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Examining the Effects of Parental Anthropometry and Gestational Weight Gain on Neonatal Health: Evidence from Rural India

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ABSTRACT
Neonatal health, a key indicator of population health, is influenced by parental anthropometry and gestational weight gain. Understanding these influences is vital for improving neonatal outcomes, especially in rural areas of developing countries. This study explores the impact of parental anthropometric characteristics and gestational weight gain on neonatal outcomes in rural India, where neonatal mortality is a significant concern. This study was conducted in rural India, involving pregnant women aged 18-40 years attending antenatal clinics and their partners. Inclusion criteria included singleton pregnancies and willingness to participate, while exclusions were chronic illnesses affecting pregnancy outcomes and multiple pregnancies. Data collection involved structured interviews, clinical examinations and medical record reviews. Maternal and paternal anthropometry, gestational weight gain and neonatal outcomes were measured and analyzed using descriptive statistics, regression analysis and correlation analysis. Ethical approval was obtained and data were anonymized to ensure confidentiality. The study analyzed the anthropometric characteristics of both mothers and fathers during pregnancy. Mothers had a height of 152.4 cm, a pre-pregnancy weight of 52.1 kg and a BMI of 22.3 kg/m². Fathers had a height of 165.3 cm, a weight of 65.4 kg, and a BMI of 23.9 kg/m². Gestational weight gain was 11.4 kg, with a mean birth weight of 2987 g and a gestational age at delivery of 38.2 weeks. Parental anthropometry significantly influenced birth weight, with maternal height $\geq$150 cm resulting in 3060 g and paternal height $\geq$160 cm resulting in 3045 g. Neonatal morbidity was influenced by gestational weight gain. Maternal anthropometry was correlated with intrauterine growth parameters, including birth weight, length and head circumference. This study highlights significant associations between parental anthropometry and neonatal outcomes in rural India. Maternal height, BMI and gestational weight gain were positively correlated with better neonatal outcomes, emphasizing the need for targeted nutritional interventions. These findings can inform healthcare strategies to improve maternal nutrition and antenatal care in rural settings, ultimately enhancing neonatal health.

INTRODUCTION

Neonatal health is a crucial indicator of a population's overall health status and is influenced by factors such as maternal anthropometry and gestational weight gain. Understanding these influences is essential for designing interventions to improve neonatal outcomes, especially in developing countries, particularly in rural areas. Maternal anthropometry, including height, pre-pregnancy weight and BMI, has been extensively studied in relation to birth outcomes[1].

Taller maternal height is generally associated with better birth outcomes, including higher birth weights and lower preterm delivery risks. Adequate maternal pre-pregnancy weight and BMI are essential for ensuring sufficient nutritional reserves for fetal growth and development[2]. Gestational weight gain, both insufficient and excessive, has been associated with adverse neonatal outcomes, including low birth weight, preterm birth and neonatal morbidity. The interplay between maternal and paternal anthropometry provides a more comprehensive understanding of the determinants of neonatal health[3].

In India, neonatal mortality remains a significant concern, particularly in rural areas where healthcare access and quality are often limited. According to the National Family Health Survey (NFHS-5) 2019-21, the neonatal mortality rate in India is 24 per 1,000 live births, with higher rates in rural regions. Low birth weight, preterm birth and neonatal infections are leading causes of neonatal mortality and morbidity[4,5].

Maternal malnutrition and inadequate gestational weight gain are prevalent issues in rural India. The NFHS-5 reports that 19.7% of women aged 15-49 years are underweight (BMI < 18.5 kg/m²) and only 35.8% of pregnant women had adequate antenatal care. These factors contribute to the high prevalence of low birth weight and other adverse neonatal outcomes[6,7].

Previous studies have demonstrated the significant impact of maternal anthropometry on birth outcomes. A systematic review by Kramer[3] (2003) highlighted that maternal height is positively associated with birth weight and negatively associated with the risk of preterm birth. Similarly, maternal pre-pregnancy weight and BMI have been shown to influence neonatal birth weight and the risk of small-for-gestational-age (SGA) infants[2] (Han *et al.*, 2011).

This study aims to explore the impact of maternal and paternal anthropometric characteristics and gestational weight gain on neonatal outcomes in rural India. Despite the importance of these factors, there is limited research on rural populations. The findings will help healthcare providers and policymakers develop strategies to improve maternal nutrition and antenatal care, ultimately enhancing neonatal health. Interventions could include nutritional supplementation programs for underweight mothers, counseling on optimal weight gain during pregnancy, and targeted support for families at risk of adverse outcomes due to parental anthropometry.

Aims and Objectives: To evaluate the influence of parental anthropometry and gestational weight gain on intrauterine growth and neonatal outcomes in a rural Indian population.

- To assess the relationship between maternal and paternal anthropometric measurements (such as height, weight and BMI) and intrauterine growth parameters.
- To evaluate the impact of gestational weight gain on neonatal outcomes, including birth weight, gestational age at delivery and neonatal morbidity.
- To determine the combined effect of parental anthropometry and gestational weight gain on the risk of adverse neonatal outcomes, such as low birth weight and preterm birth.

MATERIALS AND METHODS

Study Design and Setting: This study was conducted in Rural India, designed to evaluate the influence of parental anthropometry and gestational weight gain on neonatal outcomes. The study was conducted in a rural setting, leveraging the local healthcare infrastructure to gather data on pregnant women and their neonates.

Study Population: The study included pregnant women attending antenatal clinics in selected rural areas and their partners.

Inclusion Criteria were:

- Pregnant women aged 18-40 years.
- Singleton pregnancies.
- Willingness to participate and provide informed consent.

Exclusion Criteria were:

- Women with pre-existing chronic illnesses affecting pregnancy outcomes (e.g., diabetes, hypertension).
- Multiple pregnancies (twins, triplets, etc.).
- Incomplete data on key anthropometric parameters or neonatal outcomes.

Data Collection: Data were collected through structured interviews, clinical examinations and medical record reviews. Trained healthcare workers conducted the interviews and clinical assessments.

Anthropometric Measurements:

- **Maternal Anthropometry:** Maternal height and pre-pregnancy weight were measured at the first antenatal visit using standardized protocols. Height was measured to the nearest 0.1 cm using a stadiometer and weight to the nearest 0.1 kg using a calibrated scale. Body Mass Index (BMI) was calculated as weight (kg) divided by height (m^2).

- **Paternal Anthropometry:** Paternal height and weight were self-reported and cross-verified with medical records when available. BMI was calculated similarly to maternal BMI.

Gestational Weight Gain: Total gestational weight gain was calculated by subtracting the pre-pregnancy weight from the weight measured at the last antenatal visit before delivery. The women were categorized into three groups based on their total gestational weight gain:

- <10 kg.
- 10-15 kg.
- >15 kg.

Neonatal Outcomes:

- **Birth Weight:** Measured to the nearest 10 grams using a calibrated digital scale within 24 hours of birth.

- **Gestational Age at Delivery:** Determined based on the last menstrual period (LMP) and confirmed by early ultrasound when available.

- **Intrauterine Growth Parameters:** Birth length and head circumference were measured within 24 hours of birth using standardized techniques.

Data Analysis:

- **Statistical Tests:** Descriptive statistics (mean, standard deviation) were used to summarize maternal and paternal anthropometric characteristics, gestational weight gain and neonatal outcomes. Independent t-tests and chi-square tests were used to compare means and proportions, respectively.

- **Regression Analysis:** Multiple linear regression models were used to assess the influence of parental anthropometry on birth weight, adjusting for potential confounders (e.g., maternal age, socioeconomic status). Logistic regression was used to analyze the association between gestational weight gain and neonatal morbidity.

- **Correlation Analysis:** Pearson correlation coefficients were calculated to examine the relationship between maternal anthropometry and intrauterine growth parameters.

Ethical Considerations: The study was approved by the Institutional Ethics Committee of the participating tertiary care center. Informed consent was obtained from all participants. Data were anonymized to ensure confidentiality and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical Software: Data were analyzed using SPSS version 25.0 (IBM). A $p<0.05$ was considered statistically significant.

RESULTS AND DISCUSSIONS

This table 1 presents the mean values and standard deviations (SD) for maternal and paternal anthropometric measurements, including height, pre-pregnancy weight and body mass index (BMI). The results show that on average, mothers had a height of 152.4 cm (SD=5.8) and a pre-pregnancy weight of 52.1 kg (SD=8.7), while fathers were taller and heavier, with a mean height of 165.3 cm (SD=7.2) and a mean weight of 65.4 kg (SD=9.3). The BMI values were 22.3 kg/m^2 (SD=3.6) for mothers and 23.9 kg/m^2 (SD=2.8) for fathers. The differences in height and pre-pregnancy weight between mothers and fathers were statistically significant ($p<0.001$) and the BMI difference also showed significance ($p=0.032$).

This table 2 highlights the mean total gestational weight gain and key neonatal outcomes. The average total gestational weight gain among the studied mothers was 11.4 kg (SD=4.2), with a range from 5-18 kg. The mean birth weight of the neonates was 2987 grams (SD=510), with a range from 2100-4100 grams. The mean gestational age at delivery was 38.2 weeks (SD=1.8), ranging from 35-41 weeks.

This table 3 illustrates the impact of parental anthropometric parameters on neonatal birth weight. Neonates born to mothers with a height of 150 cm or more had a mean birth weight of 3060 grams, with an adjusted odds ratio (OR) of 1.45 (95% CI: 1.10-1.90) and a significant p-value of 0.003. Similarly, paternal height of 160 cm or more was associated with a mean birth weight of 3045 grams, with an adjusted OR of 1.32 (95% CI: 1.05-1.66) and a p-value of 0.021. Maternal BMI of 23 kg/m^2 or more was associated with a higher mean birth weight of 3100 grams, with an adjusted OR of 1.60 (95% CI: 1.20-2.15) and a highly significant $p<0.001$.

This table 4 examines the relationship between gestational weight gain and neonatal morbidity. Neonates of mothers who gained <10 kg during

Table 1: Maternal and Paternal Anthropometric Characteristics

Parameter	Mean (SD) Maternal	Mean (SD) Paternal	p-value
Height (cm)	152.4 (5.8)	165.3 (7.2)	<0.001
Pre-pregnancy Weight (kg)	52.1 (8.7)	65.4 (9.3)	<0.001
Body Mass Index (kg/m²)	22.3 (3.6)	23.9 (2.8)	0.032

Table 2: Gestational Weight Gain and Neonatal Outcomes

Parameter	Mean (SD)	Range
Total Gestational Weight Gain (kg)	11.4 (4.2)	5 - 18
Birth Weight (g)	2987 (510)	2100 - 4100
Gestational Age at Delivery (weeks)	38.2 (1.8)	35 - 41

Table 3: Influence of Parental Anthropometry on Birth Weight

Parameter	Birth Weight (g)	Adjusted OR (95% CI)	p-value
Maternal Height = 150 cm	3060 (485)	1.45 (1.10 - 1.90)	0.003
Paternal Height = 160 cm	3045 (510)	1.32 (1.05 - 1.66)	0.021
Maternal BMI = 23 kg/m²	3100 (520)	1.60 (1.20 - 2.15)	<0.001

Table 4: Neonatal Morbidity by Gestational Weight Gain

Weight Gain Category	Neonatal Morbidity (%)	Adjusted OR (95% CI)	p-value
< 10 kg	15.2	1.75 (1.10 - 2.80)	0.018
10-15 kg	10.4	1.20 (0.80 - 1.80)	0.326
> 15 kg	8.3	0.85 (0.50 - 1.45)	0.567

Table 5: Correlation Between Maternal Anthropometry and Intrauterine Growth Parameters

Maternal Variable	Birth Weight (r)	Birth Length (r)	Head Circumference ®
Height (cm)	0.32**	0.28**	0.21**
Weight Before Pregnancy (kg)	0.25**	0.22**	0.19*
BMI Before Pregnancy (kg/m²)	0.27**	0.23**	0.20**
Gestational Weight Gain (kg)	0.45**	0.40**	0.35**

**p < 0.05, **p < 0.01

pregnancy had a morbidity rate of 15.2%, with an adjusted OR of 1.75 (95% CI: 1.10-2.80) and a significant p-value of 0.018. For mothers who gained between 10 and 15 kg, the neonatal morbidity rate was 10.4%, with an adjusted OR of 1.20 (95% CI: 0.80-1.80) and a p-value of 0.326, indicating no significant association. Neonates of mothers who gained more than 15 kg had a morbidity rate of 8.3%, with an adjusted OR of 0.85 (95% CI: 0.50-1.45) and a p-value of 0.567, also indicating no significant association.

This table 5 provides correlation coefficients (r) between various maternal anthropometric measurements and intrauterine growth parameters, including birth weight, birth length and head circumference. Maternal height showed a significant positive correlation with birth weight (r=0.32, p<0.01), birth length (r=0.28, p<0.01), and head circumference (r=0.21, p<0.05). Pre-pregnancy weight also correlated positively with birth weight (r=0.25, p<0.01), birth length (r=0.22, p<0.01) and head circumference (r=0.19, p<0.05). Similarly, maternal BMI before pregnancy had significant positive correlations with birth weight (r=0.27, p<0.01), birth length (r=0.23, p<0.01) and head circumference (r=0.20, p<0.05). Gestational weight gain showed the strongest positive correlations with birth weight (r=0.45, p<0.01), birth length (r=0.40, p<0.01) and head circumference (r=0.35, p<0.01).

The present study investigates the influence of parental anthropometry and gestational weight gain on neonatal health outcomes in a rural Indian cohort. Our findings demonstrate significant associations between both maternal and paternal anthropometric characteristics and neonatal birth weight, as well as the impact of gestational weight gain on neonatal morbidity and intrauterine growth parameters.

Parental Anthropometry and Neonatal Birth Weight: Our results indicate that maternal height, BMI and pre-pregnancy weight significantly correlate with higher birth weights. Neonates born to mothers with a height of ≥150 cm had a higher mean birth weight (3060 g) compared to those born to shorter mothers, with an adjusted odds ratio (OR) of 1.45. Similarly, maternal BMI ≥23 kg/m² was associated with higher neonatal birth weights (3100 g), with an adjusted OR of 1.60. These findings are consistent with previous studies, which have shown that maternal height and BMI are critical determinants of fetal growth and birth weight[8].

Paternal height also showed a significant association with neonatal birth weight, where neonates born to fathers with a height of ≥160 cm had a higher mean birth weight (3045 g), with an adjusted OR of 1.32. This supports existing literature that suggests paternal height may contribute to fetal growth potential, possibly due to genetic factors[9,10].

Gestational Weight Gain and Neonatal Outcomes: Gestational weight gain was found to be a critical factor affecting neonatal morbidity. Mothers who gained less than 10 kg during pregnancy had a significantly higher neonatal morbidity rate (15.2%) compared to those who gained more weight. This is in line with studies indicating that inadequate gestational

weight gain is associated with adverse neonatal outcomes, including low birth weight and higher morbidity rates[11,12]. However, gaining >15 kg did not significantly reduce neonatal morbidity, suggesting that optimal weight gain, rather than excessive weight gain, is crucial for favorable neonatal outcomes.

Correlation Between Maternal Anthropometry and Intrauterine Growth Parameters: We observed significant positive correlations between maternal anthropometric measures and intrauterine growth parameters such as birth weight, birth length, and head circumference. Maternal height, pre-pregnancy weight and BMI were all positively correlated with these parameters, with the strongest correlation observed between gestational weight gain and birth weight (r=0.45). These findings corroborate previous research demonstrating the importance of maternal nutritional status and weight gain during pregnancy on fetal growth and development[13].

Comparison with Previous Studies: Our study's findings align with those from previous research, highlighting the critical role of maternal and paternal anthropometry in determining neonatal birth weight and the impact of gestational weight gain on neonatal health. For instance, a study by Kramer[14] similarly found that maternal height and BMI were significant predictors of birth weight, emphasizing the importance of maternal nutrition and health during pregnancy. Additionally, a meta-analysis by Yu[15]. (2013) reported that low gestational weight gain was associated with increased risks of preterm birth and low birth weight, reinforcing our findings regarding neonatal morbidity.

Limitations: Our study has several limitations. Firstly, the cohort is limited to a rural Indian population, which may not be generalizable to other populations with different sociodemographic characteristics. Secondly, the self-reported pre-pregnancy weight and height could introduce recall bias. Thirdly, other factors influencing neonatal outcomes, such as maternal nutrition, physical activity and socioeconomic status, were not controlled for in this study.

CONCLUSION

Our study underscores the critical role of parental anthropometry and gestational weight gain in influencing intrauterine growth and neonatal outcomes. Specifically, maternal height, pre-pregnancy weight and BMI were positively correlated with birth weight, length and head circumference. Adequate gestational weight gain was associated with favorable neonatal outcomes, whereas insufficient weight gain (<10 kg) increased the risk of neonatal morbidity. These findings highlight the importance of monitoring and supporting appropriate gestational weight gain and considering parental anthropometry in prenatal care.

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