

# The effect of seasonal variations on food consumption, dietary habits, anthropometric measurements and serum vitamin levels of university students

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**Summary.** *Aim:* The aim of this study was to examine the effect of seasonal variations on the dietary habits, food consumption, anthropometric measurements, physical activity and some serum vitamin levels of adult females. *Methods:* The study was conducted during consecutive four seasons in October (autumn), January (winter), April (spring), and July (summer). After general information was obtained about the participants via questionnaire, their anthropometric measurements were taken, and individual records kept for 7-day individual food consumption and 3-day physical activity. Also, their body compositions (Body Stat 1500<sup>o</sup>) and resting metabolic rates (Ergospirometry-Cosmed K4b<sup>2</sup>) were measured. Participant serum samples were analyzed for levels of vitamins A, E,  $\beta$ -carotene and 25-OH Vitamin D3. *Subjects:* Thirty-five healthy, young adult females between the ages of 19 and 24 were invited into a prospective research study. *Results:* Spring was found to be the season with the highest intake of energy and nutrients compared with other seasons ( $p < 0.05$ ). A significant ( $p < 0.05$ ) decrease in the values of body weight and body mass index was found in summer compared to spring and winter, and in autumn compared to winter. A decrease in the values of body fat mass (kg) and an increase in the values of fat-free mass (kg) were found in summer compared to winter ( $p < 0.05$ ) using bioelectrical impedance analysis. A significant decrease in the values of body water (L) was measured in spring, autumn and winter compared to summer ( $p < 0.05$ ). The value of energy expended due to physical activity increases in summer compared to spring and autumn, while the value of resting metabolic rate measured through ergospirometry decreases in summer compared to winter ( $p < 0.05$ ). It was determined that the level of serum vitamin A decreased in summer compared to autumn and spring, the level of vitamin D increases in summer while it decreases in winter, and the level of  $\beta$ -carotene increases in winter compared to other seasons ( $p < 0.05$ ). No significant difference was found between serum vitamin E levels of individuals between seasons ( $p > 0.05$ ). A significant positive correlation was determined between the levels of serum  $\beta$ -carotene and dietary  $\beta$ -carotene intake in autumn ( $r = 0.37$ ,  $p < 0.05$ ). *Conclusion:* It was concluded that seasonal variations have significant effect on the nutritional status, body weights and compositions, daily energy expenditures, and particular serum vitamin levels in individuals. This should be taken into consideration when developing individual nutrition plans and establishing nutrition policies in Turkey, where all four seasons are experienced conspicuously.

**Key words:** Seasonal variations, food consumption, anthropometric measurements, serum vitamin levels

## Introduction

It is an indisputable fact that adequate and balanced nutrition is one of the fundamental requirements for individuals and nations to live strong and healthy lives and to develop socially and economically (1). Food

consumption differs between socioeconomic groups and geographical areas over the course of time. These differences arise from agricultural, seasonal, ecological, cultural and socioeconomic factors, which determine food selection or availability (2,3). Seasonal variations affect individual nutrition through psychological, emotional,

physiological, neurochemical and hormonal mechanisms (4). The data obtained from studies examining the effects of seasonal variations on food consumption is contradictory. There are studies showing that seasonal variation changes the daily intake of energy and nutrients, and in contrast studies showing otherwise (5-10). In studies evaluating the effect of seasonal variations on energy balance, body weight was found to be a sensitive indicator for the determination of the state of nutrition. In studies conducted with adults, low energy intake caused moderate weight loss seasonally (less than 10% of body weight in a year). The effect of seasonal variations on the energy metabolism of individuals was found to be associated with not only nutrition and energy intake, but also physical activity and energy expenditure (11). This effect is also seen distinctively on the basal metabolic rate. A strong negative correlation was found between annual average temperature and basal metabolic rate (12). Moreover, the effect of seasonal fluctuations on body weight draws attention (8,10). The energy intake and consumption of individuals living in rural regions of developing countries are affected considerably; their body weights and compositions change correspondingly (13). Dietary intake of vitamins and their serum concentration vary considerably between societies and are affected by a variety of factors. Gender, age, dietary intake, seasonal exposure, smoking and alcohol consumption habits are included in these factors affecting the serum concentrations of vitamins (14).

To date there is no study in Turkey examining the effect of seasonal variations on the combination of nutrition, physical activity, body composition and certain serum vitamin levels. Accordingly, in Turkey where all four seasons are distinctive, fallacies may occur concerning requirements for assessments based on food consumption studies conducted in a single season only. This study was planned and conducted with the aim of examining the effect of seasonal variations on the dietary habits, food consumption, anthropometric measurements, physical activity, and particular serum vitamin levels of adult females between the ages of 19 and 24.

## Subjects and Methods

The study, which was planned as prospective research, was conducted on young healthy adult females

between the ages of 19 and 24, studying in the department of Nutrition in the Faculty of Health Sciences, Hacettepe University. Thirty-five young adult female volunteers were involved in the study. The sample size was calculated using the Statsdirect program (StatsDirect Ltd. StatsDirect statistical software. <http://www.statsdirect.com>. England: StatsDirect Ltd. 2013). All participants were of medium socioeconomic levels and living with their families. They did not have any chronic disease or regularly use any medications, vitamin or mineral supplements, nor did they smoke or use alcohol. Furthermore, they were not following any weight-loss diet within the period of data collection. The study was conducted over the course of four successive seasons. The data for autumn, winter, spring, and summer were collected in October, January, April and July, respectively. Ethical approval was obtained from the Medical, Surgical and Drug Research Ethics Committee of University; approval number B.30.2.HAC.0.01.00.05/361.

A questionnaire consisting of multiple choice and open-ended questions was administered to collect information about individuals (such as age, period of education, marital status, health status, general dietary habits, the exposure status to seasonal variations, etc.). Following completion of the questionnaire, individual anthropometric measurements (body weight, height, mid-upper arm circumference, triceps, biceps, subscapular/suprailiac skinfold thicknesses, waist and hip circumference) were taken, and body components (body fat mass, free-fat mass, total body water quantity) were measured by bioelectrical impedance analysis (BIA) (Body Stat 1500<sup>®</sup>). In order to assess the nutritional status of individuals by season, a 7-day "individual dietary record method" was used on consecutive days. The physical activity records of individuals for 3 consecutive days, one of which fell on the weekend, during the week that records were kept of food consumed to determine their daily energy consumption. Resting metabolic rates (RMR) were measured using ergospirometry (Cosmed K4b<sup>2</sup>). Preprandial blood samples were also collected during the period when seasonal food consumption records were kept. The levels of vitamins A, E,  $\beta$ -carotene, and 25-OH Vitamin D<sub>3</sub> were analyzed for these samples.

### Statistical Data Analysis

The statistical data analysis was performed using the SPSS 15.0 statistical package program in a Windows environment. The qualitative data for the questionnaire were presented as numbers (N) and percentage (%). "Bonferroni corrected Repeated Measures" test was used for the data which showed normal distribution to assess the seasonal variations. Where difference was found in the data, the season from which the difference resulted was found with paired comparisons, using the "Bonferroni correction method". "Friedman Non-Parametric Variance Analysis" was used for data not showing normal distribution. In this case, the season from which a difference resulted was determined using the "Wilcoxon Test". "Spearman's rank correlation coefficient" was calculated to examine the correlation between two continuous variables.

## Results

### Dietary Habits :

When the seasonal variation exposure status of participants was examined, individuals stated that in spring and summer, they feel better (57.1% and 65.7%, respectively), are more social (42.9% and 54.3%, respectively), they eat less (27.3% and 66.7%, respectively), and lose weight (27.3% and 69.7%, respectively); however, in autumn and winter, they feel bad (59.4% and 46.9%), are less social (31.3% and 56.3%, respectively), they eat more (32.4% and 58.8%, respectively) and gain weight (17.1% and 65.7%, respectively).

Of the the study participants, 91.4% stated that their food and beverage preferences were affected by seasonal variations. The most distinct change they made that was affected by seasonal variations was an increase in fresh fruit and vegetable consumption (56.3%). It was stated that while the consumption of fatty and high-calorie foods was avoided in summer (12.5%), chocolate and sweet pastry consumption increased in winter (18.8%).

### Dietary intake:

The intake level of many nutrients was generally found to be higher in spring than in other seasons. This was particularly true for the difference in intake between spring and summer, summer intake being lower than

that in spring: energy intake (spring: 1956.6  $\pm$ 456.64, summer: 1742.1  $\pm$ 401.27 kcal), total fat (spring: 81.9  $\pm$ 20.46, summer: 70.2  $\pm$ 17.69 g), saturated fatty acids (spring: 25.4  $\pm$ 6.75, summer: 22.7  $\pm$ 6.51g), cholesterol (spring: 276.5  $\pm$ 71.68, summer: 233.6  $\pm$ 63.32 mg) and vitamin A (spring: 1640.9  $\pm$ 1193.5, summer: 974.3  $\pm$ 298.69  $\mu$ g). The intakes of carbohydrate (spring: 228.6  $\pm$ 58.94, winter: 201.2  $\pm$ 43.85 g) and water insoluble fibers (spring: 13.8  $\pm$ 4.45, winter:12.2  $\pm$ 3.27 g) were lower in winter than in spring. Moreover, the intakes of vitamin C (spring: 133.9  $\pm$ 60.93, autumn: 107.0  $\pm$ 38.57 mg), saturated fatty acids (spring: 25.4  $\pm$ 6.75, autumn: 22.3  $\pm$ 5.10g) and cholesterol (spring: 276.5  $\pm$ 71.68, autumn:226.6  $\pm$ 71.57 mg) were lower in autumn than in spring ( $p < 0.05$ ). Furthermore, a seasonal difference in the intake of polyunsaturated fatty acids (summer: 18.9  $\pm$ 6.04, spring: 24.2  $\pm$ 7.09, autumn: 23.1  $\pm$ 6.71 g), was found for summer compared to spring and autumn. A seasonal difference in the intake of folic acid (winter: 264.6  $\pm$ 67.8, spring: 294.4  $\pm$ 80.64, summer: 292.9  $\pm$ 65.93  $\mu$ g) was found for winter compared to spring and summer ( $p < 0.05$ ). There was no significant difference between the consumption levels of protein, plant-based protein, monounsaturated fatty acids, fiber, water soluble fiber,  $\beta$ carotene, sodium, or vitamins D and E in terms of seasons ( $p > 0.05$ ) (Table 1). The differences between the percentages of energy supplied from carbohydrate, protein and fat were not found to be statistically significant ( $p > 0.05$ ) (Figure 1).

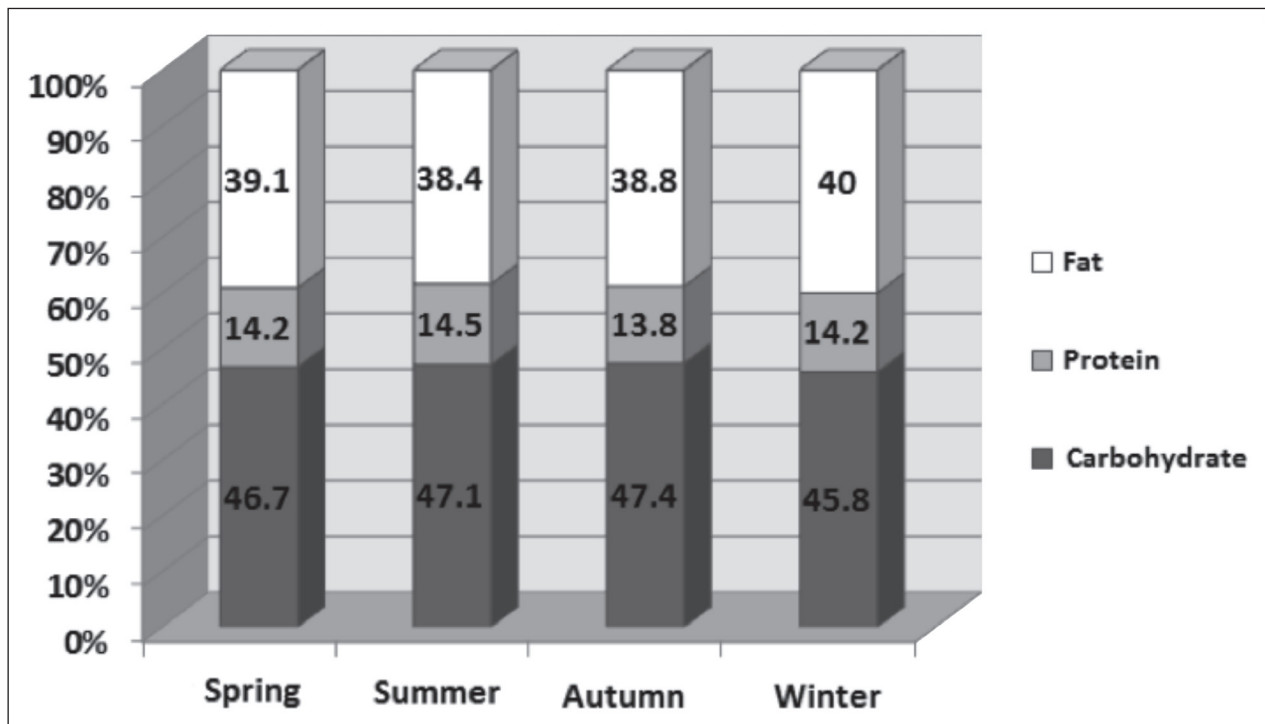
### Anthropometric Measurements and Body Compositions:

The seasonal variations in individual anthropometric measurements and body compositions individuals is shown in Table 2. The mean values of height (cm), mid-upper arm circumference (MUAC), waist and hip circumference (cm), waist/hip ratio, triceps and suprailiac skinfold thickness (SFT) (mm) did not show significant difference between seasons ( $p > 0.05$ ). A significant decrease ( $p < 0.05$ ) in body weight was seen (spring: 56.6  $\pm$ 7.21, summer: 55.9  $\pm$ 7.31, autumn: 56.2  $\pm$ 6.59, winter: 57.2  $\pm$ 7.12 kg) and in BMI (spring: 21.6  $\pm$ 2.6, summer: 21.3  $\pm$ 2.64, autumn: 21.4  $\pm$ 2.36, winter: 21.8  $\pm$ 2.53 kg/m<sup>2</sup>) for autumn compared to winter and for summer compared to spring and winter. A decrease in biceps SFT (mm) measurements was observed for spring, and a decrease in subscapular SFT

**Table 1.** Daily energy and nutrient intakes according to seasons (Mean  $\pm$ SD)

	SPRING			SUMMER			AUTUMN			WINTER		
	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median
Energy (kcal)	1956.6 <sup>a</sup>	456.64	1934.8	1742.1 <sup>b</sup>	401.27	1635.3	1805.3 <sup>ab</sup>	337.99	1812.6	1765.5 <sup>ab</sup>	379.87	1745.3
Carbohydrate (g)	228.6 <sup>a</sup>	58.94	215.3	205.4 <sup>ab</sup>	53.10	189.7	214.8 <sup>ab</sup>	49.98	212.2	201.2 <sup>b</sup>	43.85	198.6
Protein (g)	69.2	15.90	68.3	62.6	14.00	61.6	61.9	13.42	62.7	63.3	17.63	60.8
Plant protein (g)	29.6	8.53	27.3	27.5	6.93	26.4	28.9	6.56	28.9	28.0	7.11	26.7
Fat (g)	81.9 <sup>a</sup>	20.46	78.7	70.2 <sup>b</sup>	17.69	71.1	74.4 <sup>ab</sup>	14.69	74.3	75.3 <sup>ab</sup>	17.67	73.2
Saturated fatty acids (g)	25.4 <sup>a</sup>	6.75	25.0	22.7 <sup>b</sup>	6.51	21.5	22.3 <sup>b</sup>	5.10	21.9	23.8 <sup>ab</sup>	5.92	24.3
Monounsaturated fatty acids (g)	27.0	7.29	26.9	23.9	7.17	22.1	24.3	4.60	24.8	25.4	6.65	24.3
Polyunsaturated fatty Acids (g)	24.2 <sup>a</sup>	7.09	22.3	18.9 <sup>b</sup>	6.04	18.7	23.1 <sup>a</sup>	6.71	22.9	21.4 <sup>ab</sup>	5.65	21.4
Cholesterol (mg)	276.5 <sup>a</sup>	71.68	301.6	233.6 <sup>b</sup>	63.32	243.1	226.6 <sup>b</sup>	71.57	232.9	232.9 <sup>ab</sup>	90.40	214.0
Fiber (g)	21.2	6.59	19.7	19.8	5.10	19.5	19.3	4.69	46.8	19.1	5.50	18.3
Water soluble fiber (g)	6.5	2.14	5.8	6.0	1.68	5.9	6.1	1.51	6.0	6.1	1.91	6.2
Water insoluble fiber (g)	13.8 <sup>a</sup>	4.45	12.6	13.6 <sup>ab</sup>	3.55	13.8	12.6 <sup>ab</sup>	3.10	12.0	12.2 <sup>b</sup>	3.27	11.9
Vitamin A ( $\mu$ g)	1640.9 <sup>a</sup>	1193.5	1280.6	974.3 <sup>b</sup>	298.69	1031.7	1195.0 <sup>ab</sup>	722.30	992.1	1341.3 <sup>ab</sup>	888.8	1205.0
Carotene ( $\mu$ g)	4.5	2.76	4.0	3.4	1.19	3.1	3.5	1.69	3.0	4.1	2.49	3.83
Vitamin D ( $\mu$ g)	2.5	3.78	1.2	1.8	2.77	0.9	1.5	2.04	0.89	1.7	2.83	0.8
Vitamin E (mg)	22.0	6.43	20.7	18.6	5.59	18.8	21.4	5.67	20.7	19.7	5.31	18.5
Folic Acid ( $\mu$ g)	294.4 <sup>a</sup>	80.64	292.2	292.9 <sup>a</sup>	65.93	290.5	265.8 <sup>ab</sup>	61.9	269.2	264.6 <sup>b</sup>	67.8	262.7
Vitamin C (mg)	133.9 <sup>a</sup>	60.93	127.9	133.7 <sup>ab</sup>	49.85	127.8	107.0 <sup>b</sup>	38.57	106.8	122.9 <sup>ab</sup>	49.37	109.3

<sup>a,b</sup> Values within row with different superscripts are significantly different ( $p < 0.05$ ) (ex. Energy consumption in spring<sup>a</sup> is significantly different than in summer<sup>b</sup>, not different than in autumn<sup>ab</sup> and winter<sup>ab</sup>.)

**Figure 1.** Percentages of energy supplied from carbohydrate, protein and fat according to seasons

**Table 2.** Anthropometric measurements according to seasons (Mean  $\pm$ SD)

	SPRING			SUMMER			AUTUMN			WINTER		
	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median
Height (cm)	161.9	5.23	162.0	161.9	5.23	162.0	161.9	5.23	162.0	161.9	5.23	162.0
Body weight (kg)	56.6 <sup>ac</sup>	7.21	54.8	55.9 <sup>b</sup>	7.31	53.9	56.2 <sup>ab</sup>	6.59	54.5	57.2 <sup>c</sup>	7.12	55.9
BMI (kg/m <sup>2</sup> )	21.6 <sup>ac</sup>	2.56	20.8	21.3 <sup>b</sup>	2.64	20.7	21.4 <sup>ab</sup>	2.36	21.2	21.8 <sup>c</sup>	2.53	21.4
MUAC(cm)	25.8	2.36	25.5	25.7	2.43	25.5	25.7	2.23	25.4	25.9	2.36	25.5
Waist Circumference (cm)	67.7	4.64	66.1	67.6	4.48	66.1	67.8	4.06	66.5	68.1	4.14	66.5
Hip Circumference (cm)	96.1	5.94	95.0	95.7	6.05	94.5	95.5	5.53	94.5	96.0	6.02	94.5
Waist/Hip Rate	0.71	0.03	0.70	0.71	0.03	0.71	0.71	0.03	0.71	0.71	0.03	0.71
<b>Body Composition</b>												
Fat mass (%)	25.8 <sup>a</sup>	5.39	26.4	23.9 <sup>b</sup>	5.23	24.4	25.6 <sup>a</sup>	4.60	26.7	27.5 <sup>c</sup>	1.79	28.0
Fat mass (kg)	14.9 <sup>a</sup>	4.81	13.8	13.6 <sup>b</sup>	4.54	12.9	14.6 <sup>a</sup>	3.91	14.7	15.9 <sup>c</sup>	4.44	15.6
Fat-free mass (kg)	41.7 <sup>ab</sup>	3.73	41.4	42.3 <sup>a</sup>	3.99	41.7	41.6 <sup>ab</sup>	3.82	41.5	41.1 <sup>b</sup>	4.10	40.6
Body water (kg)	29.3 <sup>ac</sup>	2.10	29.6	29.9 <sup>b</sup>	2.34	29.8	29.3 <sup>a</sup>	2.13	29.0	28.7 <sup>c</sup>	2.25	28.3

BMI: Body Mass Index, MUAC: Mid-upper arm circumference, SFT: Skinfold thickness.

<sup>a,b,c</sup> Values within row with different superscripts are significantly different ( $p < 0.05$ ). (ex. Body weight in spring<sup>a</sup> is significantly different than in summer<sup>b</sup>, not different than in autumn<sup>ab</sup> and winter<sup>c</sup>)

(mm) measurements was observed for summer and autumn compared to winter ( $p < 0.05$ ).

The body fat mass (kg) values determined by the bioelectrical impedance analysis method (Body Stat 1500 $\Omega$ ) showed a decrease in summer compared to winter ( $p < 0.05$ ). The fat-free body mass (kg) increased in summer compared to winter (winter: 41.1  $\pm$  4.10, summer: 42.3  $\pm$  3.99 kg) ( $p < 0.05$ ). A significant decrease in the measurements of body water (kg) was observed in spring, autumn and winter compared to summer ( $p < 0.05$ ). The difference between winter and

spring was not found to be significant ( $p > 0.05$ ). The mean ( $\pm$ SD) values of body water for spring, summer, autumn and winter are 29.3  $\pm$  2.10, 29.9  $\pm$  2.34, 29.3  $\pm$  2.13, and 28.7  $\pm$  2.25 kg, respectively.

#### Physical Activity and Total Energy Expenditure:

The daily energy expenditure values of individuals are displayed in Table 3. The energy values expended for physical activity increased significantly in summer compared to spring and autumn (spring: 2207.8  $\pm$  207.84, autumn: 2219.7  $\pm$  232.22, summer: 2541.3

**Table 3.** Anthropometric measurements according to seasons (Mean  $\pm$ SD)

	SPRING			SUMMER			AUTUMN			WINTER		
	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median
<b>The energy expended for physical activity (kcal/day)</b>	2207.8 <sup>a</sup>	207.84	2175.2	2541.3 <sup>b</sup>	716.22	2188.0	2219.7 <sup>ab</sup>	232.22	2140.8	2170.1 <sup>a</sup>	185.03	2141.0
RMR (kcal/day) Ergospirometry	1193.2 <sup>a</sup>	142.79	1145.0	1161.9 <sup>a</sup>	122.71	1117.6	1327.3 <sup>b</sup>	170.73	1285.6	1483.3 <sup>c</sup>	207.35	1562.5
TEE (kcal/day) Ergospirometry	1832.7 <sup>a</sup>	300.63	1799.4	2067.2 <sup>abc</sup>	685.37	1837.2	2049.1 <sup>b</sup>	357.75	1994.9	2233.5 <sup>c</sup>	351.34	2283.8
PAL (kcal/day) Ergospirometry	1.5 <sup>a</sup>	0.14	1.5	1.8 <sup>b</sup>	0.49	1.5	1.5 <sup>ab</sup>	0.16	1.5	1.5 <sup>a</sup>	0.13	1.5

RMR: Resting metabolic rate, TEE: Total energy expenditure, PAL: Physical activity level.

<sup>a,b,c</sup> Values within row with different superscripts are significantly different ( $p < 0.05$ ) (ex. Total energy expenditure in spring<sup>a</sup> is significantly different than in summer<sup>b</sup> but not different than in autumn<sup>ab</sup> and winter<sup>c</sup>)

$\pm 716.22$  kcal) ( $p < 0.05$ ). The resting metabolic rate (RMR) value measured with ergospirometry decreased in summer compared to winter (winter:  $1483.3 \pm 207.35$ , summer:  $1327.3 \pm 170.73$  kcal) ( $p < 0.05$ ). The difference between spring and summer was not found to be significant ( $p > 0.05$ ). Daily total energy expenditure increased in winter ( $p < 0.05$ ). The difference between summer and other seasons is not statistically significant ( $p > 0.05$ ). The total energy expenditure values for spring, summer, autumn and winter are  $1832.7 \pm 300.63$ ,  $2067.2 \pm 685.37$ ,  $2049.1 \pm 357.75$ , and  $2233.5 \pm 351.34$  kcal, respectively. The physical activity level calculated from RMR using ergospirometry increased in summer compared to other seasons ( $p < 0.05$ ).

#### *Serum Vitamin A, E, D and $\beta$ -Carotene Levels:*

It was determined that serum vitamin A level decreased in summer compared to autumn and winter (autumn:  $35.5 \pm 5.74$ , winter:  $37.7 \pm 6.49$ , summer:  $33.0 \pm 4.76$   $\mu\text{g/dL}$ ) ( $p < 0.05$ ). Vitamin D level increased in summer while decreasing in winter ( $46.1 \pm 15.32$  and  $22.9 \pm 9.28$   $\mu\text{g/L}$ , respectively) ( $p < 0.05$ ). No significant difference between spring ( $35.9 \pm 12.56$   $\mu\text{g/L}$ ) and autumn ( $34.4 \pm 9.93$   $\mu\text{g/L}$ ) was found ( $p > 0.05$ ); however, both seasons were found to be different from summer and winter ( $p < 0.05$ ). A statistically significant increase in serum levels of  $\beta$ -carotene was found in winter compared to other seasons ( $p < 0.05$ ). The difference between the serum E vitamin levels of individuals by season was not significant ( $p > 0.05$ ) (Table 4).

When the correlation between serum vitamin levels and nutrients was examined, a significant positive cor-

relation between serum  $\beta$ -carotene level and  $\beta$ -carotene intake level was determined ( $r = 0.37$ ,  $p < 0.05$ ).

## Discussion

Turkey is not only a developing country in terms of nutrition, but also shares the problems of developed nations. The nutritional condition of society differs significantly by regions, seasons, socio-economic level and urban-rural settlement locations (15). Taking seasonal variation into consideration is important because of its pivotal role in physical activity, food consumption, working capacity and nutritional status (16). This study examined the effect of seasonal variations on the dietary habits, food consumption, anthropometric measurements, physical activity, and particular serum vitamin levels of young, adult females between the ages of 19 and 24, who were studying at university.

Seasonal affective disorder is defined as a periodic depression that is repeated regularly in autumn and winter and decreases in the following spring. The overconsumption of starchy foods and concomitant increase in appetite are characterized by weight gain and too much sleep (17). In this study, individuals stated that in spring and summer they feel better, are more social, they eat less, and lose weight; while in autumn and winter, they feel bad, are less social, they eat more, and gain weight. They were determined to sleep less in winter and more in summer. In their study, Rohan and Sigmon (18) stated that female university students feel worse, sleep more, and are less social in January,

**Table 4.** Serum vitamin levels according to seasons (Mean  $\pm$ SD)

	SPRING			SUMMER			AUTUMN			WINTER		
	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median	$\bar{X}$	SD	Median
SERUM VITAMIN LEVELS												
Vitamin A ( $\mu\text{g/dL}$ )	35.0 <sup>b</sup>	7.35	34.7	33.0 <sup>b</sup>	4.76	33.7	35.5 <sup>a</sup>	5.74	34.4	37.7 <sup>a</sup>	6.49	37.1
							(27.7-47.2)			(26.3-54.6)		
Vitamin E (mg/dL)	0.84	0.23	0.83	0.82	0.24	0.83	0.91	0.21	0.86	0.86	0.19	0.84
							(0.6-1.7)			(0.6-1.4)		
Vitamin D ( $\mu\text{g/L}$ )	35.9 <sup>a</sup>	12.56	34.2	46.1 <sup>b</sup>	15.32	44.1	34.4 <sup>a</sup>	9.93	32.3	22.9 <sup>c</sup>	9.28	21.9
							(18.7-64.8)			(11.4-46.5)		
$\beta$ - Carotene ( $\mu\text{g/mL}$ )	1.56 <sup>a</sup>	0.44	1.42	1.61 <sup>a</sup>	0.39	1.52	1.47 <sup>a</sup>	0.37	1.40	1.86 <sup>b</sup>	0.46	1.8
							(0.8-2.5)			(1.1-3.1)		

<sup>a,b,c</sup> Values within row with different superscripts are significantly different ( $p < 0.05$ ) (ex. Vitamin A in spring<sup>b</sup> is significantly different than in summer<sup>a</sup> but not different than in autumn<sup>c</sup> and winter<sup>c</sup>)

and that they eat more and gain weight in December. Their sleep status in summer is better than in spring. In another study, it was reported that females display characteristics such as feeling good, being more social, weight loss, eating and sleeping less, to a greater degree in summer; while they display characteristics such as being less social, tendency to gain weight, feeling bad and sleeping more, to a greater extent in winter (17). According to other studies as well as this study, the negative behaviors of individuals are observed in winter months, while their positive behaviors are observed more often in summer months.

Acar Tek (19) found that the dietary habits of 68.2% of adult females were affected by seasonal variations, and the fact that individuals want to consume seasonal and abundant foods, that they avoid consuming early grown food, and they prefer easily prepared, meat-based and high-calorie meals in winter are the primary reasons for this. In this study, 91.4% of individuals stated that their food and beverage preferences were affected by seasonal variations. The most distinct change in their food preferences was found to be an increase in consumption of fresh fruit and vegetables in summer. Of the participants, 12.5% stated that they avoid consuming fatty and high-calorie foods in summer, and 18.8% stated that they increase chocolate and sweet pasty consumption in winter. Because females included from different age groups were involved in the study, it is normal that there are differences in their food preferences and in their sensitivity to seasonal variations. Abdullah and Wheeler (20) reported that the energy and protein consumption of females is higher in spring than in other seasons. In another study examining seasonal energy intake by age group, it was found that the greatest seasonal difference for the entire sample was in autumn (21). Rakıcioğlu et al. (22) found that the energy and nutrients consumption of individuals by season (winter, spring, summer, autumn), consumption of daily energy, total protein, plant-based protein, iron, vitamins A and C, thiamine, riboflavin, and niacin were higher in summer than in spring and winter. In this study, it was observed that the season making the most difference in the intake of energy and nutrients is spring; the intake of nutrients in this period increases compared with other seasons ( $p < 0.05$ ). However, when other studies conducted on this subject were evalua-

ted, it was observed that the results were contradictory. Generally, a difference between summer and winter is observed and there are studies showing that spring and autumn also make a difference. This contradiction is thought to result from the factors such as age, gender, socioeconomic level, and accessibility of food within the context of studies of different samples.

The differences between the percentages of energy supplied from carbohydrate, protein and fat in spring, summer, autumn and winter were not statistically significant ( $p > 0.05$ ). This may have resulted from the fact that the study sample consists of students receiving nutrition education. Rakıcioğlu et al (22). determined that there was no seasonal difference in the percentages of energy supplied from carbohydrate, protein and fat. In another study conducted on adult females, the percentage of energy supplied from protein was found to be lower in autumn than in spring and summer (19). In their study, Ma et al. (23) observed that the percentages of energy supplied from carbohydrate and protein are not seasonally different; however, the percentage of energy from fat decreased in spring and winter compared to autumn. The suggested ideal daily percentages of energy supplied from carbohydrate, protein and fat are 55-60%, 10-15%, and 25-30% in daily, respectively (24). Similarly to other studies, in this study the percentage of energy supplied from carbohydrate was measured as below that suggested, and the percentage of energy supplied from fat above that suggested. The high percentage of energy from fat intake observed in this study resulted from the fact that the the percentage of energy supplied by carbohydrate was below that suggested and, due to high consumption of food of animal origin, the dietary protein percentage was close to the maximum recommended; although, within the accepted range.

The seasonal variations in climate and environment, and thus accessibility of food, are causal factors affecting body weight in the annual cycle. The seasonal change in body weight is a reflection of the systemic change in energy balance. When the ambient temperature falls after summer, weight gain occurs as a result of the fact that energy intake moves ahead of energy expenditure. When the ambient temperature increases after winter, weight loss occurs as a result of the fact that energy expenditure moves ahead of energy intake. One of the potential mechanism is the annual change in

thyroid activity triggered by ambient temperature and day length. Thyroid volume increases by 25% in winter compared to summer (25). Ma et al.(23) determined that the average difference of body weight between winter and summer, winter and autumn, and spring and autumn, was significant. Chen et al.(26) indicated that the BMI, waist circumference and waist/hip ratio values are higher in winter than in summer. Ockene et al.(27) found that there is no significant difference in the BMI, waist and hip circumference and waist/hip ratio of females between the four seasons. In this study, a significant decrease in values of body weight and BMI was observed in summer compared to spring and winter, and in autumn compared to winter ( $p < 0.05$ ).

Body fat mass (kg) values determined by the bioelectrical impedance analysis method (Body Stat 1500 $\text{\textcircled{C}}$ ) showed a decrease in summer compared to winter ( $p < 0.05$ ); body fat mass in percentages displayed a similar seasonal pattern. The fat-free body mass (kg) increases in summer compared to winter ( $p < 0.05$ ). This may result from the decrease in body weight and body fat mass, and increase in physical activity and energy expenditure. A significant decrease in the values of body water (kg) was observed in spring, autumn and winter compared to summer ( $p < 0.05$ )., This correlates with the significant decrease in daily water consumption in winter compared to summer. In their study conducted for all four seasons, Plasqui et al. (28) found no significant seasonal difference in fat-free body mass (kg). In contrast, another study found that body fat mass (% and kg) increased and the fat-free body mass decreased (kg) in winter compared to summer (29).

In this study, compared to spring and autumn, energy expenditure for physical activity increased significantly in summer. Moreover, the value of resting metabolic rates (RMR) measured with ergospirometry decreased in summer compared to winter ( $p < 0.05$ ). The daily total energy expenditure increased in winter ( $p < 0.05$ ). The physical activity level calculated from RMR using ergospirometry increased in summer compared to other seasons ( $p < 0.05$ ). Also, this study observed an increased energy expenditure, reflecting the increase in physical activity in summer compared to winter, just as the increase in body weight and body fat mass in winter can be associated with the decrease of energy expended in physical activity. Furthermore,

while stating that changes occurred seasonally, individuals remarked that they are more active, eat more and lose weight in summer. However, when the total energy intakes of individuals were examined, it was seen that there is no statistically significant difference between those values in winter and summer. It can be considered that this lack of difference may result from the significant increase of RMR value, which is used in the calculation of total energy expenditure in winter and, on the other hand, the significant increase of energy expended due to the increase of physical activity in summer. Given the fact that seasonal temperature differences and potential seasonally dependent hormonal changes in females are important factors affecting BMR, the increase of BMR in winter is an expected result. Moreover, the higher PAL value in summer reflected on the physical activity energy expenditure causing this value to be higher in summer than in winter.

There are widely conducted studies of serum concentrations and dietary intakes of carotenoids, retinol and tocopherols on various populations because the inverse correlation between these nutrients and the progress of various diseases including cancer, cardiovascular disorders, and cataract formation (30,31). Serum carotenoid concentrations are affected by a range of factors while availability of  $\alpha$ -tocopherol and retinol is lower (13). Beta-carotene serum concentration correlates with food intake and changes seasonally. The most important reason for this fluctuation is the fact that the accessibility of different fruit and vegetables changes throughout the year (30,32). Factors affecting the serum concentrations of antioxidants include gender, age, smoking and alcohol use, seasonal variations, and geographical nature of the region (30). In this study, the level of serum vitamin A was found to decrease in summer compared to autumn and spring ( $p < 0.05$ ). The level of  $\beta$ -carotene increased in winter compared to other seasons ( $p < 0.05$ ). The difference between the serum vitamin E levels of individuals by season was not significant ( $p > 0.05$ ). The increase of serum beta-carotene and vitamin A concentration in winter can be associated with the increase in consumption of green-leaf vegetables and citrus fruits in this season. When the correlation between serum vitamin levels and nutrients was examined, a signifi-



cant positive correlation between serum  $\beta$ -carotene level and  $\beta$ -carotene intake was determined ( $r = 0.37$ ,  $p < 0.05$ ). The fact that there is a positive correlation between the variations in dietary intake of green-yellow leaf vegetables and citrus fruits and variations in serum  $\beta$ -carotene concentration was indicated in other studies (33,34).

In that study, the seasonal variation in serum vitamin E was not significant in parallel with the fact that no seasonal change was observed in daily vitamin E consumption. Also, no correlation was found between serum vitamin E levels and vitamin E consumptions. Similarly in other studies, it was stated that there was no significant correlation between dietary vitamin E consumption and plasma concentrations (35,36).

Vitamin D is an essential vitamin for calcium and phosphorus balance and bone metabolism (37), and is named as the "sun light vitamin" (38). The photosynthesis of vitamin D changes depending on the density of ultraviolet rays and latitude, season, and different times of day. Inadequate sun light, aging, and keeping the skin covered affect the intake levels of vitamin D (37). In this study, vitamin D levels increased in summer and decreased in winter ( $46.1 \pm 15.32$  and  $22.9 \pm 9.28$   $\mu\text{g/L}$ , respectively) ( $p < 0.05$ ). There is no significant difference in vitamin D levels between spring and autumn ( $p > 0.05$ ). However, both seasons were different from summer and winter ( $p < 0.05$ ). The increase of serum vitamin D in summer results from increased exposure of participants to sun light; the fundamental source of vitamin D. Similarly, serum 25-hydroxy vitamin D3 levels were measured to be higher in summer than in winter in many other studies conducted on different gender and age groups. Vitamin D supplementation and the consumption of enriched food increase the dietary intake of vitamin D (39). In this study, no significant correlation was found between the the consumption of dietary vitamin D and serum vitamin D levels. Even though no seasonal difference was identified in the consumption levels of vitamin D, of which limited intake is an issue, the benefits of exposure to sun light in spring and summer are likely to have contributed to the increase of serum vitamin D in those seasons.

Participants, whom were all nutrition and dietetic students (3<sup>rd</sup> grade), were interested in nutrition and paid attention to what they eat. This might be consid-

ered as a limitation but on the other hand, these students were well educated about keeping food diaries which enhanced the quality of the data. Moreover, all of the anthropometric and BMR measurements were conducted via the same device by the same person which also improved the quality of the data.

## Conclusion

As a result of its geographical location, Turkey experiences four distinctive seasons and is also rich in food diversity. Food and nutrition patterns can change according to the different climate types of seven geographical regions. As well as urban and rural area differences, individuals living in the same area can be affected differently by seasonal variations depending on factors such as different age groups, gender, and socio-economic conditions. To obtain more representative results it would be appropriate carry out a broader but similar study including groups with different socio-economic level, gender, and age with a wider population sample taken from urban and rural settlement locations of different regions. Food consumption studies conducted in just a single season can give rise to fallacies about nutrient requirements. The effects of seasonal variations should be considered when establishing food and nutrition policies in Turkey.

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