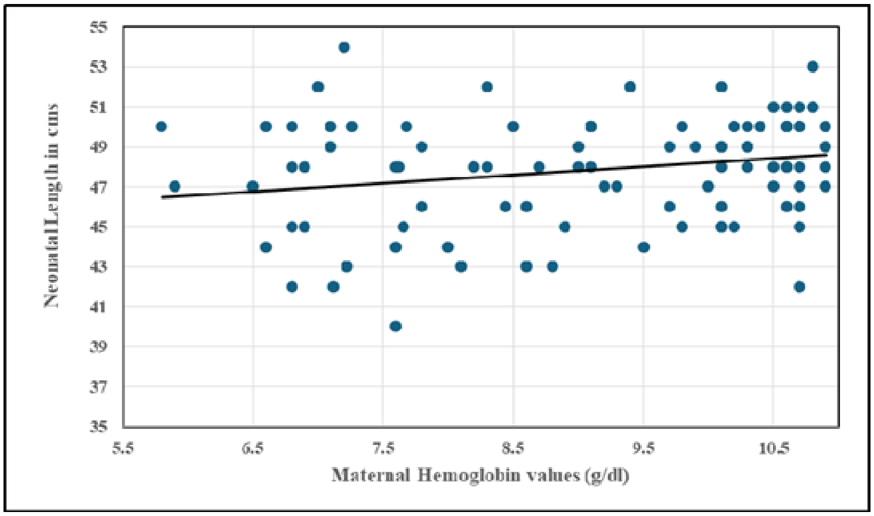
The scatter plot demonstrates a very weak positive correlation between maternal hemoglobin levels and neonatal birth weight (r = 0.090, p = 0.371). Although higher maternal hemoglobin levels appear to be associated with slightly greater birth weight, the strength of the correlation is minimal. Furthermore, the association is not statistically significant, indicating that no meaningful relationship was observed between maternal hemoglobin levels and neonatal birth weight in this study.

Figure 6: Scatter plot diagram shows correlation between maternal hemoglobin values with neonatal head circumference



The scatter plot demonstrates a weak but statistically significant positive correlation between maternal hemoglobin levels and neonatal head circumference (r = 0.246, p = 0.014). This indicates that higher maternal hemoglobin levels are associated with larger neonatal head circumference. Conversely, lower maternal hemoglobin levels tend to be associated with reduced neonatal head circumference. Although the strength of the correlation is weak, the association is statistically significant, suggesting a meaningful relationship between maternal anemia severity and fetal head growth.

Figure 7: Scatter plot diagram shows correlation between maternal hemoglobin values with neonatal length



The scatter plot demonstrates a weak but statistically significant positive correlation between maternal hemoglobin levels and neonatal length ($r = 0.237$, $p = 0.018$). This indicates that higher maternal hemoglobin levels are associated with greater neonatal length. Conversely, lower maternal hemoglobin levels tend to be associated with shorter neonatal length. Although the strength of the correlation is weak, the statistically significant p–value suggests a meaningful association between maternal anemia severity and fetal linear growth.

Discussion

Maternal anemia remains one of the most prevalent and preventable nutritional disorders affecting pregnancy outcomes, particularly in low– and middle–income countries such as India. Despite ongoing public health interventions and iron–folic acid supplementation programs, the burden of anemia during pregnancy continues to remain high and contributes significantly to adverse maternal and neonatal outcomes.[4,9] A total of 100 postnatal mothers with third–trimester anemia (hemoglobin<11 g/dL) and their singleton term neonates were included. The present study was undertaken to evaluate the effect of the severity of maternal anemia during the third trimester on neonatal anthropometric parameters – namely birth weight, head circumference and crown–heel length and to compare the findings with existing literature. The mean maternal age in the present study was 27.96 ± 3.99 years, with the majority (75%) belonging to the 18–30 year age group. In the study, 44% of mothers had mild anemia, 45% had moderate anemia and 11% had severe anemia, with a mean hemoglobin level of 9.15 ± 1.46 g/dL.

Correlation analysis in the present study demonstrated that maternal hemoglobin levels showed a statistically significant positive correlation with neonatal length ($r = 0.237$, $p = 0.018$) and head circumference ($r = 0.246$, $p = 0.014$), whereas no significant correlation was observed with birth weight. Although the correlation coefficients indicate a modest strength of association, their statistical

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significance suggests a consistent directional relationship between maternal hemoglobin status and specific fetal growth parameters.

Conclusion

The present study demonstrates that maternal hemoglobin concentration has a measurable influence on neonatal anthropometric outcomes. While birth weight did not show a significant correlation with maternal hemoglobin levels, neonatal length and head circumference exhibited statistically significant positive associations. A severity–dependent trend was observed, with increasing maternal anemia associated with reduced neonatal anthropometric parameters. These findings reinforce the importance of early detection and appropriate management of maternal anemia during pregnancy to optimize fetal growth and developmental outcomes. Maternal anemia should therefore be recognized not merely as a hematological abnormality, but as a modifiable risk factor for subtle yet clinically meaningful intrauterine growth restriction.

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