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Dietary macronutrient composition and perinatal outcomes according to pre-pregnancy BMI

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ABSTRACT

Aims: Dietary habits and nutritional balance during pregnancy have been linked to maternal and neonatal well-being. This study aimed to compare the quantity and distribution of dietary macronutrient intake among pregnant women with varying pre-pregnancy body-mass index (BMI) categories, to evaluate their nutritional habits, and to explore the potential impact of these factors on perinatal outcomes.

Methods: This study was designed as a prospective cohort with retrospective collection of baseline data included 120 pregnant women between 24-28 weeks of gestation who underwent an oral glucose tolerance test. Participants were divided into two groups based on pre-pregnancy BMI: those with a BMI between 18.5 and 24.9 kg/m^2, classified as having normal weight, and those with a BMI between 30 and 39.9 kg/m^2, classified as having obesity. Women diagnosed with gestational diabetes, impaired glucose tolerance, or pre-existing metabolic disorders were excluded. Daily dietary intake was assessed using 72-hour food diaries, which included detailed information on the timing and content of six daily meals (three main and three snacks), the types and amounts of foods and beverages consumed, preparation methods, and the location of each meal. Perinatal outcomes, including gestational age at delivery, birth weight, Apgar scores, and neonatal intensive care unit (NICU) admission, were recorded and compared between groups.

Results: Sixty participants were included in each group. The mean daily energy intake was higher among women with obesity (2117.1 kcal vs. 2004.6 kcal), with a significantly greater proportion of energy derived from carbohydrates (51.7% vs. 44.6%; p=0.026). Weight gain during pregnancy was significantly higher in women with obesity across all trimesters. Based on participants' self-reports, physical activity levels decreased with advancing gestation in both groups, though the difference between groups was not statistically significant. No significant differences were observed in gestational age at delivery, birth weight, or Apgar scores. However, NICU admission was more frequent among women with obesity (9 cases vs. 2 cases; p=0.046).

Conclusion: Pregnant women with higher pre-pregnancy BMI demonstrated greater carbohydrate intake and increased weight gain throughout pregnancy, potentially indicating elevated metabolic risk. Balanced macronutrient intake and early monitoring of gestational weight gain may be essential components of antenatal care. Larger prospective studies are needed to validate these findings and support tailored nutritional interventions in this population.

Keywords: Dietary proteins, maternal obesity, weight gain

INTRODUCTION

Obesity is recognized as one of the most significant public health challenges of the 21st century.[1] According to the World Health Organization (WHO), by 2024, approximately 43% of the global adult population was classified as overweight [body mass index (BMI): 25-29.9 kg/m²], and 16% as obese (BMI ≥30 kg/m²).[2] The global prevalence of obesity, which was reported as 6.4% in 1975, has more than doubled over the past few decades, demonstrating an alarming trend.[3]

The association between obesity and increased morbidity and mortality has long been established. During pregnancy, obesity poses various health risks not only for the mother but also for the fetus. It has been associated with increased maternal morbidity as well as obstetric complications such as preterm birth, macrosomia, and a higher rate of cesarean delivery.[4,5] Obesity-related impairment of placental function may alter fetal nutrient transport, while elevated levels of insulin resistance and inflammation in pregnant women with obesity may adversely affect fetal metabolism.[6,7]

Fetal growth, oxidative metabolism, and fundamental biological processes are largely dependent on protein synthesis sustained by placental amino acid transport.[8] In pregnancies affected by maternal obesity, elevated levels of insulin, leptin, and insulin-like growth factor 1 (IGF-1) may enhance fetal amino acid transfer by activating various placental

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signaling pathways.[9] Disruptions in maternal-fetal transport mechanisms may influence fetal metabolic status from the time of implantation. Moreover, insufficient maternal protein intake has been associated with fetal growth restriction (FGR) and increased rates of perinatal morbidities. Conversely, excessive protein intake may negatively affect embryonic and fetal development due to increased amino acid catabolism and competitive inhibition among transporters.[10,11]

In this context, assessing both the quantity and quality of the maternal diet has important implications for pregnancy outcomes, as the amount and source of protein intake may influence fetal growth and contribute to long-term metabolic development in childhood.[12] However, there is limited evidence in the literature directly comparing macronutrient intake and distribution among pregnant women with different pre-pregnancy BMI categories.

Therefore, this study aimed to evaluate the relationship between daily dietary intake patterns-including macronutrient distribution-maternal BMI, and overall lifestyle characteristics during pregnancy across BMI-based groups. Furthermore, we sought to explore the potential impact of these differences on key perinatal outcomes.

METHODS

Participant Selection

This was prospective cohort study with retrospective collection of baseline data, including pregnant women between 24 and 28 weeks of gestation who underwent an oral glucose tolerance test (OGTT) at a tertiary maternity hospital between January 2 and May 8, 2025. The study was approved by the Ankara Etlik City Hospital Ethics Committee (Date 14.05.2025, Decision No: AESH-BADEK1-2025-206) and conducted in accordance with the Declaration of Helsinki. All participants received verbal and written information about the study, and written informed consent was obtained prior to enrollment.

Participants were divided into two BMI-based groups to enable a clear comparison between metabolically distinct populations. Overweight women (BMI 25.0-29.9 kg/m^2) were excluded to reduce potential heterogeneity and avoid dilution of group differences in dietary and metabolic parameters. Group 1 consisted of participants with a pre-pregnancy BMI between 18.5 and 24.9 kg/m^2 (classified as having normal weight), and group 2 included those with a BMI between 30 and 39.9 kg/m^2 (classified as having obesity).

During the study visit, we measured weight using a Calibrated Digital Scale, with participants wearing light clothing and no shoes. Height was measured using a stadiometer, and BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2). First and second trimester weight gain was documented based on pregnancy records, while third-trimester weight gain was recorded at the time of hospital admission for delivery. Additionally, during the same visit, participants' physical activity levels were recorded based on self-reported changes and categorized as "increased," "decreased," or "unchanged."

We excluded women who underwent OGTT at their initial antenatal visit, those who received a 100 g OGTT following an abnormal 50 g glucose challenge test, and those diagnosed with impaired glucose tolerance or gestational diabetes based on OGTT results. Additional exclusion criteria included maternal age over 40 years, known metabolic disorders, smoking, alcohol or substance use, history of bariatric surgery, prior dietary counseling, or working night shifts. To minimize potential confounding factors affecting neonatal outcomes, we also excluded cases with multiple gestation, cervical insufficiency, structural and/or chromosomal fetal anomalies, and preterm birth before 37 weeks of gestation. Following participant selection, we recorded perinatal outcomes including gestational age at delivery, birth weight, 1- and 5-minute Apgar scores, and the need for neonatal intensive care unit (NICU) admission.

A priori power analysis using G*power 3.1.9.7 indicated that 60 participants per group were required to detect a moderate effect size (Cohen's d=0.52) with 80% power and a two-tailed alpha of 0.05. Accordingly, 120 participants were included in the study.

Assessment of Nutrient Intake

We assessed participants' daily dietary intake using a retrospective 24-hour dietary recall questionnaire administered during their morning visit to the outpatient clinic. For each of the three main meals and three snacks consumed the previous day, the time of consumption, types and amounts of food and beverages, preparation methods, place of consumption, and the participant's perceived level of hunger before eating were recorded.

Participants were also asked to complete two additional 24-hour dietary recall forms-one on a weekday and one on a weekend day-resulting in a total of 72 hours of dietary intake data. Although this 3-day recall method is widely used in nutritional studies, we acknowledge that it may not fully reflect long-term dietary habits during pregnancy, when eating patterns may vary. To minimize recall bias and potential under- or over-reporting, participants were provided with visual guidance on portion sizes using a photographic food atlas and were instructed to complete the forms on the same day as food consumption.

We analyzed the dietary data using the Nutrition Information System (BeBIS), a computer-assisted dietary assessment software developed within the scope of the national nutrition monitoring program. BeBIS enables standardized analysis of food records by referencing an extensive Turkish food composition database and calculating macro- and micronutrient content based on portion size, preparation methods, and frequency of consumption. Through this system, we obtained detailed estimates of total energy intake and the distribution of protein, fat, and carbohydrate intake for each participant.

Statistical Analysis

We performed statistical analyses using IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp., Armonk, NY, USA).

We assessed the distribution of continuous variables using the Kolmogorov-Smirnov and Shapiro-Wilk tests. For normally distributed data, we compared groups using the independent samples T test and reported the results as mean±standard deviation (SD). For non-normally distributed data, we used the Mann-Whitney U test and presented the results as median (minimum-maximum).

Categorical variables were expressed as numbers (n) and percentages (%), and group comparisons were performed using the Pearson chi-square test or Fisher's exact test, as appropriate. A p-value <0.05 was considered statistically significant for all analyses.

RESULTS

We enrolled a total of 120 pregnant women in this study, with 60 participants in each group based on BMI classification. There were no statistically significant differences between the groups in terms of maternal age, gravida, parity, or number of previous abortions (p>0.05). Similarly, the distribution of educational levels was comparable between the groups (p=0.66). The mean pre-pregnancy BMI was 22.7 (range: 19.2-24.8) in the normal-weight group and 31.6 (range: 30.0-38.6) in the group of women with obesity.

Total gestational weight gain was higher among women with obesity, with an average of 17.6 kg compared to 13.6 kg in the normal-weight group. This difference was consistent across all three trimesters, with statistically significant increases particularly during the first two trimesters (p=0.009).

We found no significant differences between the groups regarding changes in physical activity throughout pregnancy (p=0.95). However, most participants in both groups reported a decline in physical activity frequency after the onset of pregnancy. Other clinical and demographic characteristics of the participants are summarized in Table 1.

Daily energy and nutrient intake data are presented in Table 2. There were no substantial differences in the number of main meals or snacks between the groups. The mean daily energy intake was higher among women with obesity (2117.1 kcal vs. 2004.6 kcal; p=0.045), and a significantly greater proportion of this energy was derived from carbohydrates (51.7% vs. 44.6%; p=0.026). In contrast, the normal-weight group obtained a larger proportion of their energy from protein (p=0.025), whereas fat-derived energy did not differ significantly between the groups (p>0.05).

There were no significant differences between the groups in gestational age at delivery, birth weight, or Apgar scores. The mean birth weight was 3170 (±410) g in the normal-weight group and 3210 (±395) g in the group of women with obesity (p>0.05). However, the rate of NICU admission was significantly higher in the group of women with obesity (9 cases vs. 2 cases; p=0.046). Among these cases, indications for NICU admission included respiratory problems (n=4), Apgar score <7 at 5 minutes (n=2), hypoglycemia (n=2), and hyperbilirubinemia (n=1). In the normal-weight group, both NICU admissions were due to respiratory problems. Other perinatal outcomes are summarized in Table 3.

Table 1. Comparison of demographic and clinical characteristics between study groups

	Normal weight women (n=60)	Women with obesity (n=60)	p-value
Maternal age*	29.8 (20-37)	30.6 (19-38)	0.422
Gravidity*	1.47 (1-3)	1.65 (1-4)	0.256
Parity*	1.32 (0-2)	1.45 (0-3)	0.401
Number of abortions*	0.15 (0-2)	0.20 (0-3)	0.573
Education level†			
Primary school	12 (20%)	9 (15%)	0.631
High school	13 (21.6%)	16 (26.6%)	0.670
University	24 (40%)	25 (41.6%)	0.462
Postgraduate	11 (18.3%)	10 (16.6%)	0.295
1st trimester hyperemesis†			
Yes	24 (40%)	11 (18.3%)	0.020
No	36 (60%)	49 (81.6%)	
Gestational weight gain (kg)*			
1st trimester	2.7 (0-4.6)	4.3 (0-6.2)	0.009
2nd trimester	4.4 (2.9-7.1)	5.9 (1.7-8.3)	0.009
3rd trimester	6.5 (3.1-8.2)	7.4 (2.6-9.9)	0.012
Change in physical activity†			
Increased	12 (20%)	14 (%23.3)	0.822
Decreased	27 (45%)	25 (%41.6)	0.857
No change	21 (35%)	21 (%35)	1.000

*Presented as mean (min–max); †Presented as n (%); Statistical significance was assessed using Mann-Whitney U test or chi-square test as appropriate

Table 2. Daily energy and nutrient intake in normal-weight women and women with obesity

	Normal weight women (n=60)	Women with obesity (n=60)	p-value
Number of main meals	3.4 (3-4)	3.5 (3-4)	0.350
Number of snacks	2.3 (1-3)	2.6 (1-3)	0.458
Total energy (kcal/day)	2004.6 (1704-2886)	2117.1 (1071-2969)	0.045
Carbohydrates (g/day)	221.4 (87-380)	253.5 (130-370)	0.030
%energy from carbohydrates	44.6 (34-59)	51.7 (32-70)	0.026
Protein (g/day)	77.1 (49-118)	70.2 (45-121)	0.049
%energy from protein	17.3 (9-32)	13.3 (10-28)	0.025
Fat (g/day)	84.3 (47-156)	77.6 (41-165)	0.120
%energy from fat	37.2 (16-51)	34.2 (17-48)	0.115
Saturated fatty acids (g/day)	26.6 (12-46)	22.6 (9-47)	0.210
Unsaturated fatty acids (g/day)	49.5 (7-51)	48.9 (6-49)	0.170

All variables are continuous and presented as median (minimum-maximum). Comparisons were performed using the Mann-Whitney U test

Table 3. Perinatal outcomes

	Normal weight women (n=60)	Women with obesity (n=60)	p-value
Gestational age at delivery*	38.5 (37-40.2)	38.4 (37-40.1)	0.681
Birthweight (kg)*	3170 (2470-4130)	3210 (2630-4310)	0.543
Apgar score at 1 minute*	8 (5-9)	8 (6-9)	0.217
Apgar score at 5 minutes*	9 (7-10)	9 (7-10)	0.434
NICU admission†	2 (3.3%)	9 (15.0%)	0.046

*Presented as mean (min-max); †Presented as n (%); Statistical significance was assessed using Mann-Whitney U test or chi-square test as appropriate

DISCUSSION

Pregnancy is a unique physiological period characterized by significant changes in maternal metabolism to support normal embryonic and fetal development. Throughout this period, maternal nutritional status plays a key role in shaping both maternal and fetal health outcomes.[13] It is theorized that intrauterine epigenetic changes may be influenced by maternal nutrition and have been associated with an increased risk of metabolic disorders in childhood-such as obesity and insulin resistance-with consequences extending into adulthood.[14,15] In this context, maternal obesity-which alters metabolic and hormonal pathways-has been associated with an increased risk of various adverse outcomes affecting both the mother and the fetus.[16]

Evaluating nutritional habits before and during pregnancy can provide clinically relevant insights for both the management of obesity and the improvement of perinatal outcomes. In this context, we compared dietary energy and macronutrient distribution between different maternal BMI groups. Our findings demonstrated that normal-weight women had higher daily protein intake and derived a greater proportion of their energy from protein and fat, suggesting a more balanced dietary pattern. In contrast, the higher-BMI group consumed a greater proportion of energy from carbohydrates. This carbohydrate-dominant intake could contribute to metabolic dysregulation observed in individuals with elevated pre-pregnancy BMI.

Contrary to popular belief, limited weight gain during pregnancy has not been definitively shown to adversely affect fetal development. While extreme restrictions-such as those observed during famine or war-are associated with low birth weight and increased perinatal mortality, studies have shown that women who gain minimal weight within physiological limits can still support adequate fetal growth without significantly increasing adverse outcomes.[17,18] In contrast, excessive gestational weight gain is associated with a higher risk of gestational diabetes, preeclampsia, macrosomia, cesarean delivery, and NICU admission.[19,20] Furthermore, excessive weight gain during pregnancy may increase the risk of metabolic disorders in offspring during childhood.[21]

Given these considerations, the institute of medicine (IOM) recommends limiting gestational weight gain in women with elevated pre-pregnancy BMI, particularly restricting weight gain to a maximum of 2 kg during the first trimester.[22] Despite these recommendations, participants with higher pre-pregnancy BMI in our study exhibited significantly greater weight gain during the first trimester compared to those with normal BMI. This difference may be partly attributable to the lower incidence of hyperemesis gravidarum among women with obesity, although this relationship warrants further investigation.

Nevertheless, we observed no significant differences between the groups in terms of gestational age at delivery, birth weight, or Apgar scores. However, NICU admission rates were significantly higher in the group with obesity, primarily due to respiratory problems, low Apgar scores, hypoglycemia, and hyperbilirubinemia. These findings are consistent with previous large-scale studies demonstrating that excessive gestational weight gain is associated with an increased risk of neonatal complications such as macrosomia, shoulder dystocia, and neonatal hypoglycemia.[23]

Our study also revealed a marked reduction in physical activity levels during pregnancy compared to pre-pregnancy in both groups. This finding is consistent with previous studies[24] and suggests that awareness and counseling regarding physical activity during pregnancy may be insufficient.

A combined evaluation of dietary composition and physical activity plays a critical role in achieving healthy gestational weight gain. Among women with obesity, balancing macronutrient intake and maintaining physical activity levels may support improved maternal and perinatal outcomes. Therefore, enhancing preconception counseling services and developing individualized follow-up strategies-particularly for controlling weight gain during the early stages of pregnancy, when energy requirements have not yet significantly increased, and for establishing appropriate nutritional targets in high-risk groups-should be prioritized. Similar education levels in both groups may have helped reduce the impact of socioeconomic disparities on dietary intake. However, as other dimensions of socioeconomic status-such as income or access to healthy food-were not assessed, this remains a potential source of residual confounding.

Limitations

Our study has several limitations that should be considered when interpreting the findings. First, the relatively small sample size may limit the generalizability of the results. Second, dietary intake was assessed using self-reported 24-hour recall forms, which are inherently subject to recall bias-particularly during pregnancy, when daily routines and eating behaviors may fluctuate. This may have led to under- or overestimation of certain food groups or portion sizes. Although we attempted to mitigate this risk by providing standardized visual aids and instructing participants to complete the forms on the same day as food consumption, some degree of recall bias remains inevitable. Finally, although the observational design makes it difficult to establish cause-effect relationships, the methodological rigor of our study enhance the clinical relevance and reliability of the findings.

CONCLUSION

Differences in dietary composition and macronutrient distribution across maternal BMI categories may provide valuable insights for individualized nutritional counseling during pregnancy. Encouraging a protein-rich and balanced dietary pattern, rather than a carbohydrate-dominant one, among women with higher pre-pregnancy BMI may be associated with improved maternal and fetal outcomes. Further prospective studies are essential to inform evidence-based nutritional counseling strategies tailored to maternal BMI.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Ankara Etlik City Hospital Ethics Committee (Date 14.05.2025, Decision No: AESH-BADEK1-2025-206).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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