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STUDY OF DIETARY MODIFICATIONS ON FETAL WEIGHT DURING PREGNANCY AND ITS BIRTH OUTCOMES

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Abstract

Background: Low birth weight (LBW) and poor maternal weight gain during pregnancy are significant public health concerns, particularly in low-resource settings like rural India. Nutritional interventions during pregnancy may help improve these outcomes. This study aimed to evaluate the effect of dietary modifications on maternal weight gain, fetal birth weight, and neonatal outcomes. **Materials and Methods:** A total of 290 pregnant women were enrolled in a randomized controlled trial, with 143 in the intervention group and 147 in the control group. The intervention group received targeted dietary guidance starting in the first trimester, while the control group followed standard antenatal care. Nutritional intake was assessed at baseline, mid-pregnancy, and late pregnancy using a 24-hour dietary recall. Maternal and neonatal outcomes, including birth weight, maternal weight gain, and the incidence of low birth weight, were analyzed using multivariate regression. **Result:** Women in the intervention group had significantly higher total maternal weight gain (12.7 ± 3.1 kg vs. 11.0 ± 3.0 kg, p=0.001) and mean birth weight (3122.7 ± 440.4 g vs. 2871.9 ± 472.6 g, p=0.001) compared to the control group. The incidence of LBW was significantly lower in the intervention group (10.5% vs. 22.4%, p=0.009). Nutritional intake, particularly protein, iron, and folic acid, increased significantly in the intervention group throughout pregnancy. No significant differences were observed in preterm birth rates (p=0.097) or cesarean delivery rates (p=0.372). **Conclusion:** Dietary modifications during pregnancy positively impacted maternal and neonatal outcomes, particularly by increasing birth weight and reducing the incidence of LBW. Nutritional interventions should be considered a critical component of antenatal care, particularly in low-resource settings, to improve pregnancy outcomes.

INTRODUCTION

Maternal nutrition plays a vital role in determining fetal growth and birth outcomes. Proper dietary intake during pregnancy is essential for maternal health, optimal fetal development, and a healthy birth weight. Both undernutrition and overnutrition during pregnancy can result in adverse outcomes, including low birth weight (LBW), preterm birth, and macrosomia, which can predispose infants to long-term developmental issues, metabolic diseases, and increased perinatal morbidity and mortality.[1]

Globally, LBW (birth weight less than 2,500 grams) remains a significant public health challenge, affecting 15-20% of all live births, with a majority of cases occurring in developing countries.[2] In India, the prevalence of LBW is estimated to be around 18-30%, depending on the region.[3] This is largely attributed to maternal malnutrition, which affects approximately 20-40% of pregnant women.[4] The National Family Health Survey (NFHS-5) reports that over 50% of women of reproductive age in India suffer from anemia, a condition that further exacerbates the risk of adverse pregnancy outcomes such as intrauterine growth restriction (IUGR) and preterm labor.[5] Additionally, maternal overweight and obesity, which have been rising in urban and rural areas, increase the likelihood of macrosomia, a condition linked to complicated deliveries, postpartum hemorrhage, and future metabolic disorders in the child.[6] Mechanistically, fetal weight is primarily influenced by maternal nutrient intake, which supplies the necessary substrates for fetal growth through the placenta. The placenta acts as a mediator of nutrient transfer, regulating glucose, amino acids, and fatty acid availability to the fetus.[7] Macronutrients (carbohydrates, proteins, and fats) and micronutrients (iron, calcium, folic acid, and vitamins) play distinct roles in fetal development. For instance, maternal protein intake affects fetal muscle growth, while carbohydrates are essential for energy production and fetal tissue development.[8] Micronutrient deficiencies, such as low iron and folic acid levels, are directly linked to poor fetal growth, contributing to conditions like anemia and neural tube defects, respectively.[9] Several studies have demonstrated the impact of dietary interventions on pregnancy outcomes. A systematic review of randomized controlled trials indicated that balanced energy and protein supplementation during pregnancy led to a significant reduction in the incidence of LBW by up to 31%.[10] Moreover, a meta-analysis reported that micronutrient supplementation, particularly with iron and folic acid, decreased the risk of preterm birth by 14% and improved fetal growth.[11] However, these findings often vary depending on the population and geographical setting, highlighting the need for context-specific studies.[12] In India, where dietary patterns are shaped by socio-economic, cultural, and regional factors, many pregnant women face challenges in meeting their nutritional needs.[13] This is particularly true in rural areas, where access to nutrient-rich foods may be limited, and traditional diets may lack essential nutrients. Furthermore, cultural practices, such as dietary restrictions during pregnancy, can further exacerbate nutrient deficiencies.[14] Thus, dietary modifications tailored to the specific needs of pregnant women, particularly in resource-limited settings, have the potential to significantly improve fetal outcomes and reduce the incidence of LBW and other complications.[15]

The objective of this study was to assess the impact of specific dietary modifications on fetal weight and birth outcomes in pregnant women. By providing insights into the relationship between maternal nutrition and fetal growth, this study aimed to contribute to the development of evidence-based dietary guidelines for improving pregnancy outcomes, especially in rural settings where the burden of malnutrition is high.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective cohort study conducted under the department of Obstetrics and Gynaecology at a tertiary care hospital in North India, for a period of One year from September 2023 to August 2024. The study population comprised pregnant women attending antenatal clinics, who were followed from their first trimester until delivery. The study aimed to evaluate the impact of dietary modifications on fetal weight and birth outcomes.

Study Population

A total of 313 pregnant women aged between 18 and 35 years were enrolled in the study. Participants were included if they were in their first trimester (up to 12 weeks of gestation), carrying a singleton pregnancy, and willing to adhere to the prescribed dietary modifications. Women with pre-existing medical conditions, such as diabetes, hypertension, thyroid disorders, or those carrying multiple pregnancies, were excluded from the study. Additionally, women with a history of pregnancy complications, such as recurrent miscarriage or preterm birth, or those who were on strict dietary regimens due to other medical conditions, were also excluded to ensure a homogenous study population.

Sample Size Calculation

The sample size was calculated using an estimated prevalence of low birth weight (LBW) in India at 24%, with a desired precision of 5% and a 95% confidence level. Using the formula for sample size estimation in proportions: $n=Z^2 P(1-P)/d^2$; where Z = 1.96, P = 0.24, and d = 0.05, the initial sample size was 281. Adjusting for a 10% dropout rate, the final sample size required was 316 participants.

Study Intervention

Participants were divided into two groups: Intervention Group (n=158): This group received tailored dietary advice aimed at improving fetal growth. The diet plan was designed by a certified dietitian and included increased intake of macronutrients (proteins, carbohydrates, fats) and micronutrients (iron, calcium, folic acid, and vitamins) as per national dietary guidelines for pregnant women. Nutrient-dense foods such as fruits, vegetables, legumes, dairy products, and whole grains were emphasized. Iron and folic acid supplements were provided according to standard antenatal care guidelines. Control Group (n=158): This group received standard antenatal care without specific dietary modifications. They were advised to follow routine dietary practices based on their individual preferences.

Dietary Assessment

Nutritional intake was assessed using a 24-hour dietary recall method at three time points: baseline (first trimester), mid-pregnancy (second trimester), and late pregnancy (third trimester). Participants were asked to recall all foods and beverages consumed in the past 24 hours, including portion sizes and preparation methods. The dietary data were analyzed using Nutritionist Pro software to estimate daily intake of macronutrients (proteins, carbohydrates, and fats) and micronutrients (iron, calcium, folic acid, vitamins, etc.). Nutrient intake was compared between the intervention and control groups at each time point to assess the effect of dietary modifications on overall nutrient consumption. Compliance with the dietary intervention was monitored through follow-up interviews and dietary logs.

Outcome Measures

The primary outcome measure was fetal weight at birth. Secondary outcomes included birth outcomes such as gestational age at delivery, incidence of low birth weight (defined as birth weight < 2,500 grams), preterm birth (defined as delivery before 37 weeks of gestation), and macrosomia (birth weight > 4,000 grams).

Data Collection and Measurement

Fetal weight was measured using a calibrated digital weighing scale immediately after birth. Gestational age was determined based on the last menstrual period (LMP) and confirmed through early ultrasound. Maternal weight gain during pregnancy was recorded at each antenatal visit using a standard weighing scale. Information on maternal dietary intake, compliance with the dietary intervention, and socio-demographic factors (age, education, socioeconomic status) was collected through structured interviews and questionnaires.

Statistical Analysis

Descriptive statistics were used to summarize the baseline characteristics of the study population. Continuous variables, such as birth weight and gestational age, were compared between the two groups using an independent t-test or Mann-Whitney U test, depending on data normality. Categorical variables, such as the incidence of LBW and preterm birth, were compared using chi-square tests. A multivariate regression analysis was performed to assess the independent effect of dietary modifications on birth weight, adjusting for potential confounding factors such as maternal age, parity, and socioeconomic status. A p-value of < 0.05 was considered statistically significant. All analyses were conducted using SPSS version 20.0.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee of tertiary care hospital. Written informed consent was obtained from all participants prior to enrollment. All participants were assured of confidentiality and were free to withdraw from the study at any time without any impact on their standard medical care.

RESULTS

In our study, the initial sample size was determined to be 158 participants for both the intervention and control groups. However, due to various factors such as participant dropout and non-compliance, the final sample size comprised 143 participants in the intervention group and 147 in the control group. The baseline characteristics of the study population were similar between the intervention group (n=143) and control group (n=147). The mean maternal age (26.4 ± 3.9 vs. 25.8 ± 4.2 years, p=0.421), gestational age at enrollment (9.1 ± 1.4 vs. 9.4 ± 1.6 weeks, p=0.317), and pre-pregnancy BMI (22.5 ± 2.8 vs. 23.8 ± 2.7 kg/m², p=0.522) showed no significant differences. Socioeconomic status (p=0.682), education level (p=0.551), and parity (p=0.739) were also comparable between the two groups [Table 1].

There was a significant increase in nutrient intake across pregnancy. Energy intake rose from 1752.1 ± 312.3 kcal/day at baseline to 2333.1 ± 289.2 kcal/day by late pregnancy (p=0.001). Protein intake increased from 52.2 ± 9.4 g/day to 78.9 ± 12.4 g/day (p=0.002), while carbohydrate intake rose from 210.6 ± 45.5 g/day to 319.0 ± 44.1 g/day (p=0.004). Fat intake also increased, from 45.9 ± 15.1 g/day to 70.4 ± 12.5 g/day (p=0.012). Iron, calcium, and folic acid intake similarly showed significant increases (p=0.001 to 0.002) as pregnancy progressed [Table 2].

The intervention group had a significantly higher total maternal weight gain compared to the control group (12.7 ± 3.1 kg vs. 11.0 ± 3.0 kg, p=0.001). Gestational age at delivery was similar between the groups (38.4 ± 1.3 weeks vs. 38.1 ± 1.5 weeks, p=0.153). Preterm birth rates were lower in the intervention group (6.3% vs. 11.6%, p=0.097), though not statistically significant. Cesarean delivery rates (37.1% vs. 41.5%, p=0.372) and postpartum hemorrhage rates (2.8% vs. 5.4%, p=0.267) were also comparable between the groups [Table 3].

The intervention group had a significantly higher mean birth weight compared to the control group (3122.7 ± 440.4 g vs. 2871.9 ± 472.6 g, p=0.001). The incidence of low birth weight was significantly lower in the intervention group (10.5% vs. 22.4%, p=0.009). There was no significant difference in macrosomia rates (4.9% vs. 3.4%, p=0.497) or Apgar scores at 1 minute (p=0.211) and 5 minutes (p=0.068). Neonatal ICU admissions were also comparable between the groups (6.3% vs. 9.5%, p=0.325) [Table 4].

The multivariate analysis showed that the dietary intervention was significantly associated with better birth outcomes, with an adjusted odd ratio (AOR) of 1.9 (95% CI: 1.3–2.8, p=0.003), indicating that women in the intervention group were nearly twice as likely to have favorable outcomes. Pre-pregnancy BMI below 18.5 kg/m² was also a significant predictor, with an AOR of 1.4 (95% CI: 1.1–1.7, p=0.019), suggesting increased risk in underweight women. Other variables, including maternal age, gestational age at delivery, parity, and socioeconomic status, did not show significant associations with birth outcomes (p>0.05) [Table 5].

Table 1: Baseline Characteristics of Study Population.

Variables	Intervention Group (n=143)	Control Group (n=147)	p-value
	Frequency (%)/mean ± SD		
Maternal Age (years)	26.4 ± 3.9	25.8 ± 4.2	0.421
Gestational Age at Enrollment (weeks)	9.1 ± 1.4	9.4 ± 1.6	0.317
Pre-pregnancy BMI (kg/m²)	22.5 ± 2.8	23.8 ± 2.7	0.522
Socioeconomic Status			
Lower	64 (48.9%)	69 (51.1%)	0.682
Middle	57 (47.9%)	62 (52.1%)	
Higher	22 (57.9%)	16 (42.1%)	
Education Level			

Illiterate	50 (50.5%)	49 (49.5%)	0.551
Primary/Secondary	64 (46.4%)	74 (53.6%)	
Higher or above	29 (54.7%)	24 (45.3%)	
Parity			
Nulliparous	72 (50.3%)	71 (49.7%)	0.739
Multiparous	71 (48.3%)	76 (51.7%)	

Table 2: Dietary Intake Comparison Between Groups.

Nutrient	Baseline	Mid-pregnancy	Late-pregnancy	p-value
	mean ± SD			
Energy (kcal/day)	1752.1 ± 312.3	2133.4 ± 254.5	2333.1 ± 289.2	0.001
Protein (g/day)	52.2 ± 9.4	62.3 ± 11.4	78.9 ± 12.4	0.002
Carbohydrates (g/day)	210.6 ± 45.5	270.1 ± 54.8	319.0 ± 44.1	0.004
Fat (g/day)	45.9 ± 15.1	55.3 ± 11.9	70.4 ± 12.5	0.012
Iron (mg/day)	18.3 ± 4.3	26.4 ± 5.7	32.7 ± 6.3	0.001
Calcium (mg/day)	854.9 ± 122.8	1123.7 ± 134.8	1311.3 ± 150.2	0.002
Folic Acid (mcg/day)	342.0 ± 71.5	488.2 ± 84.8	601.9 ± 100.1	0.001

Table 3: Maternal Weight Gain and Pregnancy Outcomes.

Variable	Intervention Group (n=143)	Control Group (n=147)	p-value
	Frequency (%)/mean ± SD		
Total Maternal Weight Gain (kg)	12.7 ± 3.1	11.0 ± 3.0	0.001
Gestational Age at Delivery (weeks)	38.4 ± 1.3	38.1 ± 1.5	0.153
Preterm Birth	9 (6.3%)	17 (11.6%)	0.097
Cesarean Delivery	53 (37.1%)	61 (41.5%)	0.372
Postpartum Hemorrhage	4 (2.8%)	8 (5.4%)	0.267

Table 4: Fetal and Neonatal Outcomes.

Outcome	Intervention Group (n=143)	Control Group (n=147)	p-value
	Frequency (%)/mean ± SD		
Birth Weight (grams)	3122.7 ± 440.4	2871.9 ± 472.6	0.001
Low Birth Weight	15 (10.5%)	33 (22.4%)	0.009
Macrosomia	7 (4.9%)	5 (3.4%)	0.497
Apgar Score at 1 min	7.8 ± 0.8	7.6 ± 1.0	0.211
Apgar Score at 5 min	8.6 ± 0.7	8.3 ± 0.8	0.068
Neonatal ICU Admission	9 (6.3%)	14 (9.5%)	0.325

Table 5: Multivariate Analysis of Predictors of Birth Weight

Variable	Adjusted Odds Ratio (95% CI)	p-value
Dietary Intervention	1.9 (1.3–2.8)	0.003
Maternal Age (<20 years)	1.1 (0.9–1.4)	0.217
Pre-pregnancy BMI (<18.5 kg/m2)	1.4 (1.1–1.7)	0.019
Gestational Age at Delivery (Preterm)	1.2 (0.9–1.5)	0.154
Parity (Nulliparous)	0.9 (0.8–1.1)	0.367
Socioeconomic Status (Lower)	1.1 (0.9–1.5)	0.341

DISCUSSION

This study demonstrated that dietary modifications during pregnancy significantly improved maternal and neonatal outcomes. Women in the intervention group exhibited a higher mean birth weight (3122.7 ± 440.4 g) compared to the control group (2871.9 ± 472.6 g, p=0.001). This aligns with findings from the study by Nguyen et al., where nutritional interventions during pregnancy were associated with increased birth weights.[16] For instance, a randomized controlled trial in rural India reported a significant increase in mean birth weight following a targeted dietary intervention, supporting our results.[17]

The lower incidence of low birth weight (LBW) in the intervention group (10.5% vs. 22.4%, p=0.009) is noteworthy. LBW is a significant public health concern in India, where its prevalence is estimated at 18-30%.[18] Our findings suggest that appropriate nutritional interventions can halve the risk of LBW, which could have long-term benefits in reducing neonatal morbidity and mortality. This is consistent with a meta-analysis by Imdad et al., which found that balanced protein-energy supplementation during pregnancy reduced the incidence of LBW by 32%.[19]

The positive impact of the dietary intervention on maternal weight gain (12.7 ± 3.1 kg vs. 11.0 ± 3.0 kg, p=0.001) is consistent with recommendations by the Institute of Medicine, which associates adequate gestational weight gain with improved fetal growth.[20] Inadequate maternal weight gain is often linked with poor fetal outcomes, including intrauterine growth restriction, which was mitigated in our intervention group. This supports the notion that ensuring adequate macronutrient intake, particularly protein and energy, during pregnancy is crucial for optimal fetal development.[21]

The significant association between pre-pregnancy BMI and birth outcomes is another key finding. Women with a BMI below 18.5 kg/m² had a 1.4-fold

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increased risk of adverse outcomes (AOR 1.4, 95% CI: 1.1–1.7, p=0.019). This result is in line with several studies that have reported an increased risk of LBW, preterm birth, and poor fetal growth in underweight women.[22,23] Maternal undernutrition is prevalent in India, particularly among low-income populations, and our findings reinforce the need for pre-conception nutritional interventions to address underweight among women of reproductive age.[24]

Despite these positive outcomes, the dietary intervention did not significantly affect the rates of preterm birth (6.3% vs. 11.6%, p=0.097) or cesarean delivery (37.1% vs. 41.5%, p=0.372), similar to findings from the study by Wang et al..[25] This may suggest that while nutritional interventions can improve fetal growth and birth weight, factors such as maternal health conditions and obstetric history play a larger role in determining the mode and timing of delivery.[26]

Interestingly, while the Apgar scores at 1 minute and 5 minutes were slightly higher in the intervention group, these differences were not statistically significant. However, the higher nutritional intake, particularly of folic acid and iron, may have contributed to better neonatal outcomes, as these nutrients are known to reduce the risk of neural tube defects and anemia.[27] Our study observed significant increases in nutrient intake across pregnancy in the intervention group, particularly for energy, protein, iron, calcium, and folic acid, which aligns with the increased requirements during gestation to support fetal growth.[28]

In comparison to previous studies, such as the one conducted by Rao et al., which showed similar improvements in birth weight following dietary interventions, our study adds to the growing evidence that targeted nutritional programs can effectively improve pregnancy outcomes in rural and low-resource settings.[29] However, variations in outcomes such as preterm birth and mode of delivery across different studies highlight the complex interplay of nutritional, genetic, and environmental factors influencing pregnancy outcomes.

Limitations

This study had several limitations. First, the reliance on self-reported dietary intake may have introduced recall bias. Additionally, the study was conducted in a single rural region, limiting the generalizability of the findings to other populations. While we adjusted for key confounders, unmeasured factors such as genetic predispositions or environmental influences could have impacted the outcomes. Finally, the study's follow-up period was limited to the immediate postnatal phase, preventing us from assessing long-term maternal and neonatal health impacts.

CONCLUSION

This study demonstrates that targeted dietary modifications during pregnancy significantly improve maternal weight gain and neonatal outcomes, particularly by increasing birth weight and reducing the incidence of low birth weight. These findings highlight the importance of adequate nutritional support for pregnant women, especially in low-resource settings, to optimize fetal growth and maternal health. Implementing such interventions on a broader scale could contribute to reducing neonatal morbidity and mortality. However, further research is needed to explore the long-term effects of dietary interventions on maternal and child health outcomes.

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