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The Effect of Vitamin A and D Levels and Diet Quality on Neonatal Anthropometric Measurements in Pregnant Women: A Cross-Sectional Study

Gebelerde A ve D Vitamini Düzeyleri ile Diyet Kalitesinin Yenidoğan Antropometrik Ölçümleri Üzerine Etkisi: Kesitsel Çalışma

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The study was presented as an oral presentation at the 3rd International Mediterranean Pediatric Nursing Congress, October 12-15, 2022, Ankara, Türkiye.

ABSTRACT Objective: The aim of this study is to analyze the effects of serum vitamin A and D levels and dietary quality of pregnant women on newborn anthropometric measurements. **Material and Methods:** A hospital-based cross-sectional study in northeastern Türkiye included 118 pregnant women aged 18-45 years during weeks 24-36 of pregnancy. Dietary intake was evaluated with a 3-day record and categorized as poor, moderate, or good using the Diet Quality Index for Pregnancy. Serum A and D vitamin levels were measured from blood samples, and postpartum newborn anthropometric measurements were recorded. Data analysis was performed using SPSS with a significance level of 0.05. **Results:** When pre-pregnancy Body Mass Index (BMI) values were examined, 44.5% of the pregnant women were overweight/obese. 17% of the women had poor, 38.1% had moderate, and 44.1% had good dietary quality. Only 10.2% of the women had sufficient serum vitamin D levels, while 16.9% had excessive vitamin A levels. Regression analysis showed that pre-pregnancy BMI (β=0.32, p=0.00) and dietary magnesium intake (β=0.42, p=0.01) significantly affected newborn birth weight, explaining 32% of its variance. Although diet quality had no effect on newborn anthropometric measurements, pregnant women with good dietary quality and who used dietary supplements had babies with lower birth weights compared to those who did not use supplements (p<0.01, t=2.61). **Conclusion:** High pre-pregnancy BMI and inadequate dietary magnesium intake may adversely impact newborn birth weight, underscoring the importance of balanced nutrition. Maintaining an ideal BMI prior to pregnancy is crucial, and unnecessary supplement use should be avoided in women with good dietary quality.

Keywords: Nutritional status; pregnancy; vitamin A; vitamin D; diet quality

ÖZET Amaç: Bu çalışmanın amacı, gebe kadınların serum A ve D vitamini düzeyleri ile diyet kalitesinin yenidoğan antropometrik ölçümleri üzerindeki etkilerini analiz etmektir. **Gereç ve Yöntemler:** Türkiye'nin kuzeydoğu bölgesinde hastane bazlı kesitsel bir çalışma yürütülmüş, çalışmaya 24-36. gebelik haftasında olan, 18-45 yaş aralığındaki 118 gebe kadın dâhil edilmiştir. Diyet alımları 3 günlük besin tüketim kaydı yöntemiyle değerlendirilmiş ve Gebelik Diyet Kalitesi İndeksi kullanılarak zayıf, orta ve iyi olarak sınıflandırılmıştır. Serum A ve D vitamini düzeylerini belirlemek amacıyla kan örnekleri alınmış, doğum sonrası yenidoğan antropometrik ölçümleri kaydedilmiştir. Veriler, anlamlılık düzeyi 0,05 olarak belirlenmiş SPSS programı kullanılarak analiz edilmiştir. **Bulgular:** Gebelik öncesi Beden Kitle İndeksi (BKİ) değerleri incelendiğinde, gebe kadınların %44,5'inin fazla kilolu veya obez olduğu görülmüştür. Kadınların %17'sinin diyet kalitesi zayıf, %38,1'inin orta, %44,1'inin ise iyi düzeyde olduğu belirlenmiştir. Kadınların yalnızca %10,2'sinde yeterli serum D vitamini düzeyleri saptanırken, %16,9'unda aşırı A vitamini düzeyleri tespit edilmiştir. Regresyon analizi, gebelik öncesi BKİ'nin (β=0,32, p=0,00) ve diyetteki magnezyum alımının (β=0,42, p=0,01) yenidoğan doğum ağırlığı üzerinde anlamlı bir etkisi olduğunu ve bu 2 değişkenin doğum ağırlığındaki varyansın %32'sini açıkladığını göstermiştir. Diyet kalitesinin yenidoğan antropometrik ölçümleri üzerinde bir etkisi bulunmamakla birlikte, iyi diyet kalitesine sahip ve besin takviyesi kullanan gebelerin bebeklerinin, takviye kullanmayanlara göre daha düşük doğum ağırlığına sahip olduğu gözlemlenmiştir (p<0,01, t=2,61). **Sonuç:** Gebelik öncesi yüksek BKİ ve diyetle yetersiz magnezyum alımı, yenidoğan doğum ağırlığını olumsuz etkileyebilir ve bu da dengeli beslenmenin önemini vurgulamaktadır. Gebelik öncesi ideal BKİ'nin korunması büyük önem taşımakta olup, iyi diyet kalitesine sahip kadınlarda gereksiz takviye kullanımından kaçınılmalıdır.

Anahtar Kelimeler: Beslenme durumu; gebelik; A vitamini; D vitamini; diyet kalitesi

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All micronutrients are vital during pregnancy.[1] Especially in the last trimester, the fetus requires high levels of vitamin A to meet developmental needs.[2-3] Vitamin A is an essential micronutrient for the body and is associated with proper functioning of the visual system, maintenance of epithelial integrity, red cell production, growth and development, immune and reproductive function. Since the human body does not produce this vitamin, adequate daily intake is necessary to prevent its deficiency.[4] A balanced diet usually provides the required level of vitamin A. In cases where recommended levels are not reached, vitamin A supplementation is requird.[5] However, acute poisoning such as nausea, irritability, decreased appetite, vomiting, blurred vision, headaches, dry skin, bone pain, hair loss, muscle pain, papillary edema, cerebral edema, bleeding, weakness, lethargy and altered mental status can occur after excessive vitamin A consumption.[5-6] Recent research suggests that due to limited data on the impact of maternal vitamin A on child health, more follow-up studies are urgently needed to close the knowledge gap.[2]

Vitamin D deficiency is a common health problem in newborn, children, adolescents, adults and the elderly worldwide.[7] Low vitamin D levels are also common during pregnancy, creating an unfavorable environment during critical stages of fetal development, with serious and lasting consequences on bone growth and skeletal integrity, and long-term adverse effects on fetal and neonatal health outcomes such as nutritional rickets.[8,9] Numerous interventional and observational studies have investigated the role of vitamin D in pregnancy and its potential to improve outcomes with supplementation. However, the results have been inconsistent, as some studies have found an effect on neonatal anthropometry while others have not.[10-13]

Diet quality is a multifaceted concept encompassing several dimensions, including nutrient adequacy, dietary diversity, and adherence to dietary guidelines.[14] A high-quality diet typically includes a variety of nutrient-dense foods such as vegetables, fruits, whole grains, lean proteins, low-fat dairy, and healthy oils, while limiting the intake of saturated and trans fats, added sugars, and sodium.[15] Interventions aimed at improving diet quality in children and adolescents have been linked to better nutrient adequacy and overall health improvements.[16] Diet quality holds particular significance during pregnancy, as it provides essential nutrients to support the health of both the mother and the fetus. Good diet quality during this critical period is crucial for fetal growth and development and contributes significantly to the child's physical and intellectual development.[17,18] Given its importance, this study also aims to investigate the impact of diet quality on birth outcomes.

To provide evidence for the effects of maternal vitamin A and vitamin D, maternal diet on neonatal health, this study was conducted to determine serum vitamin A and D levels and diet quality in pregnant women and to determine their effect on birth outcomes, including the anthropometric measurements of newborns.

MATERIAL AND METHODS

The study investigating the impact of maternal serum A and D vitamin levels and nutritional quality on neonatal outcomes was conducted in a cross-sectional design.

PARTICIPANTS AND SETTING

Between March and December 2021, women between the ages of 18 and 45 years at 24 and 36 weeks of gestation in the pregnant outpatient clinics of a hospital in northeastern Türkiye, who volunteered to participate in the study, had no communication problems, did not have a history of smoking, did not have without multiple pregnancies and did not have any health problems during pregnancy were included in the study.

Weeks 24-36 of pregnancy represent a critical period for nutrition and growth of both the mother and the fetus. In this process, evaluations can be made more reliable as the growth rate of the fetus and the mother's micro/macronutrient needs become clearer. In addition, since the nutritional fluctuations experienced in the early period decreased, the data were collected at 24-36 weeks, as more stable data collection could be provided in these weeks.

SAMPLE SELECTION

The G-Power analysis showed that a sample of 115 participants would be large enough to detect significant differences (95.0% power and 5.0% type I error). The sample consisted of 118 participants.

DATA COLLECTION TOOLS

Data were collected using a Questionnaire on maternal and newborn characteristics, three-day dietary record, The Dietary Diversity Form (DDF) and Diet Quality Index for Pregnancy (DQI-P).[19-21]

Body Mass Index (BMI) is calculated by dividing body weight in kilograms by the square of height in meters (kg/m²). According to the World Health Organization, a BMI below 18.5 is considered underweight, 18.5-24.9 is normal, 25.0-29.9 is overweight, and 30.0 and above is classified as obese.[22] The recommended weight gain during pregnancy is based on pre-pregnancy BMI, as outlined by Turkey Dietary Guidelines 2022. Underweight individuals should aim for 12.5-18 kg, those with a normal BMI should aim for 11.5-16 kg, overweight individuals should target 7-11.5 kg, and obese individuals should aim for a 5-9 kg weight gain.[23]

To determine participants' daily energy and nutrient intake, a 3-day dietary record was collected on consecutive days, including two weekdays and one weekend day. Participants received training from the researcher on how to record their dietary intake. At the end of each day, the dietitian contacted the participants via telephone to monitor and verify their dietary records.

Dietary records were analyzed for energy, macronutrients, and micronutrients using the "Computer-Assisted Nutrition Program, Nutrition Information System " version 8.1 developed for Türkiye.[24]

DDF was used to determine the variety of foods consumed by the participants within the framework of their dietary patterns over 19 different food groups. Dietary diversity scores were determined based on the number of food groups consumed and were classified as follows: 0 points for 6 or fewer food groups, 5 points for 7 to 16 food groups, and 10 points for 16 or more food groups. Higher scores indicate greater dietary diversity.[20] Data from 3-day dietary record and DDF were assessed using the DQI-P developed by Bodnar and Siega-Riz. Diet quality was classified as inadequate/poor, needs improvement/moderate or adequate/good.[21]

DATA COLLECTION

Blood samples from 118 pregnant women were collected for biochemical analysis and serum vitamin A and D levels were determined. The physician involved in the study requested measurement of serum vitamin A and D levels in addition to routine blood tests within the scope of biochemical analysis. Thus, these tests, which did not require additional injections from the patients, were performed at the same time during routine blood collection, and the relevant samples were collected by the staff working in the blood collection unit of the hospital and analyzed in the institutional laboratory. The additional costs of these non-routine tests were covered by Recep Tayyip Erdoğan University Scientific Research Projects in line with the determined fees. The following serum 25-OH-VitD levels were used as cutoff points: high/toxic (≥50/>80 ng/mL), normal (≥30-50 ng/mL), insufficient (≥20-<30 ng/mL), deficient (≥10-<20 ng/mL), and severely deficient (<10 ng/mL).[25] The normal reference range for serum vitamin A was 0.3-0.7 mg/L (when converted to µg/dL, is 30-70 µg/dL), with low values indicating nutritional deficiency and high values indicating nutritional excess.[26]

At the time of delivery, newborns were reached in the delivery room of the hospital. Mothers who did not give birth in the hospital were called by phone and an appointment was made for follow-up. Anthropometric measurements of all newborns were performed by the researcher pediatric nurse.

Anthropometric measurements were taken as described below. The measurement was taken twice, and if there was a discrepancy, the process was repeated. Before measuring, a disposable sheet was placed, and safety precautions were taken. The baby was positioned supine, with the vertex of the head in contact with the headboard and the body fully on the surface. The footboard was adjusted to the sole of the foot at a 90-degree angle ve it was measure.[27] The baby scale was checked. The baby's clothes were removed, leaving only the dry diaper, which was weighed afterward. The baby was placed supine on the scale, ensuring minimal movement.[27] Items like hats and headbands were removed, and head circumference was measured using a nonflexible tape from the occiput to the glabella.[27] The fontanelles were evaluated by palpation for width and length using one hand, with each finger measuring 1 cm. The measurement was taken when the baby was calm, and the procedure was consistently performed by the same researcher.[28]

Since 1 participant had stillbirth, 9 participants withdrew from the study and 2 participants could not be reached by phone, 106 newborns were followed up (Figure 1).

ETHICAL PRINCIPLES

The study was approved by the Non-Interventional Clinical Research Ethics Committee of Recep Tayyip Erdoğan University Medical Faculty (date: January 21, 2021, no: E-40465587-050.01.04-16, 2021/14). Institutional approval was obtained from the Provincial Health Directorate and informed consent was obtained from all participants. The research was conducted in accordance with the principles of the Declaration of Helsinki.

DATA ANALYSIS

The research data were analyzed using SPSS Statistics 25.0 (IBM Corp., Armonk, NY). The normal distribution of the data was analyzed by calculating the kurtosis and skewness coefficients. Mean, standard deviation and percentage values were calculated for descriptive statistics. Analysis of variance (ANOVA) and independent t-test were performed to examine the effect of maternal diet quality on newborn anthropometric measurements and fontanelles. Multiple regression analysis (forward method) was performed to examine the effect of descriptive characteristics and nutritional intake of mothers on newborn anthropometric measurements and fontanelles. Multicollinearity and independence of residuals were tested in the regression model. Durbin-Watson test statistics did not show autocorrelation. Normality of error terms and homoscedasticity conditions were met. Acceptable significance level was determined as $p<0.05$.

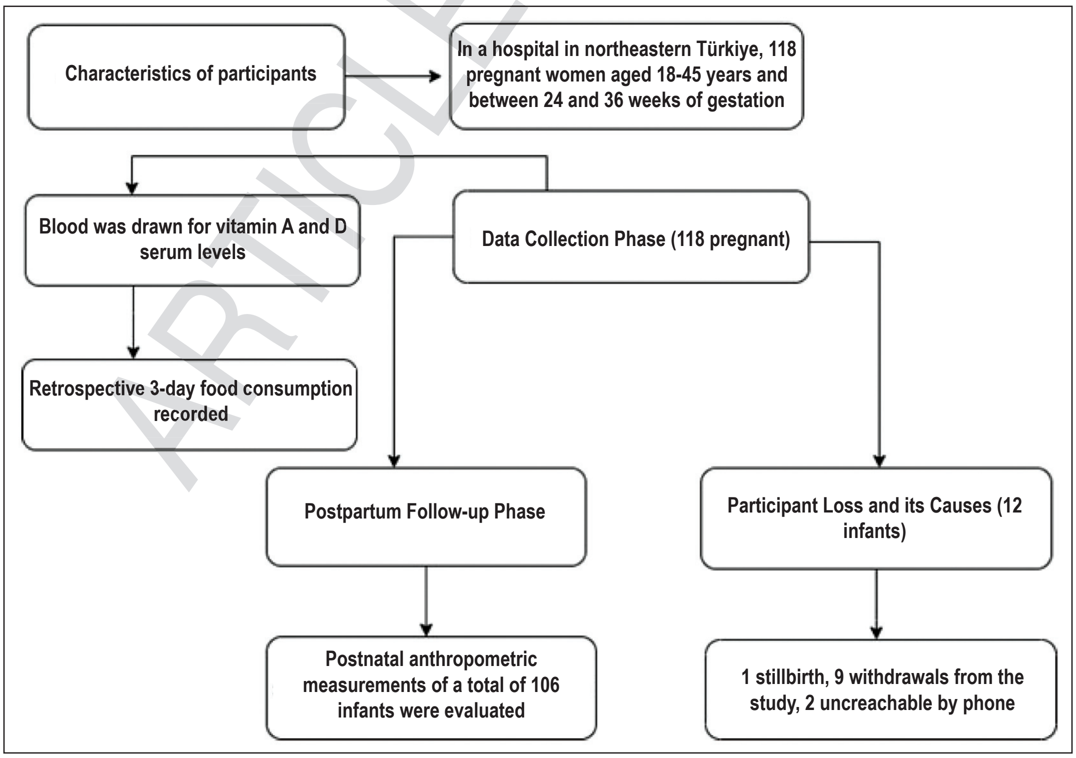

FIGURE 1: Study Process Flowchart.

RESULTS

Table 1 summarizes the demographic, maternal, and neonatal characteristics of the participants. The average maternal age was 29.77±4.91 years. One-third of the participants (33.9%) had a bachelor's degree. Most participants (74.6%) were housewives and more than half (61%) had a good socioeconomic status. Approximately half of the participants (50.4%) had a normal pre-pregnancy BMI, while 23.5% were overweight and 21% were obese. They gained an average of 13.22±6.68 kg during pregnancy. The average number of pregnancies was 2.15±1.20, with an interval of 2.54±2.94 years between pregnancies. Most pregnancies (68.6%) were planned, and 97.5% occurred naturally. Cesarean section was the most common delivery method (55.9%). Neonates had an average birth weight of 3496.12±561.07 g and an average birth length of 50.11±3.34 cm. The mean head circumference was 35.10±1.32 cm, anterior fontanel width was 3.28±1.01 and anterior fontanel length was 3.17±1.03 cm (Table 1).

The analysis of maternal diets revealed an average energy intake of 1755.68±622.06 kcal/day, with macronutrient distributions of 45.97±7.34% carbohydrates, 16.49±4.52% protein, and 37.55±5.77% fat. While sufficient intake was observed for vitamins A (78.8%), B_1 (56.8%), and B_3 (78.8%), deficiencies were prevalent for vitamin C (66.1%), vitamin E (74.6%), vitamin B_2 (77.1%), vitamin B_6 (78.8%), folic acid (50%), vitamin B_{12} (59.3%), iron (94.9%), calcium (85.6%), magnesium (69.5%), and zinc (55.9%). Maternal serum analysis showed an average vitamin D level of 18.16±10.14 ng/mL, with 26.3% of participants classified as severely insufficient, 36.4% as deficient, 27.1% as insufficient, and only 10.2% as sufficient. Vitamin A levels averaged 539.80±157.27 µg/dL, with 81.4% in the sufficient range, 16.9% at excessive levels, and 1.6% insufficient (Table 2).

Table 3 presents the results of the multiple linear regression analysis, showing that the model explained 32% of the variance in neonatal weight (f=1.69, $p<0.05$). The most significant predictors of neonatal weight were pre-pregnancy bmi (b=31.110, β=0.324, se=10.923, p=0.006) and magnesium intake from

TABLE 1: Distribution of maternal and neonatal descriptive characteristics

Variables		n	%
Educational status	Primary school	30	25.4
	Associate degree	25	21.2
	High school	23	19.5
	University	40	33.9
Working status	Working	30	25.4
	Not working	88	74.6
Planned pregnancy	Yes	81	68.6
	No	37	31.4
Presence of miscarriage, stillbirth	Yes	23	19.5
	No	95	80.5
The way pregnancy occurs	Normal	115	97.5
	Egg hatching	2	1.7
	Vaccination	1	0.8
Socioeconomic status	Good	46	39.0
	Moderate	72	61.0
Consanguineous marriage	Yes	10	8.5
	No	108	91.5
Classification of pre-pregnancy BMI values	Underweight	5	4.1
	Normal	60	50.4
	Overweight	28	23.5
	Obese	25	21.0
Recommended weight gain based on pre-pregnancy BMI	High*	54	45.4
	Normal	38	31.8
	Low	26	21.8
A DQI-P score categories (for 118 pregnant women)	Poor /Bad	21	17.8
	Moderate	45	38.1
	Good	52	44.1
Supplementation status of mothers	Mothers not using supplements	48	40.7
	Mothers using supplements	70	59.3
Alcohol use status	No	118	100.0
Desire for pregnancy	Yes	118	100.0
Baby's delivery method≠	Normal	40	33.9
	Cesarean section	66	55.9
Special care status≠	Yes	26	22.0
	No	80	67.8
Breastfeeding status≠	First 30 minutes after birth	39	33.1
	Within 30 minutes - 4 hours	36	30.5
	Within 4 hours - 1 day	7	5.9
	After 1 day	24	20.3
Baby's gender≠	Girl	53	44.9
	Boy	53	44.9
Variables		**Minimum-maximum**	**$\bar{X}$±SD**
Maternal characteristics	Maternal age (years)	18-42	29.77±4.91
	Gestational week	24-36	27.17±3.03
	Number of pregnancies	1-6	2.15±1.20
	Interval between pregnancies (years)	1-14	2.54±2.94
	Maternal height (cm)	147-176	162.34±6.19
	Pre-pregnancy weight (kg)	40126	69.00±16.04
	Pre-pregnancy BMI	16.56-44.64	26.04±5.65
	Weight gain during pregnancy (kg)	0-30	13.22±6.68
	Gestational age at birth (weeks)	35-41	38.74±1.41
Neonatal characteristics≠	Birth weight (g)	2100-5100	3,496.12±561.07
	Birth length (cm)	25-57	50.11±3.34
	Head circumference (cm)	31.00-38.50	35.10±1.32
	Anterior fontanel width (cm)	1-8	3.28±1.01
	Anterior fontanelle length (cm)	1-7	3.17±1.03

*High: Pregnant women who gain weight above the recommended weight gain range; Normal: Pregnant women who gain weight in line with the recommended weight gain range; Low: Pregnant women who gain weight below the recommended weight gain range; ≠Missing: 12 (10.2%) infant after birth, Total 118 pregnant women; SD: Standard deviation; BMI: Body mass index; DQI-P: Diet Quality Index for Pregnancy

TABLE 2: Distribution and mean scores of maternal serum vitamin levels and maternal diet intake					
Variables		**Minimum-maximum**	**$\bar{X}$±SD**		**n (%)**
Maternal serum	Vitamin D (ng/mL)	3.40-49.10	18.16±10.14	Severely Insufficient	31 (26.3%)
				Missing	43 (36.4%)
				Insufficient	32 (27.1%)
				Sufficient	12 (10.2%)
	Vitamin A (µg/dl)	110.76-985.15	539.80±157.27	Severely Insufficient	1 (0.8%)
				Missing	1 (0.8%)
				Sufficient	96 (81.5 %)
				Excessive	20 (16.9%)
Maternal diet	Energy	876.00-4212.00	1755.684±622.0563		
	CHOΩ (%)	24.00-65.00	45.9661±7.34374		
	Protein (%)	8.00-32.00	16.49±4.516		
	Fat (%)	18.00-53.00	37.55±5.771		
	Vitamin A	301.00-4140.00	1047.3941±548.07105	Sufficient	93 (78.8%)
				Insufficient	25 (21.2%)
	Vitamin C	8.80-287.10	96.5407±58.63994	Sufficient	40 (33.9%)
				Insufficient	78 (66.1%)
	Vitamin E	2.00-25.70	8.9525±4.05525	Sufficient	30 (25.4%)
				Insufficient	88 (74.6%)
	Vitamin B_1	0.40-1.60	0.8793±0.29690	Sufficient	67 (56.8%)
				Insufficient	51 (43.2%)
	Vitamin B_2	0.40-2.80	1.2398±0.47898	Sufficient	27 (22.9%)
				Insufficient	91 (77.1%)
	Vitamin B_3	3.30-29.00	12.0322±5.56695	Sufficient	93 (78.8%)
				Insufficient	25 (21.2%)
	Vitamin B_6	0.50-2.90	1.3443±0.50731	Sufficient	25 (21.2%)
				Insufficient	93 (78.8%)
	Folic acid	100.80-976.90	546.7890±214.94078	Sufficient	59 (50.0%)
				Insufficient	59 (50.0%)
	Vitamin B_{12}	0.20-21.20	4.5653±3.09006	Sufficient	48 (40.7%)
				Insufficient	70 (59.3%)
	Iron	4.10-20.40	9.7746±3.85742	Sufficient	6 (5.1%)
				Insufficient	112 (94.9%)
	Calcium	178.10-1598.00	660.0593±278.40185	Sufficient	17 (14.4%)
				Insufficient	101 (85.6%)
	Magnesium	108.80-498.00	265.7102±99.20854	Sufficient	36 (30.5%)
				Insufficient	82 (69.5%)
	Zinc	3.30-22.30	9.3678±3.89643	Sufficient	52 (44.1%)
				Insufficient	66 (55.9%)

SD: Standard Deviation; ΩCHO: Carbohydrate

food (b=2.441, β=0.427, se=0.927, p=0.010). other independent variables, such as maternal age, number of pregnancies, interval between pregnancies, weight gain during pregnancy, serum levels of vitamins a and d, energy intake, and intake of other vitamins and minerals, did not show statistically significant effects on neonatal weight (p>0.05), (Table 3).

Among the pregnant women, 18.9% had poor, 38.7% had moderate, and 42.4% had good diet quality. No significant differences were observed between maternal diet quality and neonatal anthropometric measurements (p>0.05). However, among those with good diet quality (42.4%), 40% did not use dietary supplements, while 60% did. The birth weight of

TABLE 3: Multiple regression analysis of factors influencing neonatal weight						
	Unstandardized Coefficients		Standardized Coefficients			
Independent variables	B	SE	β	t value	p value	95% CI
(Constant)	3283.60	922.08		3.56	0.00	1449.29-5117.91
Maternal Age	14.82	13.92	0.13	1.06	0.29	-12.87-42.52
Number of pregnancy	-7.12	64.29	-0.01	-0.11	0.91	-135.03-120.77
Interval between pregnancies	28.55	21.63	0.15	1.32	0.19	-14.47-71.58
Pre-pregnancy BMI	31.11	10.92	0.32	2.84	**0.00***	9.38-52.83
Weight gained during pregnancy	15.79	9.08	0.18	1.73	0.08	-2.27-33.87
Serum vitamin A	-0.10	0.36	-0.02	-0.28	0.77	-0.81-0.61
Serum vitamin D	-1.97	5.62	-0.03	-0.35	0.72	-13.15-9.20
Energy intake	-0.09	0.17	-0.10	-0.53	0.59	-0.43-0.25
Carbohydrate (%)	-16.49	10.82	-0.21	-1.52	0.13	-380.02-5.02
Protein (%)	-7.90	18.10	-0.06	-0.43	0.66	-430.92-28.11
Dietary vitamin A	-0.12	0.12	-0.12	-1.01	0.31	-0.37-0.12
Dietary calcium	-0.38	0.28	-0.19	-1.36	0.17	-0.95-0.17
Dietary magnessium	2.44	0.92	0.42	2.63	**0.01***	0.59-4.28
Dietary vitamin B_{12}	-34.86	24.27	-0.19	-1.43	0.15	-83.15-13.41
Dietary zinc	-10.96	23.38	-0.07	-0.46	0.64	-57.47-35.55
Dietary folate	-0.28	0.33	-0.10	-0.85	0.39	-0.96-0.38
Dietary iron	-4.28	20.14	-0.03	-0.21	0.83	-44.36-35.80
Dietary vitamin B_1	14.27	392.46	0.00	0.03	0.97	-766.46-795.01
Dietary vitamin B_2	148.73	202.03	0.12	0.73	0.46	-253.17-550.64
Dietary vitamin B_3	-4.67	15.95	-0.04	-0.29	0.77	-36.40-27.05
Dietary vitamin B_6	-75.19	220.99	-0.06	-0.34	0.73	-514.82-364.44
Dietary vitamin C	0.29	1.34	0.03	0.21	0.82	-2.38-2.97
Dietary vitamin E	-3.69	15.90	-0.02	-0.23	0.81	-35.32-27.94
DW=2.188; R=0.56; R^2=0.32; F=1.69; p<0.05						

BMI: Body mass index; CHO: Carbohydrate; CI: Confidence interval; SE: Standard error; β: Standardized regression coefficient; *Significance level was accepted as p<0.05. The model established with the baby's head circumference, birth length and fontanelle dimensions is meaningless. #Dependent variable=Birth weight (g)

TABLE 4: Maternal diet quality and neonatal anthropometric measurements (n=106)					
A DQI-P			Birth weight (g)	Birth length (cm)	Head circumference (cm)
Variables		n(%)	$\bar{X}$±SD	$\bar{X}$±SD	$\bar{X}$±SD
Insufficient/Bad		20(18.9%)	3399.50±439.27	49.95±1.90	35.18±1.01
Improved/Moderate		41(38.7%)	3633.04±667.63	50.23±4.81	35.15±1.44
Adequate/Good		45(42.4%)	3414.31±483.89	50.08±1.99	35.02±1.35
Total		106(100.0%)	3496.12±561.07	50.11±3.34	35.10±1.32
	F		2.03	0.05	1.07
	p value		0.13	0.95	0.28
Having a Adequate/Good diet quality (n=45)	No Supplement	18(40.0%)	3631.38±470.48	50.66±2.32	35.29±0.97
	Yes Supplement	27(60.0%)	3269.59±444.02	49.70±1.68	34.85±1.55
	t value		2.61	1.61	205.00
	p value		**0.01***	0.11	0.36

DQI-P: Diet quality index for pregnancy; SD: Standard deviation

neonates born to mothers with good diet quality who used supplements was significantly lower compared to those who did not use supplements (p<0.01, t=2.61), (Table 4).

DISCUSSION

Neonatal anthropometric measurements are a critical indicator of neonatal health, providing valuable insight into the growth and development of the newborn.[29] The nutritional status of pregnant women plays a crucial role in determining neonatal health, as it influences key outcomes such as birth weight, growth, and overall health.[30]

Vitamin A plays a crucial role in normal fetal growth and development, and its deficiency can pose serious health risks. However, excessive intake of vitamin A can also lead to significant health complications.[5,6] Complications of vitamin A toxicity include acute toxicity symptoms such as nausea, vomiting, headache, dizziness, irritability, blurred vision, and intracranial hypertension; chronic toxicity symptoms like dry, itchy skin, hair loss, bone and joint pain, fatigue, anorexia, and weight loss; and teratogenic effects during pregnancy, which can lead to craniofacial abnormalities, central nervous system malformations, and cardiovascular malformations.[31] Our findings revealed that approximately four out of five pregnant women consumed adequate amounts of vitamin A, whereas one in five consumed excessive amounts. While vitamin A is essential for maintaining normal physiological functions, excessive intake can lead to symptoms of toxicity.[5] Due to the adverse effects of vitamin A toxicity, unnecessary supplementation should be avoided. In this regard, guidance from healthcare professionals is crucial to ensure safe and appropriate supplementation practices.

According to serum vitamin A levels, 0.8% of individuals were found to be severely deficient, 81.4% had sufficient levels, and 16.9% exhibited excessive levels. Hanson et al. reported that approximately 10% of mothers were deficient, while 41% had insufficient vitamin A levels.[32] Hanson's study also demonstrated a potential positive association between birth weight and maternal vitamin A concentrations.[32] However, in our study, maternal serum vitamin A levels were not found to be associated with newborns' anthropometric measurements. Similarly, Barua et al. reported no significant relationship between maternal serum vitamin A levels and birth weight.[33] These findings underscore the complexity of the relationship between maternal vitamin A levels and neonatal outcomes.

Vitamin D is essential during pregnancy, yet only about 10% of pregnant women in our study had adequate serum levels, raising concerns. A study in Türkiye found that maternal 25-OHD levels below 10 ng/mL were a key risk factor for low levels in newborns.[34] Therefore, preventing neonatal vitamin D deficiency requires ensuring sufficient levels in mothers.[35] Vitamin D is mainly synthesized in the skin through UVB exposure (90% of needs), with dietary sources such as fatty fish and egg yolks contributing about 10%. However, dietary intake alone is inadequate, highlighting the importance of food fortification, already practiced in countries like the U.S. and Finland, but still in early stages in Türkiye.[36] Hence, adequate sun exposure remains vital.

The high prevalence of vitamin D deficiency observed in our study requires attention and may be attributed to several factors. Firstly, our research was conducted in Rize, a city located in the Eastern Black Sea region of Türkiye, which lies between the latitudes of 36° and 42°. Literature indicates that vitamin D3 synthesis in the skin is very low above and below latitudes of approximately 33°.[37] This geographical position may significantly contribute to the observed deficiency in the region. The city receives only 49.4 hours of sunlight annually, compared to 100.3 hours in southern Türkiye.[38] Furthermore, adequate vitamin D synthesis requires at least 25% skin exposure for 15-20 minutes, a challenge for those who spend much time indoors or wear clothing that covers most of their skin.[23]

In our study, we examined the effect of maternal serum vitamin D level on anthropometric measurements of newborns. Studies on the effect of vitamin D deficiency on newborn anthropometric measurements have reported conflicting results.[10-13] Some studies have reported an association between vitamin D deficiency and low birth weight, while others have found no significant effect of vitamin D deficiency on birth weight.[10-13] In the present study, no statistically significant difference was found between maternal serum vitamin D levels and newborns' birth weight. These findings highlight conflicting results regarding the effect of vitamin D deficiency on birth weight and underscore the lack of sufficient evidence concerning its impact on other anthropometric measures.

Regression analysis in the current study indicates that pre-pregnancy BMI significantly impacts the birth weight of the newborn. This finding is supported by Vats et al, who reported that an increase in pre-pregnancy BMI reduces the risk of low birth weight.[39] Similarly, the study by Sun et al. highlights that being overweight or obese before pregnancy is linked to an increased risk of macrosomia and large-for-gestational-age newborns.[40] Maintaining a healthy weight before pregnancy is of paramount importance for the health of both the mother and the newborn. Educating women of childbearing age about the significance of achieving and maintaining optimal BMI during preconception planning could help reduce the risk of adverse pregnancy outcomes.

Magnesium is an essential mineral involved in critical physiological processes, including the regulation of body temperature, nucleic acid and protein synthesis, and maintaining the electrical potentials of nerve and muscle cells.[41] There was a association between insufficient magnesium levels and adverse pregnancy outcomes with high mortality and morbidity rates.[42] These include gestational diabetes, preterm labor, preeclampsia, and small-for-gestational-age newborns or intrauterine growth retardation.[43,44]

One of the significant findings of our study showing that dietary magnesium intake during pregnancy significantly impacts birth weight, as demonstrated by regression analysis. Similarly, Doyle reported that higher magnesium intake during pregnancy is positively correlated with increased birth weight.[45] However, it is important to note that our study specifically focused on magnesium intake through diet, and did not include data on serum magnesium levels. This highlights the need for further research investigating the relationship between serum magnesium concentrations and pregnancy outcomes. In conclusion, dietary magnesium intake is a critical determinant of birth weight, with higher intakes associated with improved neonatal outcomes. Ensuring sufficient magnesium levels during pregnancy may be an effective strategy for promoting fetal growth and reducing the risk of low birth weight.

During pregnancy, a high-quality diet is crucial for promoting optimal maternal and neonatal outcomes.[18] In our study, 17.8% of participants had poor diet quality, 38.1% had moderate diet quality, and 44.1% had good diet quality (n=118). Few studies have shown the effect of diet quality on fetal anthropometric measurements.[46,47] In Rodríguez-Bernal Clara et al.'s study, an increase in diet quality was found to positively affect birth weight and length.[46] In another study, a high-quality diet during pregnancy was associated with a larger newborn size and a reduced risk of low birth weight and small for gestational age.[47] Yisahak et al. also showed that high diet quality was associated with increased birth weight.[48] However, our study did not reveal a significant relationship between diet quality and neonatal anthropometric measurements (n=106). In a similar study of pregnant Spanish women, Gesteiro and colleagues did not observe a significant difference in the birth weight of newborns born to mothers with varying diet qualities.[49] Similarly, Poon and colleagues found no significant association between maternal diet quality and newborn birth weigh.[50] The findings on the effect of maternal diet quality on birth outcomes are complex and inconsistent. This variability may be attributed to differences in the dietary indices used to assess diet quality across studies. When interpreting these findings, it is essential to consider this potential source of discrepancy.

We also conducted an analysis to determine the effect of supplement intake on neonatal anthropometric characteristics in pregnant women with good diet quality. Our results showed that newborns of participants who consumed supplements had significantly lower mean birth weight than those of participants who did not consume supplements. This result is in line with studies suggesting that supplementation has maybe a negative effect on newborns of well-nourished pregnant women.[51,52] Many pregnant women regularly take multivitamin supplements containing various micronutrients, but these products are not entirely risk-free.[53] Given that the effects of supplement intake on fetal outcomes in pregnant women with good diet quality have not been extensively explored, we believe that our findings offer valuable contributions to the existing literature. By examining this relationship, our study aims to provide further insight into the potential impact of supplement use in this specific group of pregnant women.

LIMITATIONS

One of the strengths of this study is that data were collected prospectively and through face-to-face interviews by a specialized dietitian and nurse. In addition, there was only 10% loss to follow-up from the start of the study until delivery (rationale explained in the study flow chart). Food intake records were taken by the dietitian not only for one day but also for the weekend, and food intakes were more accurately determined.

This study has several limitations. First, it only considered serum vitamin A and D values, overlooking other biochemical parameters that may influence nutritional status. Second, maternal anthropometric measurements were not included, limiting the evaluation of maternal nutritional status. Furthermore, because the data rely on self-reports, there is a possibility of under- or over-reporting in dietary intake. Future studies could address these limitations by incorporating more objective methods-such as digital food recording systems or validated food consumption questionnaires-to supplement self-reported dietary data.

CONCLUSION

High pre-pregnancy BMI and inadequate dietary magnesium intake had a negative impact on neonatal birth weight. Only one third of pregnant women achieved the recommended weight gain according to BMI. Only about half of pregnant women had good diet quality. The high prevalence of deficiencies in certain vitamin and mineral intakes among pregnant women indicates significant deficiencies in adequate and balanced nutrition. Maintaining an ideal BMI and providing advice on healthy eating during pregnancy by health professionals may reduce the risk of adverse pregnancy outcomes.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Mehtap Metin Karaaslan;* ***Design:*** *Mehtap Metin Karaaslan, İlknur Kahriman;* ***Control/Supervision:*** *Mehtap Metin Karaaslan;* ***Data Collection and/or Processing:*** *Mehtap Metin Karaaslan, İlknur Kahriman, Canan Altınsoy, Kübra Arslantürk, Deniz Dereci Delibaş;* ***Analysis and/or Interpretation:*** *Mehtap Metin Karaaslan, Beril Gürlek, İlknur Kahriman, Deniz Dereci Delibaş, Bülent Yılmaz;* ***Literature Review:*** *Mehtap Metin Karaaslan, Kübra Arslantürk, Canan Altınsoy, Beril Gürlek;* ***Writing the Article:*** *Mehtap Metin Karaaslan, Canan Altınsoy, İlknur Kahriman;* ***Critical Review:*** *Mehtap Metin Karaaslan, Bülent Yılmaz, İlknur Kahriman, Canan Altınsoy, Kübra Arslantürk, Deniz Dereci Delibaş, Beril Gürlek;* ***References and Fundings:*** *Mehtap Metin Karaaslan, Bülent Yılmaz;* ***Materials:*** *Bülent Yılmaz.*

REFERENCES

1. Massari M, Novielli C, Mandò C, Di Francesco S, Della Porta M, Cazzola R, et al. Multiple micronutrients and docosahexaenoic acid supplementation during pregnancy: a randomized controlled study. Nutrients. 2020;12(8):2432. PMID: 32823606; PMCID: PMC7468952.
2. Ma G, Chen Y, Liu X, Gao Y, Deavila JM, Zhu MJ, et al. Vitamin a supplementation during pregnancy in shaping child growth outcomes: a meta-analysis. Crit Rev Food Sci Nutr. 2023;63(33):12240-55. PMID: 35852163; PMCID: PMC9849478.
3. Bastos Maia S, Rolland Souza AS, Costa Caminha MF, Lins da Silva S, Callou Cruz RSBL, Carvalho Dos Santos C, et al. Vitamin a and pregnancy: a narrative review. Nutrients. 2019;11(3):681. PMID: 30909386; PMCID: PMC6470929.
4. Soares MM, Silva MA, Garcia PPC, Silva LSD, Costa GDD, Araújo RMA, et al. Efect of vitamin A suplementation: a systematic review. Cien Saude Colet. 2019;24(3):827-38. PMID: 30892504.
5. Carazo A, Macáková K, Matoušová K, Krčmová LK, Protti M, Mladěnka P. Vitamin a update: forms, sources, kinetics, detection, function, deficiency, therapeutic use and toxicity. Nutrients. 2021;13(5):1703. PMID: 34069881; PMCID: PMC8157347.
6. Debelo H, Novotny JA, Ferruzzi MG. Vitamin a. Adv Nutr. 2017;8(6):992-4. PMID: 29141980; PMCID: PMC5683001.
7. Palacios C, Kostiuk LK, Peña-Rosas JP. Vitamin d supplementation for women during pregnancy. Cochrane Database Syst Rev. 2019;7(7):CD008873. Update in: Cochrane Database Syst Rev. 2024;7:CD008873. PMID: 31348529; PMCID: PMC6659840.
8. Bi WG, Nuyt AM, Weiler H, Leduc L, Santamaria C, Wei SQ. Association between vitamin d supplementation during pregnancy and offspring growth, morbidity, and mortality: a systematic review and meta-analysis. JAMA Pediatr. 2018;172(7):635-45. PMID: 29813153; PMCID: PMC6137512.
9. Kiely ME, Wagner CL, Roth DE. Vitamin d in pregnancy: where we are and where we should go. J Steroid Biochem Mol Biol. 2020;201:105669. PMID: 32302652.
10. Fang K, He Y, Mu M, Liu K. Maternal vitamin d deficiency during pregnancy and low birth weight: a systematic review and meta-analysis. J Matern Fetal Neonatal Med. 2021;34(7):1167-73. PMID: 31122092.
11. Miliku K, Vinkhuyzen A, Blanken LM, McGrath JJ, Eyles DW, Burne TH, et al. Maternal vitamin d concentrations during pregnancy, fetal growth patterns, and risks of adverse birth outcomes. Am J Clin Nutr. 2016;103(6):1514-22. PMID: 27099250; PMCID: PMC5410992.
12. Hocaoğlu M, Bulut Ö, Günay T, Turgut A, Ovalı F. The effects of maternal vitamin levels on infant birth weight. Jinekoloji-Obstetrik ve Neonatoloji Tıp Dergisi. 2020;17(4):569-73. doi: 10.38136/jgon.742332
13. Almidani E, Barkoumi A, Elsaidawi W, Al Aliyan S, Kattan A, Alhazzani F, et al. Maternal vitamin d levels and its correlation with low birth weight in neonates: a tertiary care hospital experience in Saudi Arabia. Cureus. 2021;13(4):e14528. PMID: 34012736; PMCID: PMC8126481.
14. Miller V, Webb P, Micha R, Mozaffarian D; Global Dietary Database. Defining diet quality: a synthesis of dietary quality metrics and their validity for the double burden of malnutrition. Lancet Planet Health. 2020;4(8):e352-e370. PMID: 32800153; PMCID: PMC7435701.
15. Krebs-Smith SM, Pannucci TE, Subar AF, Kirkpatrick SI, Lerman JL, Tooze JA, et al. Update of the healthy eating index: HEI-2015. J Acad Nutr Diet. 2018;118(9):1591-602. Erratum in: J Acad Nutr Diet. 2019;119(10):1759. PMID: 30146071; PMCID: PMC6719291.
16. Ojeda-Rodríguez A, Zazpe I, Morell-Azanza L, Chueca MJ, Azcona-Sanjulian MC, Marti A. Improved diet quality and nutrient adequacy in children and adolescents with abdominal obesity after a lifestyle intervention. Nutrients. 2018;10(10):1500. PMID: 30322156; PMCID: PMC6213517.
17. Fleming TP, Watkins AJ, Velazquez MA, Mathers JC, Prentice AM, Stephenson J, et al. Origins of lifetime health around the time of conception: causes and consequences. Lancet. 2018;391(10132):1842-52. PMID: 29673874; PMCID: PMC5975952.
18. Robb L, Joubert G, Walsh CM. Diet quality indexes for use during pregnancy: a scoping review. Nutr Rev. 2024;82(11):1622-30. PMID: 37897078; PMCID: PMC11464799.
19. Pekcan G. Beslenme durumunun saptanması. editör. Diyet El Kitabı. Baskı. Yayın yeri: Yayınevi; 2008. p.67-141.
20. Newby PK, Hu FB, Rimm EB, Smith-Warner SA, Feskanich D, Sampson L, et al. Reproducibility and validity of the diet quality ındex revised as assessed by use of a food-frequency questionnaire. Am J Clin Nutr. 2003;78(5):941-9. PMID: 14594780.
21. Bodnar LM, Siega-Riz AM. A diet quality index for pregnancy detects variation in diet and differences by sociodemographic factors. Public Health Nutr. 2002;5(6):801-9. PMID: 12570888.
22. World Health Organization [Internet]. A Healthy Lifestyle-WHO Recommendations. ©2011 WHO [Cited: January 7, 2024]. Available from: https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle---who-recommendations
23. Sağlık Bakanlığı Halk Sağlığı Genel Müdürlüğü. Türkiye Beslenme Rehberi (TÜBER) 2022. Erişim tarihi: 7 Ocak 2021. Erişim linki: https://hsgm.saglik.gov.tr/depo/birimler/saglikli-beslenme-ve-hareketli-hayat-db/Dokumanlar/Rehberler/Turkiye_Beslenme_Rehber_TUBER_2022_min.pdf
24. BEBİS. Bilgisayar Destekli Beslenme Programı, Beslenme Bilgi Sistemleri Paket Programı (BEBİS) Versiyon: 8.1. http://bebis.com.tr/
25. Albahlol IA, Almaeen AH, Alduraywish AA, Dar UF, El-Metwally TH. Vitamin D Status and pregnancy complications: serum 1,25-di-hydroxyl-vitamin d and its ratio to 25-hydroxy-vitamin d are superior biomarkers than 25-hydroxy-vitamin d. Int J Med Sci. 2020;17(18):3039-48. PMID: 33173424; PMCID: PMC7646113.
26. Chen H, Qian N, Yan L, Jiang H. Role of serum vitamin A and E in pregnancy. Exp Ther Med. 2018;16(6):5185-9. PMID: 30542475; PMCID: PMC6257734.
27. Bindler RC, Ball JW, London ML, Davidson MR, eds. Şahiner NC, Açıkgöz A, Bal MD, çeviri editörleri. Anne ve Çocuk Hemşireliği Klinik Uygulama Becerileri Kitabı. 4. Baskı. Ankara: Nobel Akademik Yayıncılık; 2014. p.72-4.
28. Çıracı S, Özdemir Ö. Çocuklarda ön fontanel boyutları ve kapanma zamanının bilgisayarlı tomografi ile değerlendirilmesi [Evaluation of anterior fontanelle sizes and closure time in children with computed tomography]. Sakarya Tıp Dergisi. 2022;12(3):378-83. https://doi.org/10.31832/smj.1145060
29. Girma S, Fikadu T, Agdew E, Haftu D, Gedamu G, Dewana Z, et al. Factors associated with low birthweight among newborns delivered at public health facilities of Nekemte town, West Ethiopia: a case control study. BMC Pregnancy Childbirth. 2019;19(1):220. PMID: 31266469; PMCID: PMC6604438.
30. Woldeamanuel GG, Geta TG, Mohammed TP, Shuba MB, Bafa TA. Effect of nutritional status of pregnant women on birth weight of newborns at Butajira Referral Hospital, Butajira, Ethiopia. SAGE Open Med. 2019;7:2050312119827096. PMID: 30728970; PMCID: PMC6351719.
31. Olson JM, Ameer MA, Goyal A. Vitamin A Toxicity. 2023 Sep 2. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025. PMID: 30422511.
32. Hanson C, Schumacher M, Lyden E, Furtado J, Van Ormer M, McGinn E, et al. Status of vitamin a and related compounds and clinical outcomes in maternal-ınfant pairs in the Midwestern United States. Ann Nutr Metab. 2017;71(3-4):175-82. PMID: 28942446.

33. Barua D, Nasrin B, Nahar KN, Shamim S, Barua AR, Begum F. Vitamin a concentration in cord and maternal serum and its effects on birth weight. Bangladesh J Child Health. 2009;33(2):46-9. https://doi.org/10.3329/bjch.v33i2.5676
34. Andiran N, Yordam N, Ozön A. Risk factors for vitamin d deficiency in breast-fed newborns and their mothers. Nutrition. 2002;18(1):47-50. PMID: 11827764.
35. Dawodu A, Tsang RC. Maternal vitamin d status: effect on milk vitamin d content and vitamin d status of breastfeeding infants. Adv Nutr. 2012;3(3):353-61. PMID: 22585912; PMCID: PMC3649470.
36. Ilgaz Ş, Yardım N, Çimen MYB, Kanbur N, Özmert EN, Satman İ, et al. Türkiye'de besinlerin D vitamini, folik asit ve demir ile zenginleştirilmesi: Sağlık Bakanlığı önerileri. Turk J Public Health. 2020;18(3):226-48. https://dergipark.org.tr/en/download/article-file/801265
37. Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP, et al; Endocrine Society. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. J Clin Endocrinol Metab. 2011;96(7):1911-30. Erratum in: J Clin Endocrinol Metab. 2011;96(12):3908. Erratum in: J Clin Endocrinol Metab. 2024;109(10):e1991. PMID: 21646368.
38. Yemenoğlu H. Doğu Karadeniz Bölgesinde yaşayan kronik gingivitis ve kronik periodontitisli bireylerde serum D vitaminleri seviyesinin IL-6, TNF-α, CRP düzeyleri ve klinik parametrelerle ilişkisinin değerlendirilmesi [Diş hekimliği uzmanlık tezi]. Rize: Recep Tayyip Erdoğan Üniversitesi; 2017. https://tez.yok.gov.tr/UlusalTezMerkezi/TezGoster?key=MzP7PYssFqdb3WIjlroAkYcJbUSK8X__ANzi81XAKWtqFCp7o0urnte5MQM2jjoV
39. Vats H, Saxena R, Sachdeva MP, Walia GK, Gupta V. Impact of maternal pre-pregnancy body mass index on maternal, fetal and neonatal adverse outcomes in the worldwide populations: A systematic review and meta-analysis. Obes Res Clin Pract. 2021;15(6):536-45. PMID: 34782256.
40. Sun Y, Shen Z, Zhan Y, Wang Y, Ma S, Zhang S, et al. Effects of pre-pregnancy body mass index and gestational weight gain on maternal and infant complications. BMC Pregnancy Childbirth. 2020;20(1):390. PMID: 32631269; PMCID: PMC7336408.
41. Makrides M, Crosby DD, Bain E, Crowther CA. Magnesium supplementation in pregnancy. Cochrane Database Syst Rev. 2014;2014(4):CD000937. PMID: 24696187; PMCID: PMC6507506.
42. Farag M, El-Baz Z, Ahmed EH. Comparison of maternal serum magnesium level in eclampsia, preeclampsia, and normal pregnant women admitted to El-Shatby Maternity Hospital. Evid Based Womens Health J. 2022;12(4):332-7. doi: 10.21608/ebwhj.2022.163590.1201
43. Mishu FA, Haque SMT. Estimation of serum magnesium in Bangladeshi gestational diabetic mother. Anwer Khan Mod Med Coll J. 2018;9(2):110-3. https://www.banglajol.info/index.php/AKMMCJ/article/view/39205/26679
44. Hansu K, Cikim IG. Vitamin and mineral levels during pregnancy. Rev Assoc Med Bras (1992). 2022;68(12):1705-8. PMID: 36449797; PMCID: PMC9779969.
45. Doyle W, Crawford MA, Wynn AH, Wynn SW. Maternal magnesium intake and pregnancy outcome. Magnes Res. 1989;2(3):205-10. PMID: 2640903.
46. Rodríguez-Bernal CL, Rebagliato M, Iñiguez C, Vioque J, Navarrete-Muñoz EM, Murcia M, et al. Diet quality in early pregnancy and its effects on fetal growth outcomes: the Infancia y Medio Ambiente (Childhood and Environment) Mother and Child Cohort Study in Spain. Am J Clin Nutr. 2010;91(6):1659-66. PMID: 20410088.
47. Reyes-López MA, González-Leyva CP, Rodríguez-Cano AM, Rodríguez-Hernández C, Colin-Ramírez E, Estrada-Gutierrez G, et al. Diet Quality Is Associated with a High Newborn Size and Reduction in the Risk of Low Birth Weight and Small for Gestational Age in a Group of Mexican Pregnant Women: An Observational Study. Nutrients. 2021;13(6):1853. PMID: 34071717; PMCID: PMC8227044.
48. Yisahak SF, Mumford SL, Grewal J, Li M, Zhang C, Grantz KL, Hinkle SN. Maternal diet patterns during early pregnancy in relation to neonatal outcomes. Am J Clin Nutr. 2021;114(1):358-67. PMID: 33742192; PMCID: PMC8246623.
49. Gesteiro E, Rodríguez Bernal B, Bastida S, Sánchez-Muniz FJ. Maternal diets with low healthy eating index or Mediterranean diet adherence scores are associated with high cord-blood insulin levels and insulin resistance markers at birth. Eur J Clin Nutr. 2012;66(9):1008-15. PMID: 22828732.
50. Poon AK, Yeung E, Boghossian N, Albert PS, Zhang C. Maternal dietary patterns during third trimester in association with birthweight characteristics and early ınfant growth. Scientifica (Cairo). 2013;2013:786409. PMID: 24490111; PMCID: PMC3893866.
51. Oh C, Keats EC, Bhutta ZA. Vitamin and mineral supplementation during pregnancy on maternal, birth, child health and development outcomes in low- and middle-income countries: a systematic review and meta-analysis. Nutrients. 2020;12(2):491. PMID: 32075071; PMCID: PMC7071347.
52. Keats EC, Haider BA, Tam E, Bhutta ZA. Multiple-micronutrient supplementation for women during pregnancy. Cochrane Database Syst Rev. 2019;3(3):CD004905. PMID: 30873598; PMCID: PMC6418471.
53. Brown B, Wright C. Safety and efficacy of supplements in pregnancy. Nutr Rev. 2020;78(10):813-26. Erratum in: Nutr Rev. 2020;78(9):782. PMID: 31925443; PMCID: PMC7558284.