

Original Research Article

Association of neonatal anthropometry with maternal anthropometry and demographics: a hospital-based cross-sectional study from Northern India

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ABSTRACT

Background: Identifying simple maternal physical predictors of neonatal growth is essential for early risk stratification in resource-constrained settings. This study evaluated the associations between third-trimester maternal physical parameters and neonatal anthropometrics.

Methods: A prospective, hospital-based cross-sectional study was conducted among 160 healthy term mother-neonate dyads at a tertiary care center in Sitapur, Uttar Pradesh. Maternal third-trimester weight, height, body mass index (BMI), and mid-upper arm circumference (MUAC), along with sociodemographic factors, were recorded. Neonatal birth weight, crown-heel length, and head circumference were measured within 24 hours of delivery. Data were analyzed using Chi-square tests and Pearson correlation coefficients ($p < 0.05$).

Results: Mean maternal age was 26.34 ± 3.53 years and gestational age was 38.46 ± 1.06 weeks. Mean neonatal birth weight, crown-heel length, and head circumference were 2.79 ± 0.24 Kg, 46.08 ± 1.15 cm, and 33.79 ± 0.79 cm, respectively. Low birth weight (< 2.5 kg) was observed in 6.3% ($n=10$). Maternal third-trimester weight, MUAC, and BMI demonstrated highly significant categorical associations with all neonatal parameters ($p < 0.001$). Specifically, maternal weight and MUAC showed positive correlations with birth weight ($r=0.516$ and $r=0.439$, respectively), length ($r=0.668$ and $r=0.485$), and head circumference ($r=0.664$ and $r=0.461$; all $p < 0.001$). Gestational age also correlated positively with all three neonatal measurements ($p < 0.05$). Conversely, maternal height, age, parity, delivery mode, and socioeconomic status showed no statistically significant correlations with birth weight or head circumference ($p > 0.05$).

Conclusions: Maternal third-trimester weight, BMI, and particularly MUAC demonstrate positive associations with neonatal birth dimensions. MUAC serves as a practical, low-cost screening tool for antenatal nutritional surveillance in rural healthcare settings.

Keywords: Anthropometry, Birth weight, Body mass index, Fetal growth, Gestational age, Maternal nutritional status, Mid-upper arm circumference, Neonatal somatometrics

INTRODUCTION

Optimizing maternal and child health remains a pivotal focus of global and national health frameworks, explicitly targeted in India's National Health Policy 2017 and the United Nations sustainable development goals (SDGs).^{1,2}

The neonatal period, encompassing the first 28 days of life, represents the most vulnerable phase for child survival.³ Globally, neonatal mortality remains significant, standing at approximately 19 per 1,000 live births in 2021.⁴ India faces a parallel challenge, reporting

a matching neonatal mortality rate of 19 per 1,000 live births during the same period.⁴

Low birth weight (LBW), defined as a birth weight of less than 2,500 grams, serves as a primary driver of infant mortality, short-term morbidity, and long-term neurodevelopmental or physical deficits.⁵ Low birth weight remains a major public health challenge impacting 15% to 20% of live births globally (>20 million infants annually), with over 90% occurring in low- and middle-income countries, and continues to drive elevated rates of neonatal morbidity and mortality across India and particularly in Uttar Pradesh due to socioeconomic, structural, and cultural disparities.⁵

The maternal environment is the primary determinant of fetal growth, intrauterine development, and birth dimensions.⁶ Fetal anthropometric measurements, including birth weight, length, and head circumference, as well as biochemical parameters, directly reflect the mother's physiological, nutritional, and physical status, as demonstrated by strong correlations between maternal and neonatal nutrient levels at birth.^{7,8} Parameters such as maternal weight, height, body mass index (BMI), gestational weight gain, and body composition act as key determinants of neonatal somatometrics.⁹ Insufficient pre-pregnancy weight, lower maternal BMI, maternal anemia, and short stature significantly elevate the risk of delivering LBW newborns.⁹⁻¹²

Beyond physical dimensions, sociodemographic parameters, including lower socioeconomic status, maternal illiteracy, occupation, rural locality, inadequate antenatal care (ANC), and gaps in maternal health awareness, exacerbate adverse fetal and infant outcomes.^{10,13,14} While BMI is widely used to monitor maternal body habitude, it fails to differentiate between lean muscle mass, adipose tissue, and fluid expansion during late pregnancy.¹⁵ Consequently, simple and non-invasive maternal anthropometric measures, skinfold thicknesses, and dietary tracking serve as crucial, cost-effective tools for identifying high-risk pregnancies.¹⁶

Despite expanding institutional delivery rates under national health missions, tertiary care facilities across central and northern India continue to bear a disproportionate burden of high-risk pregnancies, low-birth-weight deliveries, adverse perinatal outcomes, and neonatal morbidities, such as those associated with meconium-stained deliveries.¹⁷⁻¹⁹ In these regional cohorts, unfavourable neonatal outcomes are heavily driven by lower socioeconomic status, agricultural labor, early marriage, suboptimal maternal nutrition, and delayed antenatal registration.^{13,20} However, region-specific evidence directly correlating maternal physical parameters, body composition, and dietary intake with neonatal anthropometry in these vulnerable populations remains limited.²⁰

Anthropometry represents a simple, portable, cost-effective, and non-invasive method for evaluating maternal health status and predicting fetal intrauterine growth.²¹ Identifying low-cost, reliable maternal physical predictors allows for early risk stratification, timely nutritional counselling, and appropriate delivery planning, particularly in resource-constrained regional healthcare facilities.^{22,23} Therefore, updated, context-specific research is needed to assist healthcare providers and policymakers in refining antenatal screening protocols.^{24,25}

To address this gap, this study evaluated maternal physical parameters, anthropometry, and sociodemographic factors to determine their association with neonatal outcomes. Specifically, we assessed the proportion of low birth weight among institutional deliveries, analyzed the correlation of maternal height, weight, BMI, and mid-upper arm circumference with neonatal birth metrics (weight, length, and head circumference), and examined the influence of maternal socio-demographic factors, dietary intake, and antenatal care utilization on these outcomes.

METHODS

Study design and setting

A hospital-based cross-sectional study was conducted in the department of pediatrics and department of obstetrics and gynecology at Hind Institute of Medical Sciences (HIMS), Mau, Ataria, Sitapur, Uttar Pradesh, over 18 months from August 2024 to January 2026. Institutional ethics committee clearance was obtained before initiation of the study (Approval No.: IHEC-HIMS/MD/MS-23/RD-34/07-24). Written informed consent and participant information sheets were obtained from all participating mothers in their preferred language before enrollment.

Study population and eligibility criteria

The study population comprised healthy full-term neonates (gestational age ≥ 37 weeks) born to healthy mothers with uncomplicated singleton pregnancies.

Inclusion criteria

Full-term singleton live births (≥ 37 weeks of gestation) born to mothers without pre-existing or pregnancy-associated medical illnesses.

Exclusion criteria

Mothers with gestational diabetes mellitus, pre-eclampsia, severe anemia, chronic hypertension, thyroid or parathyroid disorders, rheumatoid arthritis, hepatic, renal, or cardiovascular diseases, as well as neonates with congenital anomalies or preterm births (< 37 weeks), were excluded.

Sample size calculation

The sample size was calculated based on the expected correlation between maternal third-trimester weight and neonatal birth weight ($r=0.279$), as reported in prior literature by Tosson et al, using the sample size formula for a correlation coefficient.^{8,26}

$$n = \frac{Z_{1-\alpha/2}^2 \cdot (1 - r^2)}{d^2} + 1 + 6r^2$$

Where $Z_{(1-\alpha/2)} = 1.96$ at a 95% confidence level ($\alpha=0.05$), $r=0.279$, and $d=0.15$ (margin of error), the required sample size was calculated as $n=158.91$. Thus, a sample size of $n=160$ mother-neonate dyads was selected to ensure adequate statistical power.

Data collection and measurements

Data were systematically recorded using a standardized proforma:

Maternal sociodemographic parameters

Recorded variables included maternal age in years (categorized as <25, 25-29, ≥ 30 years) based on the sample distribution of pregnant mothers in this regional cohort, and socioeconomic status (classified using the Modified Kuppuswamy Scale).²⁷

Maternal obstetric parameters

Recorded variables included parity (primipara versus multipara), mode of delivery [vaginal versus lower segment caesarean section (LSCS)], and gestational age in weeks (categorized as 37-38, 39-40, and 41-42 weeks).

Maternal anthropometric parameters

Recorded third-trimester anthropometric metrics included height in cm (categorized as <150 cm, 150-160 cm, and >160 cm), third-trimester weight in kg (categorized as <50 kg, 50-60 kg, and >60 kg), based on the sample distribution of pregnant mothers in this regional cohort. Body mass index (BMI, calculated as weight in kg/height in m^2) was categorized as underweight ($<18.5 \text{ kg/m}^2$), normal weight ($18.5\text{--}25 \text{ kg/m}^2$), overweight ($25\text{--}30 \text{ kg/m}^2$), and obese ($\geq 30 \text{ kg/m}^2$), using the Centers for Disease Control and Prevention (CDC) adult standards.²⁸ Mid-upper arm circumference (MUAC, measured in cm at the midpoint between the acromion and olecranon processes using a non-stretchable measuring tape) was categorized into three nutritional tiers based on regional cut-offs derived by Dias et al: thin ($\leq 23.5 \text{ cm}$), normal ($>23.5\text{--}29.4 \text{ cm}$), and obese ($\geq 29.5 \text{ cm}$).²⁹

Neonatal parameters

Recorded metrics included gender and standardized neonatal anthropometric measurements of birth weight in kg (categorized as <2.5 kg, 2.5-3 kg, and $> 3 \text{ kg}$), crown-heel length in cm (categorized as <45 cm, 45-48 cm, and $>48 \text{ cm}$), and head circumference in cm (categorized as $<35 \text{ cm}$ and $\geq 35 \text{ cm}$), based on the sample distribution of full-term infants in this regional population, obtained within 24 hours of delivery.

Statistical analysis

Data were statistically analyzed and presented as mean $\pm$ standard deviation (SD) and range for continuous variables, or absolute frequencies (n) and percentages (%) for categorical parameters. Bivariate associations between categorical maternal factors (sociodemographic, obstetric, and anthropometric) and categorical neonatal outcome parameters (birth weight, crown-heel length, and head circumference) were evaluated using Pearson's Chi-square (χ^2) test. Pearson correlation analysis (r) was performed to evaluate linear relationships between continuous maternal anthropometric parameters, gestational age, and neonatal birth measurements. Statistical significance was set at a two-tailed p value <0.05 . All statistical analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS

In this study cohort of 160 mother-neonate pairs ($n=160$), the mean maternal age was 26.34 ± 3.53 years (range: 20-35 years), with an average gestational age at delivery of 38.46 ± 1.06 weeks, reflecting a full-term study population (Table 1). Maternal anthropometric evaluation during the third trimester demonstrated a mean weight of $56.83\pm 6.72 \text{ kg}$, height of $154.46\pm 10.12 \text{ cm}$, mid-upper arm circumference (MUAC) of $25.92\pm 2.69 \text{ cm}$, and body mass index (BMI) of $24.16\pm 4.48 \text{ kg/m}^2$. Among the neonates, physical parameters at birth showed a mean birth weight of $2.79\pm 0.24 \text{ kg}$, a mean crown-heel length of $46.08\pm 1.15 \text{ cm}$, and a mean head circumference of $33.79\pm 0.79 \text{ cm}$.

Categorical analysis of maternal parameters ($n=160$) showed that most mothers were aged 25-29 years ($n=74$, 46.2%) and belonged to the upper-lower socioeconomic class ($n=64$, 40.0%) (Table 2). Obstetrically, 60% ($n=96$) were multiparous, delivered via lower segment caesarean section (LSCS), and delivered at 37-38 weeks of gestation. Regarding third-trimester anthropometry, most mothers weighed 50-60 kg ($n=123$, 76.9%), had a MUAC of $>23.5\text{--}29.4 \text{ cm}$ ($n=102$, 63.7%), and had a normal BMI ($n=92$, 57.5%), while 31.3% ($n=50$) were overweight and 8.1% ($n=13$) were obese.

Table 1: Maternal anthropometric, demographic, and neonatal anthropometric characteristics of the study population (n=160).

Parameters	Category	Mean±SD	Range
Maternal parameters	Age (years)	26.34±3.53	20-35
	Third trimester weight (kg)	56.83±6.72	45-80
	MUAC (cm)	25.92±2.69	22-31
	Height (cm)	154.46±10.12	137-171
	Third trimester BMI (kg/m ²)	24.16±4.48	16.1-42
	Gestational age (weeks)	38.46±1.06	37-42
Neonatal parameters	Birth weight (kg)	2.79±0.24	2.2-3.8
	Length (cm)	46.08±1.15	44-50
	Head Circumference (cm)	33.79±0.79	33-37

*SD: standard deviation; MUAC: mid-upper arm circumference; BMI: body mass index; kg: kilograms; cm: centimetres; kg/m²: kilograms per meter squared.

Table 2: Socio-demographic, obstetric, and anthropometric profile of mothers (n=160).

Parameters	Category	Number	Percentage
Age (years)	<25	56	35
	25-29	74	46.2
	≥30	30	18.8
Socioeconomic Status	Upper	8	5
	Upper middle	24	15
	Lower middle	40	25
	Upper lower	64	40
	Lower	24	15
Parity	Primipara	64	40
	Multipara	96	60
Mode of delivery	LSCS	96	60
	Vaginal	64	40
Gestational age (weeks)	37-38	96	60
	39-40	56	35
	41-42	8	5
Third trimester weight (kg)	<50	9	5.6
	50-60	123	76.9
	>60	28	17.5
MUAC (cm)	≤23.5	14	8.8
	>23.5-29.4	102	63.7
	≥29.5	44	27.5
Height (cm)	<150	56	35
	150-160	51	31.9
	>160	53	33.1
BMI (Kg/m ²)	<18.5	5	3.1
	18.5-<25	92	57.5
	25-<30	50	31.3
	≥30	13	8.1

Categorical evaluation of neonatal characteristics (n=160) showed a slight male predominance, with 54.4% (n=87) males and 45.6% (n=73) females (Table 3). Categorical distribution of neonatal anthropometry (n=160) showed that most neonates had a birth weight of 2.5-3.0 kg (n=133, 83.1%), a crown-heel length of 45-48 cm (n=130, 81.3%), and a head circumference <35 cm (n=149,

93.1%) (Table 3). Low birth weight (<2.5 kg) was observed in 6.3% (n=10) of neonates.

Bivariate analysis revealed a highly significant association between neonatal birth weight categories and maternal anthropometric variables, including third-trimester weight ($\chi^2=37.780$, $p<0.001$), MUAC ($\chi^2=36.253$, $p<0.001$), and third-trimester BMI

($\chi^2=44.404$, $p<0.001$) (Table 4). Higher maternal weight (>60 kg), MUAC (≥ 29.5 cm), and BMI (≥ 30 Kg/m²) were strongly associated with higher birth weights (>3.0 kg). Conversely, non-anthropometric maternal factors, including age ($p=0.685$), socioeconomic status ($p=0.909$), parity ($p=0.800$), mode of delivery ($p=0.512$), gestational age ($p=0.132$), and maternal height ($p=0.102$), showed no statistically significant association with neonatal birth weight categories.

Pearson correlation analysis demonstrated a statistically significant positive correlation between neonatal birth weight and maternal third-trimester weight ($r=0.516$, $p<0.001$), mid-upper arm circumference (MUAC; $r=0.439$, $p<0.001$), and gestational age ($r=0.235$, $p=0.003$). Conversely, no statistically significant correlation was observed between neonatal birth weight and maternal age ($r=0.032$, $p=0.690$) or maternal height ($r=-0.138$, $p=0.082$).

Table 3: Categorical distribution of neonatal demographic and anthropometric characteristics (n=160).

Parameters	Category	Number	Percentage
Gender	Male	87	54.4
	Female	73	45.6
Birth weight (kg)	<2.5	10	6.3
	2.5-3	133	83.1
	>3	17	10.6
Length (cm)	<45	21	13.1
	45-48	130	81.3
	>48	9	5.6
Head circumference (cm)	<35	149	93.1
	≥ 35	11	6.9

*statistically significant.

Table 4: Association between maternal parameters and neonatal birth weight categories (n=160).

Maternal parameters	Category	Neonatal Birth weight categories (%)			χ^2 values	P value
		<2.5 kg (n=10)	2.5-3 kg (n=133)	>3 kg (n=17)		
Age (years)	<25	5 (50.0)	47 (35.3)	4 (23.5)	2.276	0.685
	25-29	3 (30.0)	62 (46.6)	9 (52.9)		
	≥ 30	2 (20.0)	24 (18.0)	4 (23.5)		
Socioeconomic Status	Upper	0 (0.0)	6 (4.5)	2 (11.8)	3.368	0.909
	Upper middle	2 (20.0)	19 (14.3)	3 (17.6)		
	Lower middle	2 (20.0)	35 (26.3)	3 (17.6)		
	Upper lower	4 (40.0)	54 (40.6)	6 (35.3)		
	Lower	2 (20.0)	19 (14.3)	3 (17.6)		
Parity	Primipara	3 (30.0)	54 (40.6)	7 (41.2)	0.447	0.80
	Multipara	7 (70.0)	79 (59.4)	10 (58.8)		
Mode of delivery	LSCS	6 (60.0)	82 (61.7)	8 (47.1)	1.338	0.512
	Vaginal	4 (40.0)	51 (38.3)	9 (52.9)		
Gestational age (weeks)	37-38	7 (70.0)	81 (60.9)	8 (47.1)	7.038	0.132
	39-40	3 (30.0)	47 (35.3)	6 (35.3)		
	41-42	0 (0.0)	5 (3.8)	3 (17.6)		
Third trimester weight (kg)	<50	2 (20.0)	5 (3.8)	2 (11.8)	37.78	<0.001
	50-60	8 (80.0)	111 (83.5)	4 (23.5)		
	>60	0 (0.0)	17 (12.8)	11 (64.7)		
MUAC (cm)	≤ 23.5	4 (40.0)	10 (7.5)	0 (0.0)	36.253	<0.001
	>23.5-29.4	6 (60.0)	92 (69.2)	4 (23.5)		
	≥ 29.5	0 (0.0)	31 (23.3)	13 (76.5)		
Height (cm)	<150	2 (20.0)	46 (34.6)	8 (47.1)	7.723	0.102
	150-160	1 (10.0)	45 (33.8)	5 (29.4)		
	>160	7 (70.0)	42 (31.6)	4 (23.5)		
BMI (kg/m²)	<18.5	1 (10.0)	3 (2.3)	1 (5.9)	44.404	<0.001
	18.5-<25	8 (80.0)	80 (60.2)	4 (23.5)		
	25-<30	1 (10.0)	45 (33.8)	4 (23.5)		
	≥ 30	0 (0.0)	5 (3.8)	8 (47.1)		

* χ^2 =Chi-square test; LSCS: lower segment cesarean section; MUAC: mid-upper arm circumference; BMI: body mass index; Data presented as N (%); $p<0.05$ considered statistically significant.

Table 5: Association between maternal parameters and neonatal length categories (n=160).

Maternal parameters	Category	Neonatal Length Categories			χ^2 values	P value
		<45 cm n=21	45-48 cm n=130	>48 cm n=9		
Age (years)	<25	14 (66.7)	39 (30.0)	3 (33.3)	11.688	0.020
	25-29	6 (28.6)	63 (48.5)	5 (55.6)		
	≥30	1 (4.8)	28 (21.5)	1 (11.1)		
Socioeconomic Status	Upper	1 (4.8)	5 (3.8)	2 (22.2)	10.539	0.229
	Upper middle	2 (9.5)	20 (15.4)	2 (22.2)		
	Lower middle	8 (38.1)	32 (24.6)	0 (0.0)		
	Upper lower	7 (33.3)	53 (40.8)	4 (44.4)		
	Lower	3 (14.3)	20 (15.4)	1 (11.1)		
Parity	Primipara	7 (33.3)	55 (42.3)	2 (22.2)	1.863	0.394
	Multipara	14 (66.7)	75 (57.7)	7 (77.8)		
Mode of delivery	LSCS	17 (81.0)	75 (57.7)	4 (44.4)	5.037	0.081
	Vaginal	4 (19.0)	55 (42.3)	5 (55.6)		
Gestational age (weeks)	37-38	19 (90.5)	73 (56.2)	4 (44.4)	14.928	0.005
	39-40	2 (9.5)	51 (39.2)	3 (33.3)		
	41-42	0 (0.0)	6 (4.6)	2 (22.2)		
Third trimester weight (kg)	<50	1 (4.8)	8 (6.2)	0 (0.0)	47.829	<0.001
	50-60	20 (95.2)	103 (79.2)	0 (0.0)		
	>60	0 (0.0)	19 (14.6)	9 (100.0)		
MUAC (cm)	≤23.5	6 (28.6)	8 (6.2)	0 (0.0)	36.641	<0.001
	>23.5-29.4	12 (57.1)	90 (69.2)	0 (0.0)		
	≥29.5	3 (14.3)	32 (24.6)	9 (100.0)		
Height (cm)	<150	5 (23.8)	47 (36.2)	4 (44.4)	2.974	0.562
	150-160	6 (28.6)	43 (33.1)	2 (22.2)		
	>160	10 (47.6)	40 (30.8)	3 (33.3)		
BMI (kg/m ²)	<18.5	1 (4.8)	4 (3.1)	0 (0.0)	49.356	<0.001
	18.5-<25	17 (81.0)	74 (56.9)	1 (11.1)		
	25-<30	3 (14.3)	45 (34.6)	2 (22.2)		
	≥30	0 (0.0)	7 (5.4)	6 (66.7)		

*P<0.05 considered statistically significant.

Bivariate analysis showed a highly significant association between neonatal length categories and maternal third-trimester weight ($\chi^2=47.829$, $p<0.001$), MUAC ($\chi^2=36.641$, $p<0.001$), and BMI ($\chi^2=49.356$, $p<0.001$) (Table 5). Neonatal length >48 cm was overwhelmingly observed in mothers with higher weight (>60 kg), larger MUAC (≥29.5 cm), and obese BMI (≥30 kg/m²). Additionally, maternal age ($\chi^2=11.688$, $p=0.020$) and gestational age ($\chi^2=14.928$, $p=0.005$) demonstrated statistically significant associations with neonatal length, with younger maternal age (<25 years) and earlier term gestational age (37-38 weeks) accounting for the vast majority of neonates measuring <45 cm. Socioeconomic status, parity, mode of delivery, and maternal height showed no statistically significant association with neonatal length (all $p>0.05$).

Pearson correlation analysis demonstrated a strong, statistically significant positive correlation between neonatal crown-heel length and maternal third-trimester weight ($r=0.668$, $p<0.001$), mid-upper arm circumference (MUAC; $r=0.485$, $p<0.001$), and gestational age ($r=0.363$,

$p<0.001$). In contrast, no statistically significant correlation was observed between neonatal length and maternal age ($r=0.042$, $p=0.599$) or maternal height ($r=0.092$, $p=0.249$).

Bivariate analysis indicated a highly significant association between neonatal head circumference categories and maternal third-trimester weight ($\chi^2=35.235$, $p<0.001$), MUAC ($\chi^2=17.554$, $p<0.001$), and BMI ($\chi^2=69.456$, $p<0.001$) (Table 6). A neonatal head circumference >35 cm was significantly more prevalent among infants born to mothers with higher third-trimester weight (>60 kg; $n=9$, 81.8%), higher MUAC (≥29.5 cm; $n=9$, 81.8%), and obese BMI (≥30 kg/m²; $n=8$, 72.7%). In contrast, non-anthropometric parameters including maternal age, socioeconomic status, parity, mode of delivery, gestational age, and maternal height showed no statistically significant association with neonatal head circumference (all $p>0.05$).

Pearson correlation analysis demonstrated a robust, statistically significant positive correlation between neonatal head circumference and maternal third-trimester

weight ($r=0.664$, $p<0.001$), mid-upper arm circumference (MUAC; $r=0.461$, $p<0.001$), and gestational age ($r=0.292$, $p<0.001$). In contrast, no statistically significant

correlation was observed between neonatal head circumference and maternal age ($r=-0.002$, $p=0.983$) or maternal height ($r=-0.078$, $p=0.329$).

Table 6: Association between maternal parameters and neonatal head circumference categories (n=160).

Maternal parameters	Category	Neonatal head circumference categories (%)		χ^2 values	P value
		≤ 35 cm (n=149)	> 35 cm (n=11)		
Age (years)	<25	51 (34.2)	5 (45.5)	0.621	0.733
	25-29	70 (47.0)	4 (36.4)		
	≥ 30	28 (18.8)	2 (18.2)		
Socioeconomic status	Upper	6 (4.0)	2 (18.2)	5.499	0.240
	Upper middle	22 (14.8)	2 (18.2)		
	Lower middle	39 (26.2)	1 (9.1)		
	Upper lower	60 (40.3)	4 (36.4)		
	Lower	22 (14.8)	2 (18.2)		
Parity	Primipara	61 (40.9)	3 (27.3)	0.797	0.372
	Multipara	88 (59.1)	8 (72.7)		
Mode of delivery	LSCS	90 (60.4)	6 (54.5)	0.416	0.702
	Vaginal	59 (39.6)	5 (45.5)		
Gestational age (weeks)	37-38	91 (61.1)	5 (45.5)	4.528	0.104
	39-40	52 (34.9)	4 (36.4)		
	41-42	6 (4.0)	2 (18.2)		
Third trimester weight (kg)	<50	8 (5.4)	1 (9.1)	35.235	<0.001
	50-60	122 (81.9)	1 (9.1)		
	> 60	19 (12.8)	9 (81.8)		
MUAC (cm)	≤ 23.5	14 (9.4)	0 (0.0)	17.554	<0.001
	$> 23.5-29.4$	100 (67.1)	2 (18.2)		
	≥ 29.5	35 (23.5)	9 (81.8)		
Height (cm)	<150	50 (33.6)	6 (54.5)	2.164	0.339
	150-160	48 (32.2)	3 (27.3)		
	> 160	51 (34.2)	2 (18.2)		
BMI (kg/m^2)	<18.5	4 (2.7)	1 (9.1)	69.456	<0.001
	18.5-<25	92 (61.7)	0 (0.0)		
	25-<30	48 (32.2)	2 (18.2)		
	≥ 30	5 (3.4)	8 (72.7)		

* $P<0.05$ considered statistically significant.

DISCUSSION

This study evaluated the relationship between maternal anthropometric characteristics and neonatal anthropometry among 160 healthy term mother–neonate dyads. The principal finding was that maternal third-trimester weight, MUAC, and BMI were consistently associated with neonatal birth weight, length, and head circumference. In contrast, most sociodemographic characteristics showed no significant association. These findings support the importance of maternal anthropometric status in determining neonatal size and are consistent with previous studies reporting relationships between maternal and neonatal anthropometry.^{4,7,9,10,21,22}

The mean neonatal birth weight was 2.79 ± 0.24 kg, with 6.3% of neonates having birth weight < 2.5 kg. Because

the study included only healthy, full-term singleton pregnancies and excluded several important maternal complications, this proportion should not be interpreted as a population prevalence. The relatively low proportion of low-birth-weight neonates may partly reflect the selected nature of the study population. Previous Indian studies have reported a greater burden of low birth weight in broader or higher-risk populations.^{3,5}

Maternal third-trimester weight demonstrated a significant association with neonatal birth-weight categories ($\chi^2=37.780$, $p<0.001$) and showed a moderate positive correlation with birth weight ($r=0.516$, $p<0.001$). The association was also observed with neonatal length ($\chi^2=47.829$, $p<0.001$; $r=0.668$, $p<0.001$) and head circumference ($\chi^2=35.235$, $p<0.001$; $r=0.664$, $p<0.001$). These findings are consistent with previous reports demonstrating positive relationships between maternal

weight and neonatal anthropometric measurements.^{4,7,9,21,22,25} The stronger correlations with length and head circumference suggest that maternal body size in late pregnancy was related not only to fetal mass but also to linear and cranial growth. However, as noted by Graafland et al and Boucher et al, third-trimester maternal weight reflects cumulative gestational weight gain and fluid volume changes, and therefore cannot be considered fully equivalent to pre-pregnancy baseline nutritional status.^{6,16}

MUAC demonstrated similarly consistent associations and showed the strongest correlations among the maternal anthropometric measures examined. Maternal MUAC was significantly associated with birth-weight categories ($\chi^2=36.253$, $p<0.001$), neonatal length categories ($\chi^2=36.641$, $p<0.001$), and head-circumference categories ($\chi^2=17.554$, $p<0.001$). Pearson correlations were strong for birth weight ($r=0.439$, $p<0.001$), length ($r=0.485$, $p<0.001$), and head circumference ($r=0.461$, $p<0.001$). Similar relationships between maternal MUAC and neonatal anthropometry have been described previously.^{10,21,22} These findings highlight MUAC as a simple and potentially useful marker for maternal nutritional assessment during antenatal care. Nevertheless, the present study establishes association rather than predictive performance, and diagnostic measures such as sensitivity, specificity, or optimal MUAC cut-offs cannot be derived from these data.

Maternal BMI was also significantly associated with neonatal birth-weight categories ($\chi^2=44.404$, $p<0.001$), length categories ($\chi^2=49.356$, $p<0.001$), and head-circumference categories ($\chi^2=69.456$, $p<0.001$). The greater representation of higher BMI categories among neonates with larger anthropometric measurements is consistent with previous studies examining maternal BMI and newborn anthropometry.^{7,23} Studies examining maternal adiposity have similarly reported associations with infant anthropometry and perinatal outcomes.^{15,16} However, BMI measured during the third trimester is influenced by gestational weight gain and fluid changes; therefore, these findings should be interpreted as associations rather than evidence that maternal obesity directly caused greater neonatal size.

Gestational age was positively correlated with all three neonatal measurements: birth weight ($r=0.235$, $p=0.003$), length ($r=0.363$, $p<0.001$), and head circumference ($r=0.292$, $p<0.001$). It was also significantly associated with neonatal length categories ($\chi^2=14.928$, $p=0.005$), although its categorical association with birth-weight groups was not significant ($p=0.132$) or with head-circumference groups ($p>0.05$). The positive correlations are biologically consistent with progressive fetal somatic growth and skeletal lengthening during late gestation, as highlighted by Gaba et al and Asadi et al.^{4,7} Maternal age was significantly associated with neonatal length categories ($\chi^2=11.688$, $p=0.020$), but was not significantly correlated with birth weight ($r=0.032$, $p=0.690$), length

($r=0.042$, $p=0.599$), or head circumference ($r=-0.002$, $p=0.983$). This suggests that the isolated association with length should be interpreted cautiously, as supported by Tosson et al and Tyagi et al, who similarly reported that maternal age alone does not serve as an independent linear driver of neonatal body dimensions when adjusting for nutritional and physical parameters.^{9,21}

Maternal height did not show significant associations with birth weight, length, or head circumference, with Pearson correlations of $r=-0.138$ ($p=0.082$), $r=0.092$ ($p=0.249$), and $r=-0.078$ ($p=0.329$), respectively. Parity, mode of delivery, and socioeconomic status also showed no significant associations with the neonatal anthropometric outcomes (all $p>0.05$). Although maternal height and socioeconomic factors have been associated with fetal growth in some populations, their effects may vary according to population characteristics and maternal nutritional status.^{9,24} The absence of significant associations in the present study may partly reflect the relatively homogeneous and selected study population.

This study's primary strength lies in its prospective design, which minimized recall bias by capturing real-time third-trimester maternal metrics and post-delivery neonatal measurements. By enforcing strict eligibility criteria, the research successfully excluded confounding maternal medical conditions (e.g., preeclampsia, gestational diabetes) and neonatal anomalies. The evaluation relied on standardized, calibrated instruments and validated frameworks, such as the Modified Kuppaswamy Scale, to simultaneously analyze multiple physical parameters (maternal weight, BMI, MUAC) against key neonatal dimensions (birth weight, length, head circumference). Ultimately, this rigorous methodological framework yields highly reliable, actionable epidemiological data tailored specifically to maternal-fetal outcomes in a northern Indian tertiary care setting.

The study has several limitations. It was a single-center study restricted to healthy, full-term singleton pregnancies, limiting generalizability. The cross-sectional design and predominantly bivariate analysis preclude causal inference and do not account for potential confounding. Pre-pregnancy weight, early-pregnancy nutritional status, gestational weight gain, and detailed dietary intake were not incorporated into the analysis. In addition, the small numbers in extreme neonatal anthropometric categories limit interpretation of subgroup comparisons. Larger prospective multicentre studies using serial maternal anthropometry and multivariable analysis are warranted.

CONCLUSION

Maternal third-trimester weight, body mass index (BMI), and mid-upper arm circumference (MUAC) demonstrated significant, consistent positive associations with neonatal birth weight, crown-heel length, and head circumference.

While maternal weight showed the strongest overall correlations, MUAC demonstrated comparable, moderate-to-strong positive associations across all neonatal parameters. As a simple, low-cost, and non-invasive metric unaffected by gestational fluid accumulation, MUAC holds high practical value for routine antenatal nutritional surveillance and risk stratification in resource-constrained regional healthcare settings.

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