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ORIGINAL ARTICLE

Effect of Vitamin D Supplementation According to Daily Dietary Levels on Biochemical Parameters in 25-Hydroxyvitamin D Deficiency of Women with Obesity

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ABSTRACT

Objectives: This study examined how vitamin D supplementation based on daily dietary intake affects biomarkers in obese women with 25-hydroxyvitamin D deficiency.

Materials and Methods: Group D (n= 14) used vitamin D supplements daily for 2 months, and Group C (n= 16) did not receive supplements. Three blood samples were collected from the volunteers during the initial phase of the study. In this study, blood was collected from the volunteers: first measurement (M1), second measurement (M2), and third measurement (M3).

Results: Compared with Group C, Group D had lower high-density lipoprotein (HDL) levels at M2 and fasting serum glucose (FSG) levels at M3 ($p < 0.05$), and lower HDL levels at M2 and FSG levels in normal-weight individuals at M3 ($p < 0.05$). In addition, 25-hydroxyvitamin D levels were higher in normal-weight women than in obese women according to M3 ($p= 0.043$). There was a higher negative correlation between HDL-C in M1 and FSG in Group D (r= -0.710, $p= 0.004$). 25-hydroxyvitamin D was moderately positively correlated with dietary vitamin D in M2 in Group D (r= 0.559, $p= 0.038$). Significant positive correlations were observed between iodine intake and triiodothyronine (T3) levels, whereas no significant difference was observed between thyroid-stimulating hormone and T3 levels.

Conclusion: Vitamin D intake improves HDL levels in normal-weight individuals and causes an effect on FSG to be at the desired low level, whereas in individuals with obesity, although serum 25-hydroxyvitamin D levels increased in the last measurement, no effect was observed. Women with normal vitamin D levels have higher serum 25-hydroxyvitamin D levels than those who are obese.

Keywords: Vitamin D supplement, fasting serum glucose, high-density lipoprotein, obesity, thyroid hormones,

INTRODUCTION

Two types of vitamin D have a fat-soluble sterol structure known as calciferol. Of these, ergocalciferol is taken from the diet (D2), whereas cholecalciferol is synthesized in the skin by sunlight (D3). The most significant indicator of human vitamin D status is 25-hydroxyvitamin D concentration. While its deficiency or insufficiency is frequently observed worldwide, its excess causes toxic effects. This deficiency, which is common worldwide, can be restored to normal levels with orally supplemented vitamin D.[1]

It has been reported that there is an opposite association between 25-hydroxyvitamin D and fasting blood glucose (FSG), and vitamin D intake improves FSG and HbA1c levels.[2]

Deficiency in 25-hydroxyvitamin D levels is also crucial for lipid profiles, which are markers of cardiovascular disease. It was reported that low or decreased 25-hydroxyvitamin D levels are related to hyperglycemia, high serum triglyceride (TG) levels, high cholesterol, and low high-density lipoprotein (HDL) levels.[3] In another study, vitamin D supplementation helped reduce blood levels of TGs, low-density lipoprotein (LDL), and total cholesterol (TC).[4]

One study stated that vitamin D levels were associated with thyroid-stimulating hormone (TSH).[5] A low vitamin D level in youth has been related to low wandering triiodothyronine (T3) levels.[6] When vitamin D was given to subjects with Hashimoto's thyroid, there was also a significant reduction in TSH hormone compared with the baseline.[7]

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When the literature is examined, the effects of circulating serum 25-hydroxyvitamin D levels on serum lipids, especially in cross-sectional and experimental studies, provide conflicting results.[8] Thus, further research on the effects of vitamin D supplementation on blood vitamin D levels is required. This study aimed to determine how vitamin D supplementation based on daily dietary intake affects TSH, T3, FSG, and lipid levels in normal-weight and obese women with 25-hydroxyvitamin D deficiency.

MATERIALS AND METHODS

Thirty volunteer women aged between 18 and 23 years who were known to have vitamin D deficiency were involved in this investigation. The research was conducted between February 2023 and April 2023 in the Avrasya University. The participants were divided into two groups (experimental and control groups). The experimental group received 10 mL of vitamin D [a total of 150,000 international units (IU)]. The volunteers consumed vitamin D for 2 months and received 3,200 IU of vitamin D per day. In the control group, no dietary supplementation was recommended. Patients with diabetes, thyroid disorders, and hypertension were not included in the study. The study did not include individuals with FPG levels › 100 or 25-hydroxyvitamin D levels › 20.

After the first measurement (M1, beginning) was obtained from the women, two more measurements were obtained with an average interval of 28 days. Blood was collected from the volunteers three times: M1, second measurement (M2, week four), and third measurement (M3, week eight). 25-hydroxyvitamin D levels were measured at each blood draw. Next, the blood was separated into serum by centrifugation (four thousand rpm for ten minutes) and preserved at 80 °C (Figure 1).

Routine biochemical analysis results

Biochemical parameters were examined by women participating in the study *via* the e-Pulse system (Republic of Türkiye Ministry of Health).

Serum 25-hydroxyvitamin D level

25-hydroxyvitamin D content was measured using an SD Biosensor Fluorescent Immunological device. The temperature was adjusted to 37 °C in the SD Biosensor (F200 Analyzer), and the extractor was activated. The test cassette was then inserted into the device to be read. With a micropipette, 155 microliters of bumper solvent and 35 microliters of serum specimen were added to the reaction tablet. This solution and test tape were placed in the incubator for 30 min, and then the material from reaction tablet two was added to this solution. After homogenization, the solution was completely transferred to the test tape well using a micropipette and then incubated for 15 days. The 25-hydroxyvitamin D level was then determined by scanning the cassette. The proposed method and device have been accepted in the literature.[9]

Fasting serum glucose level

Serum glucose levels during fasting were measured after subjects had fasted for an average of 6 to 8 hours. The American Diabetes Association has determined impaired FSG tolerance to be › 100 mg/dL.[10]

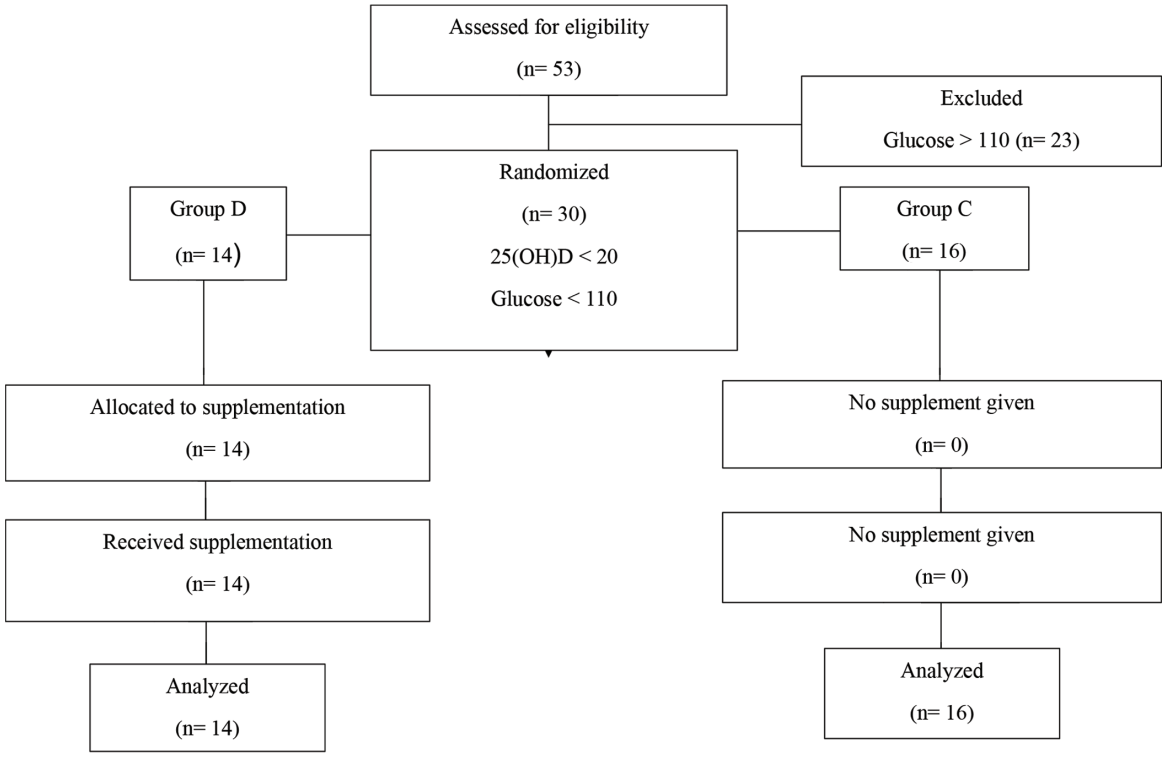

Figure 1. CONSORT flowchart the flow of participants through the trial is represented by a diagram, as suggested by the CONSORT group. Group C: No reinforcement; group D: Vitamin D supplement

FSG measurements were performed using the Accu-Chek Performa Nano device when taking samples.[9] After the device was activated, an unused measuring strip was placed in the device, and 35 microliters of serum specimen were taken from the blood serum using a micropipette. The sample was dripped onto the tip of the strip. The measurement results were taken immediately afterward.

Measurement of serum lipid levels

After the stored serums thawing, LDL, HDL, non-HDL, TC, and TG levels were measured with a Standard LipidoCare Analyzer and a Lipid Profile Test Strip. The SD LipidoCare is an approved device that diagnoses patients rapidly and precisely in a clinical setting.[11]

The device was turned on, and the measurement setting was set to serum. The lid of the device was opened, and 35 L of serum specimen was received with a micropipette and placed into the application hole of the device, and the lid was closed. Results were obtained after a 3-minute waiting period.

Measuring ranges

100-450 mg/dL for TC, 25-95 mg/dL for HDL cholesterol, 0-130 mg/dL for LDL, and 45-650 mg/dL for TGs. This study considered TC ideal for < 200 mg/dL and high for > 240 mg/dL. In HDL-C levels, > 55 mg/dL in women and > 45 mg/dL in men are ideal. TG < 150 mg/dL was accepted as ideal.

Serum TSH level

A 35 µl sample was taken from the serum using a STANDARD Ezi tube and distributed in the extraction buffer. Then, the sample and buffer were mixed 2-3 times with a 100 µL pipette and placed in the test cassette, and the result was obtained after 15 minutes. The normal range for TSH has been determined as 0.45-4.5 mIU/mL.

Serum T3 levels

A standard D-BLOCK incubator device was prepared and its temperature was raised to 37 °C. Using a micropipette, 100 L of serum was obtained. The sample was added to the extraction buffer, and a Spoitte tablet was dissolved. The cells were kept in the incubation device and previously brought to 37 °C for 10 minutes. The tester was placed in the test slot of the analyzer. A hundred µl of the incubated sample mixture was taken and applied to the specimen well of the test device. The result was obtained 15 deeps after the test start button was pressed. The measuring range of the device is 0.3-10.0 nmol/L, and the normal range for T3 is specified as 1.3-3.1 nmol/L.

Anthropometric measurements

Using the bioelectrical impedance analysis (BIA) approach, the TANITA MC-780MA was used to assess weight body fat, protein, muscle, waist-hip ratio, visceral fat level, basal metabolic rate, waist circumference, and mineral levels. A stadiometer was used for height measurement. Women were classified as obese or normal according to the fat ratio determined by the BIA method. Obese (D group = 6, C group = 9), and normal (D group = 8, C group = 7) were determined. A power analysis of obese and normal women was performed, and the effect size was found to be 1.70, and the power was found to be 92% One-Way and 85% Two-Way.

Diet quality calculation

Diet quality was calculated using frequency questionnaires on food consumption among women. Diet quality was assessed using the Diet Quality Index-International scale.[12]

Ethics statement

The ethics committee approval for this study was approved by the Avrasya University Ethics Committee (approval number: 2022-52/14, date: 21.07.2022). Informed consent was obtained from all participants. This study was registered with ClinicalTrials.gov (identifier number: NCT05447065).

Statistical analysis

Data were analyzed using R language and R studio v.0.98.501. The data were evaluated using the Kolmogorov-Smirnov or Shapiro-Wilk tests to determine their normal distribution. Continuous variables are presented as mean ± standard deviation (SD). The Wilcoxon signed rank test and the Mann-Whitney U test were, respectively, used to assess the data of dependent and independent groups that did not exhibit normal distribution. If a Three-Way comparison was made between independent groups, the results were analyzed using Friedman's variance. Food consumption records and food frequency forms were analyzed using CEBEBIS. G-Power v. 3.1.9.4 software was used to calculate the sample size, and statistical significance was determined as $p < 0.05$.

RESULTS

Women with low vitamin D levels were included in this study. The participants consisted of a total of 30 volunteer women, including those who took vitamin D supplements (n= 14) and those who did not take vitamin D supplements (n= 16). The mean ages of groups D and C were 20.07 ± 1.33 and 20.56 ± 1.36, respectively. Frequency of food consumption, anthropometric measurements, FSG levels, serum lipids (LDL, HDL, TG, and TC), serum TSH, and serum T3 levels were measured.

Regarding age and routine biochemical values, there was not a significant difference between Group D and C (except from NEUTROPHIL). A comparison of Group D to Group C revealed significant decreases in the intake of cheese, butter, eggs, sunflower oil, margarine, yogurt, and white bread. The data on the frequency of each person's food consumption was analyzed after one year. Energy, protein, fat, MUFA, PUFA, linolenic acid, linoleic acid, myristic acid, lauric acid, palmitic acid, oleic acid, cholesterol, retinol, folate, vitamin D, vitamin E, and vitamin B 1 values in group D A decreased in vitamin B2, sodium, potassium, phosphorus, and zinc values compared to group C. In addition, in the comparison of Groups D and C, the w-3/w-6 ratio was higher in Group D (Table 1).

When the anthropometric measurements between the groups were analyzed, no difference was observed between the three measurements (Table 2).

When the anthropometric measurements of the women were analyzed, no significant difference was found between the

Table 1. Comparison of the characteristics of healthy volunteers, routine biochemical findings, frequency of food consumption, average daily energy consumption, and food consumption frequencies of the groups[a]

	Group D (n= 14)	Group C (n= 16)	*p*[b]
Routine biochemical findings			
Age (years)	20.07 ± 1.33	20.56 ± 1.36	0.334
PA (met-min./week)	2744.40 ± 2944.13	2473.94 ± 1953.27	0.773
ALT (U/L)	12.57 ± 6.03	13.75 ± 0.95	0.358
AST (U/L)	13.91 ± 3.76	19.29 ± 7.41	0.140
BASOPHIL (10*3/uL)	0.07 ± 0.04	0.06 ± 0.04	0.709
NEUTROPHIL (10*3/uL)	5.22 ± 1.64	4.10 ± 1.18	0.029
EOSINOPHIL (10*3/uL)	0.20 ± 0.13	0.11 ± 0.08	0.259
LYMPHOCYTE (10*3/uL)	2.63 ± 0.75	2.3 ± 0.92)	0.624
MONOCYTE (10*3/uL)	0.70 ± 0.18	0.56 ± 0.27	0.093
RBC (10*6/uL)	4.67 ± 0.39	4.60 ± 0.53	0.311
HGB (g/dL)	12.73 ± 1.55	12.74 ± 1.38	0.732
MCV (fL)	81.14 ± 8.29	85.73 ± 10.18	0.105
MCH (pg)	27.193 ± 0.88	28.34 ± 4.28	0.368
MCHC (g/dL)	33.45 ± 2.20	33.02 ± 2.48	0.471
HCT (%)	37.98 ± 3.21	38.51 ± 3.31	0.857
PLT (10*3/uL)	295.58 ± 94.35	273.01 ± 81.83	0.328
MPV (fL)	8.33 ± 1.09	8.86 ± 1.68	0.328
PDW (fL)	17.23 ± 3.60)	18.04 ± 8.17	0.496
PCT (%)	0.25 ± 0.11	0.24 ± 0.08	0.586
WBC (10*3/uL)	8.89 ± 1.88	8.09 ± 2.56	0.247
Average daily energy and food consumption frequencies			
Energy (kcal)	1225.80 ± 354.43	1763.29 ± 668.78	0.011
CHO (g)	145.98 ± 51.88	194.78 ± 110.20	0.262
Protein(g)	33.57 ± 9.16	53.93 ± 22.72)	0.009
Fat (g)	55.37 ± 25.94	83.88 ± 19.03	< 0.001
Cholesterol (mg)	120.81 ± 67.51	262.86 ± 136.50	0.001
Fiber (g)	13.39 ± 6.10	17.47 ± 10.38	0.271
Alcohol (g)	0.01 ± 0.04	0.05 ± 0.13	0.437
Saturated fatty acid (g)	24.29 ± 8.65	32.63 ± 11.56	0.067
Myristic acid (g)	2.02 ± 1.32	3.30 ± 1.75	0.034
Lauric acid (g)	0.85 ± 0.44	1.34 ± 0.69	0.045
Palmitic acid (g)	11.31 ± 4.11	15.59 ± 5.12	0.029
Monounsaturated fatty acid (g)	20.23 ± 11.20	29.28 ± 7.85	0.002
Oleic acid (g)	18.47 ± 10.55	26.98 ± 7.57	0.002
Polyunsaturated fatty acid (g)	7.11 ± 6.06	14.88 ± 4.54	< 0.001
Linoleic acid (g)	5.76 ± 5.76	12.99 ± 4.49	< 0.001
a-linolenic acid(g)	0.60 ± 0.27	0.98 ± 0.39	0.007

Table 1. Continued

	Group D (n= 14)	Group C (n= 16)	p^b
Average daily energy and food consumption frequencies			
Omega-3/Omega-6	0.14 ± 0.07	0.09 ± 0.05	0.023
Water (g)	934.86 ± 442.41	1097.76 ± 507.08	0.198
Retinol (µg)	330.37 ± 339.90	600.66 ± 557.17	0.013
A (µg)	710.66 ± 487.27	1040.01 ± 746.89	0.088
D (µg)	2.34 ± 1.45	5.01 ± 3.67	0.023
E (mg)	6.19 ± 7.49	14.04 ± 5.77	0.000
Thiamine (mg)	0.54 ± 0.26	0.78 ± 0.38	0.015
Riboflavin (mg)	0.87 ± 0.22	1.41 ± 0.52	0.005
Niacin (mg)	6.44 ± 1.80	8.64 ± 4.08	0.280
B6 vit. (µg)	0.60 ± 0.15	0.80 ± 0.37	0.062
Folate (µg)	168.04 ± 94.18	247.63 ± 126.20	0.025
B12 vit. (µg)	2.09 ± 1.33	3.77 ± 2.41	0.005
C vit. (µg)	63.42 ± 33.81	72.61 ± 47.52	0.678
Sodium (mg)	990.82 ± 388.95	1679.03 ± 843.69	0.009
Potassium (mg)	1416.24 ± 468.59	1877.40 ± 805.27	0.031
Calcium (mg)	465.33 ± 103.96	713.39 ± 312.40	0.051
Phosphorus (mg)	654.05 ± 160.00	964.71 ± 393.95	0.009
Magnesium (mg)	178.59 ± 57.72	235.08 ± 98.39	0.051
Iron (mg)	4.89 ± 1.89	6.51 ± 3.31	0.124
Zinc (mg)	5.25 ± 1.30	7.38 ± 2.89	0.013
Essential amino acid (µg)	17.14 ± 5.07	27.64 ± 10.95	0.006
Comparison of food consumption frequency			
Black tea (%)	3.47 ± 6.03	2.75 ± 2.57	0.447
Turkish coffee (%)	2.03 ± 2.62	3.64 ± 4.48	0.538
Instant coffee (%)	3.79 ± 5.31	2.53 ± 4.91	0.356
Herbal teas (%)	1.93 ± 3.54	4.17 ± 6.28	0.086
Fizzy drinks (cola, soda, etc.) (%)	2.65 ± 4.05	3.18 ± 5.83	0.882
Mineral water (%)	2.97 ± 4.86	3.58 ± 5.85	0.966
Instant juice (%)	2.97 ± 5.73	3.57 ± 6.53	0.717
Alcoholic beverages (%)	0.00 ± 0.00	0.00 ± 0.00	1.000
Bagel/Pastry (%)	1.94 ± 3.07	3.59 ± 6.85	0.292
Rice (%)	2.80 ± 3.06	3.55 ± 4.67	0.830
Bulgur rice (%)	3.30 ± 7.99	2.97 ± 4.12	0.172
Pasta (%)	3.02 ± 4.11	2.36 ± 2.44	0.931
Cake/Biscuit (%)	2.27 ± 3.36	3.71 ± 3.55	0.076
Diet biscuits (%)	6.56 ± 18.17	0.51 ± 1.56	0.442
Dumplings (%)	1.39 ± 2.01	4.06 ± 5.61	0.092
Milky desserts (%)	1.51 ± 1.87	4.51 ± 6.32	0.108

Table 1. Continued

	Group D (n= 14)	Group C (n= 16)	p^b
Comparison of food consumption frequency			
Chocolate (%)	2.92 ± 2.58	1.95 ± 1.46	0.570
Jam, honey, and molasses (%)	3.00 ± 3.77	3.03 ± 7.06	0.657
Olives (%)	2.49 ± 4.26	3.56 ± 3.67	0.208
Butter (%)	0.92 ± 2.92	4.22 ± 8.51	0.026
Margarine (%)	0.00 ± 0.00	4.40 ± 10.87	0.049
Olive oil (%)	2.23 ± 4.15	3.14 ± 3.52	0.146
Sunflower oil (%)	1.44 ± 3.39	4.89 ± 3.73	0.003
Red meat (%)	2.52 ± 1.58	3.38 ± 5.93	0.390
Chicken meat (%)	2.53 ± 3.14	3.84 ± 4.02	0.531
Fish (%)	2.18 ± 2.89	3.72 ± 3.32	0.108
Egg (%)	1.04 ± 1.51	3.97 ± 3.58	0.008
Salami/Sausage etc. (%)	2.57 ± 3.15	3.79 ± 5.83	0.656
Dry beans (%)	2.45 ± 4.12	3.39 ± 3.80	0.186
Oilseeds (%)	1.87 ± 2.10	3.39 ± 3.80	0.086
Offal (%)	2.02 ± 6.54	4.48 ± 12.46	0.701
Yogurt (%)	1.89 ± 1.92	3.97 ± 2.60	0.025
Buttermilk (%)	2.14 ± 2.35	3.73 ± 5.12	0.362
Kefir (%)	1.48 ± 3.10	4.96 ± 14.61	0.757
Cheese (%)	2.42 ± 3.77	3.65 ± 3.33	0.049
Green leafy vegetables (%)	2.60 ± 3.05	3.62 ± 3.28	0.223
Other vegetables (%)	3.00 ± 3.01	3.20 ± 2.75	0.471
Dried fruit (%)	5.96 ± 12.05	1.04 ± 1.25	0.911
Fresh fruit (%)	2.96 ± 3.09	2.94 ± 3.51	0.786
Freshly squeezed fruit juice (%)	2.75 ± 5.24	3.71 ± 7.72	0.565
White bread (%)	0.93 ± 1.35	5.32 ± 8.52	0.020
Whole wheat bread (%)	0.96 ± 2.48	4.84 ± 7.21	0.185
Whole grain bread (%)	4.39 ± 5.21	2.29 ± 4.29	0.128

[a]Data are expressed as mean ± SD, [b]*p* values were determined using a Mann-Whitney U test. D group, vit-D supplemented group; C, no reinforcement. PA: Physical activity, ALT: Alanine aminotransferase, AST: Aspartate transaminase, RBC: Red blood cells, HGB: Hemoglobin, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, HCT: Hematocrit, PLT: Platelets, MPV: Mean platelet volume, PDW: Platelet distribution width, PCT: Plateletcrit, WBC: White blood cells, vit.: Vitamin, SD: Standard deviation

within-group and between-group analyses (Table 3). The fat values of the obese group were M1 (mean ± SD = 31.05 ± 3.40), M2 (mean ± SD = 30.80 ± 3.24) and M3 (mean ± SD = 31.62 ± 2.94), respectively. The fat values of the normal weight group were M1 (mean ± SD = 19.99 ± 4.24), M2 (mean ± SD = 21.11 ± 4.15) and M3 (mean ± SD = 21.31 ± 3.98).

A significant increase in FSG and TG levels in group C was observed between both the M1-M2 and the M2-M3. In addition, between M2 and M3, HDL values significantly decreased (Table 4).

There were no significant differences between groups for all values in M1. HDL levels were found to be higher in Group D in M2. In M3, although the FSG levels were lower, the vitamin D levels were significantly higher in Group D. However, there were no significant differences in LDL, non-HDL, TC, TSH, T3, and HDL/LDL levels among the M3 (Table 4).

Between M1 and M2 in Group D, FSG levels significantly decreased. A significant increase in HDL levels was observed between stations M2 and M3. A significant increase in TG levels was observed in M1 and M3. A significant increase in

Table 2. Comparison of food consumption record[a]									
	Group D (n= 14)			Group C (n= 16)			p^b	p^c	p^d
	M1	M2	M3	M1	M2	M3			
Energy (kcal)	969.91 ± 342.66	1041.88 ± 403.34	1188.75 ± 353.97	1206.99 ± 438.70	1230.28 ± 426.44	1407.65 ± 530.58	0.105	0.198	0.239
Water (g)	675.62 ± 226.98	677.48 ± 241.73	673.28 ± 232.71	797.57 ± 249.77	863.16 ± 188.24	853.38 ± 245.76	0.170	0.011	0.074
Protein (g)	45.38 ± 15.43	42.69 ± 29.65	43.26 ± 11.97	45.72 ± 17.80	43.84 ± 14.65	53.16 ± 17.37	0.967	0.506	0.111
Fat (g)	47.25 ± 19.47	53.51 ± 21.94	56.85 ± 17.42	60.56 ± 25.65	57.62 ± 22.28	63.91 ± 25.20	0.157	0.547	0.663
CHO (g)	88.91 ± 37.30	92.67 ± 37.53	123.51 ± 53.40	117.19 ± 47.10	131.33 ± 56.59	152.14 ± 68.97	0.135	0.081	0.275
Fiber (g)	9.16 ± 4.87	9.15 ± 4.08	9.98 ± 3.42	10.41 ± 5.18	11.10 ± 4.60	11.29 ± 4.42	0.183	0.158	0.407
Polyunsaturated fatty acid (g)	8.17 ± 3.04	10.36 ± 3.77	10.97 ± 7.14	8.67 ± 3.54	9.34 ± 5.96	11.04 ± 5.61	0.618	0.146	0.663
Cholesterol (mg)	214.52 ± 146.08	264.56 ± 223.31	200.64 ± 101.33	295.72 ± 162.82	236.46 ± 104.11	279.86 ± 142.74	0.124	0.647	0.127
Vitamins									
D (µg)	3.41 ± 4.44	1.50 ± 1.17	2.19 ± 3.03	3.37 ± 3.37	4.04 ± 2.73	4.36 ± 3.32	0.299	0.003	0.023
A (mg)	596.68 ± 429.33	635.98 ± 359.44	1117.49 ± 2070.88	882.76 ± 627.28	707.84 ± 444.92	550.96 ± 234.41	0.124	0.533	0.793
E (mg)	6.18 ± 2.97	6.81 ± 3.96	7.68 ± 4.22	7.54 ± 3.04	7.90 ± 5.33	8.45 ± 3.76	0.190	0.677	0.458
Carotene (mg)	2.07 ± 2.26	1.81 ± 1.31	1.77 ± 1.31	1.88 ± 1.26	1.99 ± 2.52	1.13 ± 0.57	0.533	0.442	0.256
Thiamine (mg)	0.48 ± 0.14	0.46 ± 0.22	0.50 ± 0.14	0.51 ± 0.24	0.54 ± 0.21	0.62 ± 0.21	0.738	0.316	0.142
Riboflavin (mg)	0.69 ± 0.36	0.73 ± 0.36	0.80 ± 0.38	0.92 ± 0.36	0.91 ± 0.22	0.98 ± 0.37	0.151	0.077	0.205
Pyridoxine (mg)	0.85 ± 0.42	0.85 ± 0.43	0.93 ± 0.26	0.83 ± 0.45	0.78 ± 0.38	0.99 ± 0.39	0.851	0.479	0.827
Folate (µg)	152.51 ± 73.06	147.79 ± 69.09	154.86 ± 76.37	175.49 ± 86.60	175.35 ± 92.36	158.68 ± 63.03	0.253	0.406	0.663
Minerals									
Iodine (mg)	249.43 ± 124.36	273.39 ± 117.76	271.29 ± 110.79	337.52 ± 112.59	356.30 ± 144.33	329.21 ± 140.45	0.061	0.135	0.239
Sodium (mg)	1744.81 ± 741.73	1748.40 ± 901.61	2194.08 ± 1041.97	2237.35 ± 738.27	2360.82 ± 814.64	2528.34 ± 912.43	0.081	0.056	0.256
Potassium (mg)	1362.60 ± 450.46	1359.87 ± 660.28	1511.67 ± 412.08	1501.22 ± 600.62	1579.38 ± 527.95	1667.94 ± 542.77	0.480	0.198	0.458
Calcium (mg)	343.79 ± 225.60	307.87 ± 189.17	394.24 ± 112.93	416.61 ± 202.73	460.99 ± 148.62	481.46 ± 195.24	0.360	0.028	0.256
Magnesium (mg)	146.07 ± 45.81	144.94 ± 49.42	163.16 ± 33.97	167.48 ± 73.45	174.99 ± 61.00	195.07 ± 59.87	0.280	0.114	0.127
Iron (mg)	6.04 ± 1.97	5.50 ± 2.54	6.32 ± 1.84	6.38 ± 2.86	6.26 ± 2.13	7.65 ± 2.49	0.693	0.170	0.106
Zinc (mg)	6.16 ± 2.35	6.10 ± 2.76	6.30 ± 2.50	6.69 ± 2.46	6.29 ± 2.28	7.58 ± 2.22	0.350	0.787	0.127

D group, vit-D supplemented group; C, no reinforcement. [a]Data are expressed as mean ± SD. [b-d]*p* values were determined using a Mann-Whitney U test. vit.: Vitamin, SD: Standard deviation, M1: First measurement, M2: Second measurement, M3: Third measurement

Table 3. Comparison of anthropometric measurements of all volunteers[a]

	Group D (n= 14)			Group C (n= 16)			p^b	p^c	p^d
	M1	M2	M3	M1	M2	M3			
Weight (kg)	60.81 ± 10.15	61.50 ± 9.77	62.06 ± 10.30	61.72 ± 11.38	62.10 ± 11.10	62.29 ± 11.10	0.803	0.917	0.861
Height (cm)	161.79 ± 3.24	161.86 ± 3.30	161.79 ± 3.24	162.13 ± 6.73	162.13 ± 6.73	161.53 ± 6.52	0.868	0.917	0.896
BMI (kg/m^2)	23.21 ± 3.64	23.46 ± 3.57	23.69 ± 3.71	23.40 ± 3.48	23.56 ± 3.45	23.79 ± 3.36	0.835	0.901	0.861
Waist/Hip	0.78 ± 0.05	0.78 ± 0.05	0.79 ± 0.05	0.80 ± 0.07	0.78 ± 0.05	0.79 ± 0.05	0.465	0.950	0.948
Waist (cm)	75.29 ± 10.17	75.93 ± 9.98	76.71 ± 10.25	75.88 ± 10.78	76.38 ± 10.29	72.65 ± 22.26	0.851	0.967	0.861
Visceral fat	1.86 ± 1.17	1.79 ± 1.12	2.00 ± 1.24	1.81 ± 1.11	1.81 ± 1.11	2.07 ± 1.16	0.964	0.837	0.814
Muscle (%)	70.85 ± 6.76	70.39 ± 6.39	69.97 ± 6.69	70.55 ± 6.32	70.18 ± 5.46	69.32 ± 5.38	0.934	0.967	1.000
Mineral (%)	4.79 ± 0.98	4.64 ± 0.93	4.83 ± 0.93	4.84 ± 0.90	4.82 ± 0.88	4.93 ± 0.83	0.934	0.519	0.662
Protein (%)	15.97 ± 1.61	15.97 ± 1.62	15.63 ± 1.58	15.69 ± 1.27	15.74 ± 1.35	15.38 ± 1.30	0.493	0.662	0.727
PBF (%)	25.34 ± 7.15	25.84 ± 6.75	26.29 ± 7.04	25.68 ± 6.66	26.06 ± 5.77	26.98 ± 5.66	0.934	1.000	0.983
BMR (Kcal)	1398.6 ± 129.73	1407.07 ± 120.77	1409.21 ± 126.10	1410.25 ± 144.43	1414.38 ± 146.93	1404.27 ± 147.74	0.852	0.983	0.810

D group, vit-D supplemented group; C, no reinforcement. [a]Data are expressed as mean ± SD, [b-d]*p* values were determined using a Mann-Whitney U test. BMI: Body mass index, PBF: Body fat percentage, BMR: Basal metabolic rate, SD: Standard deviation, M1: First measurement, M2: Second measurement, M3: Third measurement

FSG and TG levels was observed between M1 and M2 in Group C. In addition, a significant decrease in FSG and HDL levels was observed between M2 and M3. There was a significant difference in HDL values in M2 between groups D and C. The M3 FSG and LDL levels were lower in the experimental group, whereas the 25-hydroxyvitamin D levels were higher (Table 4).

In group D, a significant difference was observed between the FSG values of obese and normal-weight women in the M2 and M3. In addition, 25-hydroxyvitamin D levels were higher in normal-weight women than in obese women according to M3. In Group C, M2 showed that normal-weight women had lower TG values than obese women (Table 5).

When women were categorized as obese and normal-weight, HDL levels of normal-weight women were found to be lower in group D than in group C in the M2. In M3, 25-hydroxyvitamin D levels of normal women in the D group were significantly higher, whereas FSG levels were significantly lower than in group C. FSG levels in group D were significantly lower in the M2 of obese women than in group C. In the M3 of obese individuals, 25-hydroxyvitamin D levels were significantly higher in the D group than in group C. The M1 showed no significant difference between the obese and normal-weight women's groups (Group C and Group D) (Figure 2).

In M1 of group C, a moderate positive correlation was found between 25-hydroxyvitamin D and TG and LDL, respectively (r= 0.531 p= 0.034, r= 0.516 p= 0.041). In M2 of group C, a moderately strong positive correlation was observed between iodine intake and TSH level (r= 0.594, p= 0.015). M2 of HDL had a moderate positive correlation with α-linolenic acid, linoleic acid, MUFA, PUFA, and fat intake. In contrast, no significant correlation was found between M1 and M2, respectively (r= 0.653 $p < 0.001$, r= 0.571 p= 0.001, r= 0.436 p= 0.016, r= 0.573 p= 0.001, r= 0.536 p= 0.002).

In the M2 and M3 of the D group, a moderately strong positive correlation was observed between iodine intake and T3 values. At the same time, a moderately positive relationship was found between dietary vitamin D and serum 25-hydroxyvitamin D levels. There was no significant relationship between vitamin D intake and other serum 25-hydroxyvitamin D levels (M1, M3). While FSG and HDL in M1 in group D showed a highly negative correlation, no significant correlation was found between other measurements (M2, M3). In the M3 group, a moderate positive association was found between HDL and iodine intake and between T3 and vitamin D intake (Figure 3).

DISCUSSION

The current study investigated the effects of vitamin D supplementation on fasting serum glucose, serum lipid, serum TSH, and T3 levels in obese and normal-weight women with vitamin D deficiency.

Both groups (D and C) were evaluated in detail in terms of anthropometric values, frequency of food consumption, and routine biochemical parameters, and it was determined that the groups were close to each other.

Table 4. Responses of all volunteers to biochemistry parameters between and within groups[a]

	Group D (n= 14)			Group C (n= 16)			p^x	p^b	p^c	p^d	p^e	p^f	p^g	p^h	p^i
	M1	M2	M3	M1	M2	M3									
Fasting serum glucose level (mg/dL)	81.00 ± 5.55	76.71 ± 8.34	78.93 ± 11.98	86.25 ± 8.47	81.69 ± 9.62	87.60 ± 10.88	0.030	0.706	0.624	0.043	0.026	0.865	0.144	0.163	0.044
LDL (mg/dL)	81.21 ± 18.76	77.11 ± 16.48	75.20 ± 17.54	85.36 ± 27.71	79.76 ± 25.69	90.93 ± 24.55	0.109	0.975	0.209	0.423	0.084	0.638	0.835	0.787	0.048
HDL (mg/dL)	48.64 ± 13.79	44.07 ± 10.77	49.57 ± 9.51	52.81± 11.39	56.31 ± 9.10	47.21 ± 10.48	0.102	0.017	0.950	0.352	0.019	0.346	0.441	0.004	0.629
Non-HDL	93.57 ± 22.01	90.00 ± 18.77	89.93 ± 18.12	94.19 ± 30.47	93.44 ± 27.17	105.43 ± 26.50	0.162	0.530	0.432	0.897	0.069	0.278	0.852	0.632	0.161
TC (mg/dL)	142.64 ± 25.46	134.07 ± 21.71	139.50 ± 19.91	147.00 ± 30.91	149.75 ± 25.19	152.64 ± 20.23	0.059	0.132	0.638	0.552	0.249	0.507	0.708	0.088	0.089
TG (mg/dL)	61.50 ± 28.95	64.86 ± 30.19	73.57 ± 34.77	57.38 ± 14.27	67.75 ± 19.13	71.79 ± 21.56	0.700	0.330	0.033	0.035	0.551	0.026	0.950	0.140	0.476
TSH (mIU/mL)	1.83 ± 1.24	1.63 ± 0.82	1.51 ± 0.65	1.43 ± 0.75	1.59 ± 0.90	1.77 ± 1.11	0.925	0.552	0.660	0.918	0.706	0.198	0.360	0.835	0.927
T3 (nmol/L)	2.66 ± 1.17	2.55 ± 0.65	2.64 ± 0.60	2.22 ± 0.60	2.26 ± 0.70	2.41 ± 1.03	0.917	0.346	0.551	1.000	0.184	0.132	0.417	0.119	0.476
25-hydroxyvitamin D (ng/mL)	10.94 ± 2.58	13.66 ± 3.76	24.47 ± 10.13	11.78 ± 2.40	12.11 ± 3.87	15.01 ± 11.12	0.052	0.001	0.001	0.717	0.925	0.331	0.129	0.056	< 0.001
LDL/HDL	1.79 ± 0.61	1.84 ± 0.59	1.56 ± 0.40	1.68 ± 0.458	1.49 ± 0.64	2.04 ± 1.01	-	-	-	-	-	-	0.868	0.074	0.295
TC/HDL	3.10 ± 0.77	3.16 ± 0.75	2.89 ± 0.56	2.87 ± 0.68	2.73 ± 0.71	3.37 ± 3.14	-	-	-	-	-	-	0.647	0.105	0.407

D group, vit-D supplemented group; C, no reinforcement. [a]Data are expressed as mean ± SD. Group D [M1-M2 (p^x)], [M2-M3 (p^b)], and [M1-M3 (p^c)] were determined using the paired Wilcoxon Test for within-group differences. Group C [M1-M2 (p^d)], [M2-M3(p^e)], and [M1-M3(p^f)] were determined using the paired Wilcoxon Test for within-group differences. Differences between groups D and C [M1-M1 (p^g)], [M2-M2 (p^h)], and [M3-M3 (p^i)] were determined using the Mann-Whitney U test. SD: Standard deviation, M1: First measurement, M2: Second measurement, M3: Third measurement, LDL: Low-density lipoprotein, HDL: High-density lipoprotein, TC: Total cholesterol, TSH: Thyroid-stimulating hormone, T3: Triiodothyronine, TG: Triglyceride

Vitamin D deficiency is common nowadays and can lead to many negative consequences. Therefore, to eliminate this deficiency and prevent its effects, vitamin D supplementation should be administered at appropriate doses to reach serological levels. The recommended daily vitamin D supplement level by the WHO is 200-400 IU/day.[13]

Participants in the study by Hirschler et al.[14] received a monthly vitamin D dose of 100,000 IU. In another study, volunteer women with vitamin D deficiency were given 2800 IU of vitamin D daily for 12 weeks.[15] When the studies were examined, it was stated that no side effects were observed. In this study, 75,000 IU vitamin D supplements per month were administered to volunteers with vitamin D deficiency, and no side effects were detected.

Serum 25-hydroxyvitamin D levels were correlated with glucose homeostasis after reviewing experimental and observational studies on the impact of vitamin D supplementation were reviewed.[16] Low serum 25-hydroxyvitamin D levels impair insulin secretion and increase the risk of developing T2DM. Low vitamin D levels are associated with high FSG.[17] In another study, the use of vitamin D3 supplementation did not result in a significantly lower risk of diabetes among individuals with vitamin D deficiency.[18] This study found that fasting serum glucose levels decreased significantly when serum 25-hydroxyvitamin D levels increased concurrently with vitamin D management in women with vitamin D deficiency. A study examining glucose metabolism and lipid profiles in young people, excluding vitamin D, reported a significant negative correlation between FSG and HDL levels.[19] Similarly, in this study, a significant negative correlation was found between FSG and HDL in the M1 in group D. In addition, FSG levels at the M2 in group D significantly decreased compared with the M1.

Body fat distribution is also important for glucose, lipid metabolism, and 25-hydroxyvitamin D levels. In another study, obese children were found to have lower HDL-C and higher TG levels than healthy children. At the same time, glucose, LDL, and TC levels were lower in normal children than in obese children.[20] In this study, the HDL levels of normal individuals in group D were lower at the M2, and the FSG levels were lower at the third. FSG levels of obese subjects in group D were lower in the M2, but there was

a similarity in the M3. At the same time, 25-hydroxyvitamin D levels were higher at the M3 in the D group in both the normal and obese groups.

Results suggest a relationship between 25-hydroxyvitamin D deficiency in the blood and thyroid diseases.[21] In a previous study, serum 25-hydroxyvitamin D levels were significantly negatively correlated with TSH levels. A study by Mansorian et al.[22] reported a decrease in T3 levels with an improvement in vitamin D status. This study found no relationship between 25-hydroxyvitamin D levels and TSH and T3 levels.

Conversely, older people with 25-hydroxyvitamin D deficiency were administered vitamin D supplements. It was found that there was no difference in the TSH and T3 levels of older people.[7] Similarly, no significant difference was found in serum TSH and T3 values between the groups in this study.

Based on the related studies, there were conflicting results on the lipid profile of vitamin D supplementation. Normal vitamin D levels were observed to improve HDL-C levels compared with low levels in the Fraser et al.[23] study. In another study examining the high- and low-dose vitamin D supplement groups, an increase in plasma TGs was noted in the high-dose group at the end of the 6th month.[24,25] In this study, 25-hydroxyvitamin D and HDL cholesterol levels significantly increased between the second and third assessments in group D. In addition, the TG

Table 5. Evaluation of biochemical parameters in obese and normal weight women in the groups[a]

Group D	**Women with obesity (n= 6)**			**Women with normal-weight (n= 8)**					
	M1	**M2**	**M3**	**M1**	**M2**	**M3**	***p*[a]**	***p*[b]**	***p*[c]**
Fasting serum glucose level (mg/dL)	79.17 ± 1.33	71.33 ±4.84	88.33 ± 11.13	82.38 ± 7.13	80.75 ± 8.31	71.88 ± 6.75	0.646	0.030	0.005
LDL (mg/dL)	90.14 ± 20.14	83.93 ± 19.17	78.50 ± 16.48	74.33 ± 15.41	72.00 ± 13.13	72.73 ± 19.01	0.115	0.191	0.563
HDL (mg/dL)	48.33 ± 13.72	44.33 ± 13.20	52.83 ± 10.67	48.88 ± 14.79	43.88 ± 9.54	47.13 ± 8.41	0.945	0.941	0.284
Non-HDL	104.83 ± 25.61	99.17 ± 22.57	93.50 ± 18.77	85.13 ± 15.52	83.13 ± 12.81	87.25 ± 18.41	0.098	0.160	0.545
TC (mg/dL)	153.17 ± 28.27	143.50 ± 20.90	146.33 ± 12.37	134.75 ± 21.61	127.00 ± 20.74	134.38 ± 23.59	0.191	0.168	0.283
TG (mg/dL)	71.67 ± 43.88	75.67 ± 42.94	75.00 ± 47.87	53.88 ± 5.11	56.75 ± 14.14	72.50 ± 24.59	0.897	0.301	0.536
TSH (mIU/mL)	2.87 ± 1.81	1.72 ± 0.99	1.38 ± 0.69	1.50 ± 0.47	1.56 ± 0.74	1.61 ± 0.65	0.352	0.744	0.871
T3 (nmol/L)	2.81 ± 1.52	2.39 ± 0.43	2.67 ± 0.70	2.55 ± 0.94	2.68 ± 0.79	2.62 ± 0.55	0.605	0.442	0.876
25-hydroxyvitamin D (ng/mL)	10.77 ± 1.60	11.68 ± 1.55	18.67 ± 4.34	11.08 ± 3.25	15.14 ± 4.33	28.83 ± 11.25	0.746	0.089	0.043
Group C	**Women with obesity (n= 9)**			**Women with normal-weight (n= 7)**					
	M1	**M2**	**M3**	**M1**	**M2**	**M3**	***p*[a]**	***p*[b]**	***p*[c]**
Fasting serum glucose level (mg/dL)	84.89 ± 7.08	79.56 ± 6.39	89.89 ± 10.59	88.00 ± 10.30	84.43 ± 12.71	88.43 ± 12.05	0.999	0.332	0.800
LDL (mg/dL)	83.51 ± 36.02	80.93 ± 24.56	90.64 ± 25.89	87.74 ± 13.33	78.26 ± 28.99	86.00 ± 24.50	0.115	0.884	0.734
HDL (mg/dL)	49.22 ±12.07	53.78 ± 11.26	49.00 ± 11.28	57.43 ± 9.25	59.57 ± 4.04	46.50 ± 9.97	0.080	0.182	0.668
Non-HDL	95.67 ± 39.20	96.00 ± 26.80	106.78 ± 27.85	92.29 ± 16.27	90.14 ± 29.42	99.17 ± 22.16	0.098	0.684	0.605
TC (mg/dL)	144.89 ± 38.72	149.78 ± 22.07	155.78 ± 18.47	149.71 ± 19.32	149.71 ± 30.62	145.67 ± 22.95	0.266	0.996	0.362
TG (mg/dL)	60.44 ± 17.22	74.78 ± 19.43	80.22 ± 24.63	53.43 ± 9.03	58.71 ± 15.54	64.83 ± 12.67	0.710	0.022	0.238
TSH (mIU/mL)	1.17 ± 0.43	1.25 ± 0.63	1.65 ± 1.03	1.77 ± 0.96	2.03 ± 1.05	1.92 ± 1.31	0.114	0.084	0.656
T3 (nmol/L)	2.36 ± 0.67	2.31 ± 0.81	2.86 ± 1.23	2.06 ± 0.48	2.11 ± 0.57	2.32 ± 0.58	0.315	0.958	0.238
25-hydroxyvitamin D (ng/mL)	11.68 ± 2.63	11.22 ± 3.14	11.76 ± 1.77	11.91 ± 2.29	13.26 ± 4.65	19.47 ± 17.28	0.633	0.265	0.409

D group, vit-D supplemented group; C, no reinforcement. [a]Data are expressed as mean ± SD. Differences between groups D and C [M1-M1 (p^x)], [M2-M2 (p^b)], and [M3-M3 (p^c)] were determined using the independent sample t-test, SD: Standard deviation, M1: First measurement, M2: Second measurement, M3: Third measurement, LDL: Low-density lipoprotein, HDL: High-density lipoprotein, TC: Total cholesterol, TSH: Thyroid-stimulating hormone, T3: Triiodothyronine, TG: Triglyceride

levels of the D group increased significantly, but this increase was associated with a return of the TG value closer to the normal range. Looking at group D in this study, it can be said that the HDL-C profile improved in parallel with the increase in vitamin D levels.

A large-scale cohort study found that increased vitamin D levels were correlated with increased TC and HDL levels but not LDL cholesterol. The meta-analysis revealed no correlation between TC and HDL-C. There was no significant correlation between LDL-C and TC levels in group D in this study.[25]

Considering the relationship between dietary iodine and thyroid hormones, a significant negative correlation was reported between iodine intake and TSH levels, but no significant relationship was found for T3 levels.[21] In another study, lambs were supplemented with iodine, and a significant reduction in T3 levels was found.[26] In the second and M3s of group D, there was a strong positive correlation between iodine intake and T3 levels as a result of this study, but no significant difference in TSH levels was found.

It has been observed that the HDL-C levels of those who eat rich monounsaturated fatty acids increase. It has been stated that feeding with high-oleic acid oils also increases HDL concentrations.[27,28] The serum LDL to HDL ratio was found to be lower in those with oleic acid consumption from the two groups compared with palmitic acid and oleic acid consumption compared with the palmitic acid consumption group in a study by Kien et al.[29] Although there was not a significant difference between the groups (D and C) in the first or last measures, it was found that HDL cholesterol levels decreased in the M2 in the present study.

In addition, no significant difference was found in the LDL: HDL ratio. Furthermore, compared with group D, group C consumed much more vitamin D, calories, protein, fat, cholesterol, linolenic acid, linoleic acid, myristic acid, lauric acid, palmitic acid, oleic

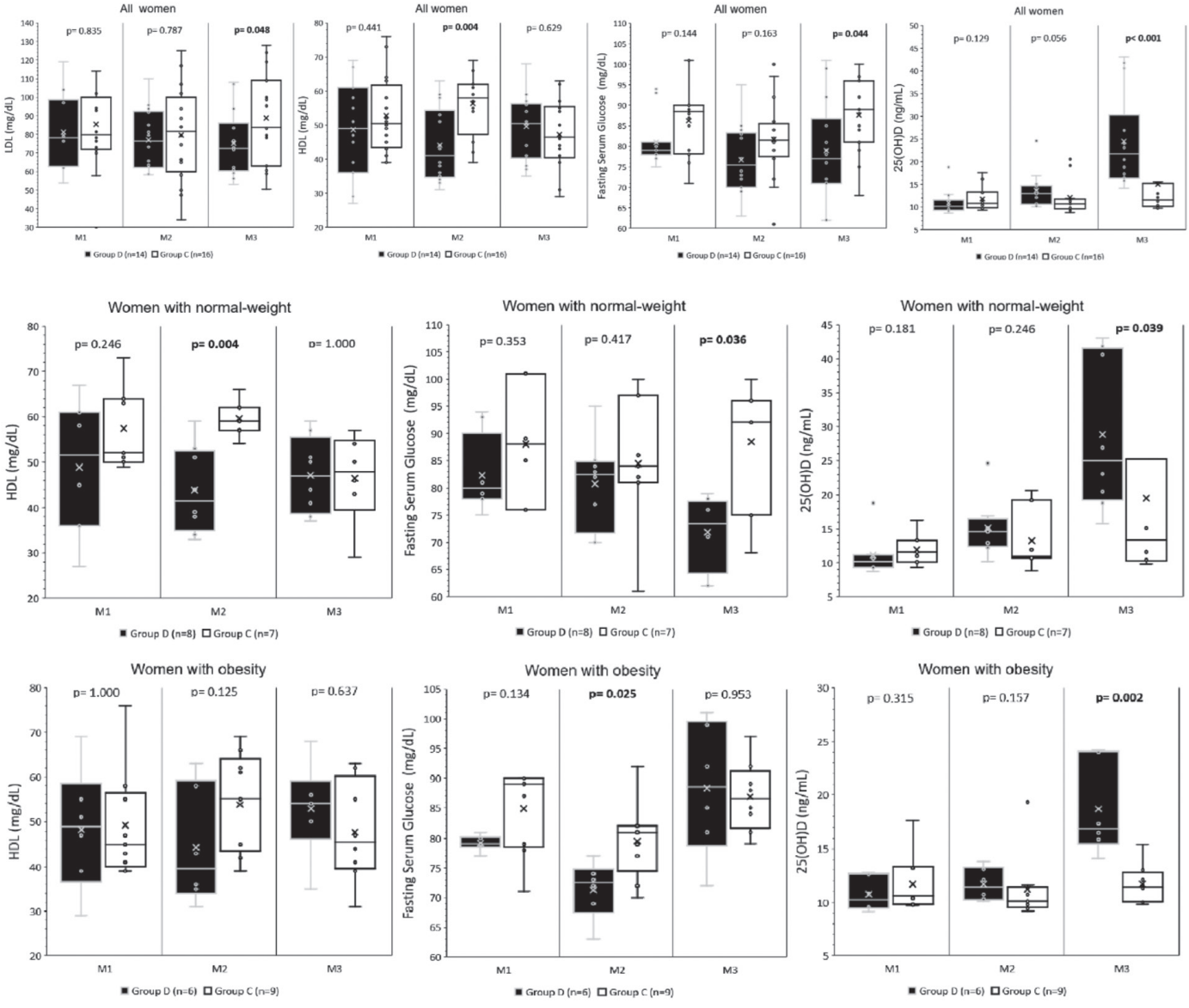

Figure 2. Responses of volunteers to biochemistry parameters between and within groups

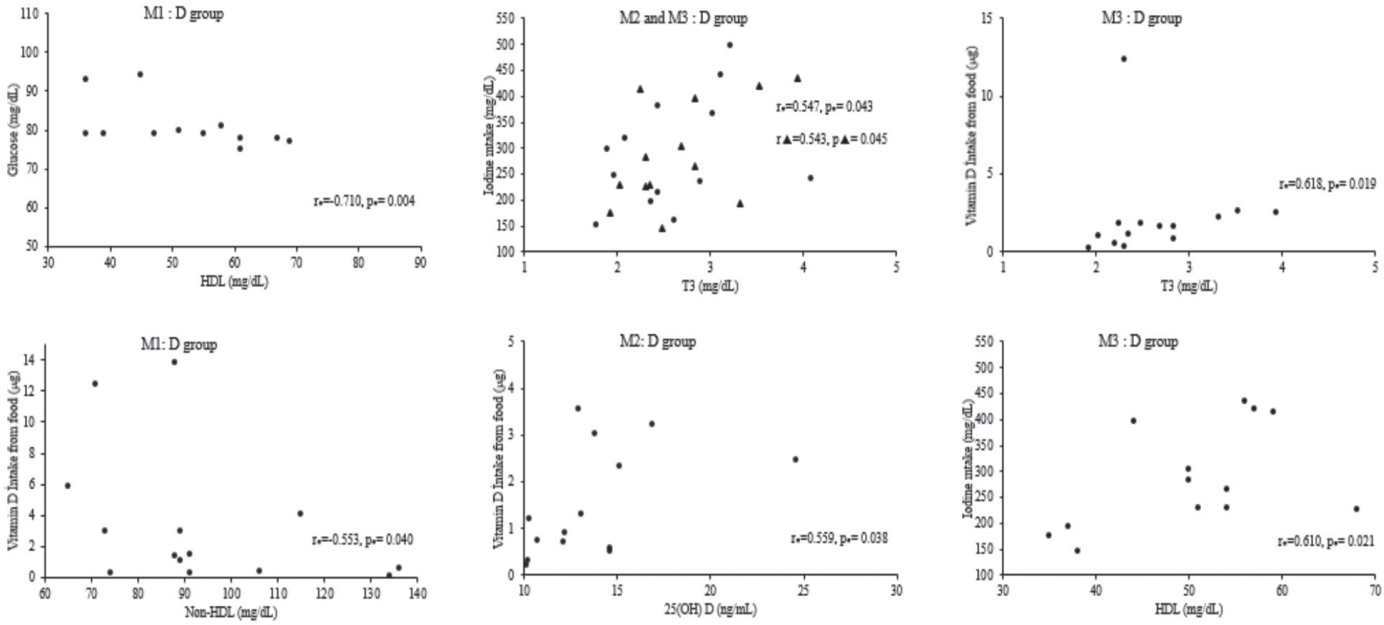

Figure 3. Correlation between group D

acid, MUFA, and PUFA. In the M2 in group C (M2), HDL levels were moderately positively correlated with α-linolenic acid, linoleic acid, MUFA, PUFA, and fat intake. It is thought that the decrease in HDL levels in the M2 was due to the experimental group being fed less in terms of monounsaturated fatty acids, such as olive oil and oilseeds; group C consumed more vitamin D than group D, and they consumed less oleic acid. There were no significant differences in TC, non-HDL, or LDL levels. Although the study included vitamin D supplementation, no dietary intervention was provided, so nutritional differences between the groups may have affected the results.

Studies have indicated that omega-3 fatty acids have advantages for healthy lipid profiles, but omega-6 fatty acids should be avoided. An important consideration for improving lipid profiles is the omega-6 to omega-3 ratio of fatty acids.[24] There are suggestions to decrease the intake of omega-6 fatty acids and increase the intake of omega-3 fatty acid supplements. The World Health Organization recommends keeping the omega-6:3 ratio between 5:1 and 10:1. Omega-3 fatty acids lower plasma TG levels and the lipid profile.[30] A significant correlation was found between LDL-C, TGs, TC, TC/HDL ratio, and omega-6/3 ratio. In the control group in this study, it was observed that there was a decrease in HDL cholesterol levels between the second and M3s, and TG levels increased from the first to the last measurement. It is thought that due to the increase in the intake of white bread, butter, eggs, sunflower oil, omega-6, and saturated fatty acids (palmitic, myristic, and lauric), the omega-6/omega-3 balance is disturbed.

Therefore, HDL-C levels may be reduced.

In summary, although group D received supplementation, dietary vitamin D intake was lower than that of group C. Therefore, no difference was observed in serum 25-hydroxyvitamin D levels between the groups in the M2. In addition, the fact that HDL levels are high in group C may also be because vitamin D intake is very high compared with that in group D. The potential to increase HDL-C levels is related to vitamin D intake. Therefore, in the final measurement, we predict that an increase in vitamin D intake will improve HDL levels and decrease fasting serum glucose levels in addition to vitamin D supplementation.

Study limitations

There are limitations to this study. The volunteers were not given a standard diet. Vitamin D consumption was assessed based on self-reported information, and intake was tracked by requesting a remote photo. Eight weeks are considered a brief duration for the study. The sample size caused the number of volunteer participants to be small due to budget limitations. Therefore, more comprehensive studies are needed to obtain more evident results.

CONCLUSION

Vitamin D intake in the body is believed to improve fasting serum glucose and HDL levels. On the other hand, when examined in more detail, vitamin D intake can be said to improve HDL levels in normal-weight individuals and to cause fasting serum glucose levels to be at the desired low level. In contrast, in individuals with obesity, although serum 25-hydroxyvitamin D levels increased during the last measurement, no effect was observed. As a consequence of vitamin D intake, serum 25-hydroxyvitamin D levels are higher in individuals with normal weight than in those with obesity. Significant positive correlations were observed between dietary vitamin D intake and serum 25-hydroxyvitamin D levels and between iodine intake and T3 levels. In addition, a high omega-6/omega-3 ratio reduces the effect of 25-hydroxyvitamin D intake on biochemical parameters.

Considering these results, it is important to implement nutritional interventions or monitor food consumption, especially when evaluating the effects on serum lipids and thyroid.

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Ethics

Ethics Committee Approval: The ethics committee approval for this study was approved by the Avrasya University Ethics Committee (approval number: 2022-52/14, date: 21.07.2022).

Informed Consent: Informed consent was obtained from all participants.

Authorship Contributions

Surgical and Medical Practices: F.C., Concept: F.C., Z.N.G., Design: F.C., Data Collection or Processing: F.C., Z.N.G., Analysis or Interpretation: F.C., Literature Search: F.C., Z.N.G., Writing: F.C., Z.N.G.

Conflict of Interest: The authors have no conflicts of interest to declare.

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