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Evaluation of Dietary Intake and Body Composition of Collegiate American Football Players

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Summary. *Aim:* The data obtained from previous studies on dietary intake and body composition of American football players, which may pose a health risk, also raise concern for collegiate American football players, especially for linemen. Therefore, this study aimed to evaluate the dietary intake and body composition of collegiate American football players by position groups. *Methods:* One-hundred and eighty-five collegiate American football players voluntarily participated in this observational study. Body composition was evaluated by both anthropometric measurements and bioelectrical impedance analysis. 3-day diet records were taken to determine dietary intake. *Results:* Energy, carbohydrate and protein intakes of defensive linemen (DL) (27.84±12.85 kcal/kg/day, 2.73±1.35 g/kg/day, and 1.29±0.68 g/kg/day respectively) and offensive linemen (OL) (25.98±9.17 kcal/kg/day, 2.47±0.85 g/kg/day, and 1.21±0.61 g/kg/day, respectively) were significantly lower than receivers (R) (41.49±20.12 kcal/kg/day, 4.31±2.34 g/kg/day, and 1.81±0.91 g/kg/day respectively). Collegiate American football players consumed high amounts of fat, dietary cholesterol, and sodium but were low in carbohydrates and potassium. Average body mass index (BMI) and body fat percentage (BFP) values of DL (31.38±4.43 kg/m² and 26.13±8.79%, respectively) and OL (32.95±4.77 kg/m² and 30.06±7.33%, respectively) were significantly higher than other position groups. *Conclusions:* In this study, collegiate American football players followed an unbalanced diet in terms of many nutrients. Most DL and OL were obese. We concluded that it would be useful to provide nutritional education for collegiate American football players, and specific nutritional strategies should be developed to reduce the risk of obesity-related diseases in linemen.

Key words: American football, sports nutrition, dietary intake, body composition, obesity

Introduction

The data obtained from previous studies on dietary intake and body composition of American football players that may pose a health risk also create concern for collegiate American football players (1-4). Accordingly, the long-term health, especially in relation to cardiovascular health, of collegiate American football players has received increasing attention from athletes, their families, and coaches (4).

It was determined that body mass index (BMI) of both defensive linemen (DL) and offensive linemen (OL) have significantly increased during the past 30 years (2). In 2003, more than 25% of the National Football League (NFL) players were classified as obese (1). It was also found that the body weights of collegiate American football players in all position groups have increased significantly over time (3). Increased body weight in athletes is associated with the risk of metabolic syndrome and cardiovascular disease (5). It was stated that linemen were already at risk for cardiometabolic syndrome (5). Collegiate American football players, who play in linemen positions, have higher body weights, waist circumferences, and BMIs than other players (5-8).

The known health outcomes of being overweight or obese make it important for collegiate American football players and team staff to understand how to increase body weight without increasing body fat mass (BFM) (9). In a study conducted with NFL players, it was reported that the difference between position groups for average lean body mass (LBM) was between 10–15%, while the difference between position groups for BFM was reported ~200% (10). In addition, it was also determined that while BFM continued to increase, LBM gain decreased after body weight exceeding ~114 kg (10). After this breakpoint, BFM had been reported to increase more than LBM, and it was emphasized that this balance is essential and body composition should be monitored (10).

Sports nutrition is important, not only for the body composition of collegiate American football players but also for their health. Abbey et al. (4) examined the dietary intake of 9 linemen specifically, and they reported that linemen consumed high amounts of total fat, saturated fat, dietary cholesterol, sodium, and potassium but their carbohydrate, fiber, and essential fat consumption were low.

In recent years, the performance levels and physiological parameters of collegiate American football players have been studied intensively, but comprehensive studies examining the dietary intake and body composition of these players are limited. For example, in Turkey, there is only one comprehensive study evaluating the body composition of collegiate American football players by position groups, but the sample size of that study was small (11), and no study has evaluated the dietary intake of these players yet. Before specific sports nutrition recommendations can be made, it is important to gain a background understanding of the dietary intake and body composition of this specific population in a large sample. Therefore, this study aimed to comprehensively evaluate the dietary intake and body composition of collegiate American football players by position groups.

Methods

Sample Size Calculation and Participants

The universe of this research was determined as the collegiate American football players in Ankara, Turkey, which were involved in the Universities Sports League. The numbers of collegiate American football players and the total numbers of male athletes were provided by the Turkey University Sports Federation. The number of collegiate American football players in Ankara for the 2016–2017 season was 438. The total number of male collegiate athletes in these universities was 1697. Based on a priori information, the ratio of the number of collegiate American football players to the total number of male collegiate athletes was calculated as 25.8%. In this framework, p and q values were taken into account as 25.8% and 74.2%, respectively (11).

$$n = \frac{Nt^2pq}{d^2(N-1) + t^2pq}$$

n: The number of subjects to be included in the sample group

N: The number of individuals in the target population

p: Frequency of occurrence of the event under consideration

q: Frequency of non-occurrence of the event under consideration

t: The theoretical value which found according to the t-table at a specified significance level

d: ± sampling error, which accepted according to the frequency of occurrence of the event

$$n = \frac{(438) \times (1.96)^2 \times (0.258) \times (0.742)}{(0.05) \times (438-1)^2 \times (1.96)^2 \times (0.258) \times (0.742)} = 176.2$$

The universe number was 438. In order to make statistical estimates with a 95% confidence interval and ±5% sampling error, the minimum suitable sample size was calculated as 176.2. To generalize and represent the universe, the number of observations to be taken should be at least 176.

In accordance with the determined sample size, 185 collegiate American football players voluntarily participated in this study. The participants were recruited from college-level teams (Ankara Cats, Baskent Knights, Bilkent Judges, Hacettepe Red Deers, METU Falcons, TOBB ETU Fire Ants) in Ankara. The participants were categorized by their playing positions into one of the five categories similar to a study by Turnagöl (12): defensive linemen (DL, n=22), offensive linemen (OL, n=23), defensive backs (DB, n=71), offensive backs (OB, n=34) and receivers (R, n=35). Cornerbacks, line backs, and safety positions were grouped into DB; quarterbacks and running back players were grouped into OB; whereas tight ends and wide receivers were grouped into R.

Assessment of Body Composition

Anthropometric measurements. Body weight was measured using a scale (InBody 570 body composition analyzer, USA) to the nearest 0.1 kg. Height was determined by a stadiometer (Seca 213 mobile stadiometer, USA) to the nearest 0.1 cm. Accordingly, BMI was calculated as body weight in kilograms divided by the square of height in meters. BMIs of players were evaluated according to the classification determined by World Health Organization (WHO) (13). Waist circumference (WC) was measured with a Seca brand ergonomic tape measure at the midpoint between the lower margin of the last rib and the top of the iliac crest while the participants were standing up and wearing the thinnest clothes. When evaluated in terms of health, it is suggested that WC measurement should be <94 cm in men; if the WC is found between 94–102 cm, it refers that chronic disease risk; and if it is >102 cm, it should be considered as a high-risk indicator (14). Thus, all WC measurements were evaluated according to these indicators. Hip circumference (HC) was also measured by the same measure at the outermost region of the buttocks on the horizontal plane, while participants were standing upright and wearing the thinnest clothes. The waist/hip ratio (WHR) of participants was calculated with the formula WC (cm)/HC (cm). According to the WHO standards, the WHR in men is recommended to be <0.90 in terms of health (14). The waist-to-height ratio (WHtR) was calculated by dividing WC (cm) by height (cm) and evaluated according to the Ashwell classification (15). In this context, if the WHtR ratio is <0.4 or >0.5, it should be perceived as a risk, and precautions should be taken (15).

Bioelectrical impedance analysis. Bioelectrical impedance analysis (BIA) was measured by an InBody 570 device. Calibration of this device was completed as per the manufacturer's standard directions in the mornings before the measurements. Before each BIA measurement, all materials (belts, metal buttons, piercing, etc.) that may cause significant attenuation were removed from participants. In addition to that, participants who had platinum excluded from the study. BIA measurements chosen for this study included basal metabolic rate (BMR), body weight, body fat mass (BFM), body fat percentage (BFP), lean body mass (LBM), and total body water (TBW).

Dietary Intake

To determine the dietary intake, 3-day diet records were obtained from participants. The average daily energy and nutrient intakes of participants were analyzed by the computer-Aided Nutrition Program Developed for Turkey, Nutrition Information System (NIS). The outputs were evaluated based on Dietary Reference Intakes (DRI) such as Acceptable Macronutrient Distribution Range (AMDR), Recommended Dietary Allowance (RDA), Adequate Intake (AI) and Estimated Average Requirement (EAR), and sports nutrition recommendations (16-21). Thus, it was detected what percentage of participants consumed nutrients below or above these reference values and recommendations.

Procedures

The methods and procedures of this observational study were approved by the Acıbadem University and Acıbadem Health Institutions Medical Research Ethics Committee (No: 2017-13/31). Procedures of the study were explained to the participants, and their written informed consent was obtained. The study was carried out at the training facilities of college-level teams during the 2017–2018 mid-season. All anthropometric and BIA measurements were performed by the researcher. Participants were instructed not to engage with heavy exercise and not to take alcohol the day before the BIA measurement (22). All measurements were performed in the morning after 8–10 hours of fasting. Diet records procedures and portion size estimations were explained to the participants by a registered dietitian. Participants completed the records on two weekdays and one weekend day and were encouraged to consume their typical diets, recording everything that they ate and drank, including supplements.

Statistical Analysis

Necessary statistical analyses and evaluations of data obtained from the research were made by using IBM SPSS (Statistical Package for Social Sciences) version 24.0. Categorical data of the study were presented as numbers (n) and percent (%), while numerical data were expressed as mean ($\bar{X}$) and standard deviation (±SD) values. The suitability of data for normal distribution was examined by the Kolmogorov-Smirnov test, and one-way variance (ANOVA) analysis was used to compare data with normal distribution according to position groups. As a result of variance analysis, the Levene test was used to analyze homogeneity of variance to determine which group caused the difference, and the Tukey HSD test was used in cases where variance was homogeneous, and if not homogeneous, Tamhane's T2 test was used. The confidence interval was accepted as 95.0% in all statistical tests, and the statistical significance was considered at $p<0.05$.

Results

Participant Characteristics

All participants were Turkish players. The mean age of the players was 19.85±1.48 years. All players completed this study. The average training experience of players was 2.00±1.19 years, and the number of training sessions per week was 3 in all teams. The average self-reported training volume was 2.75±0.25 hours for each training.

Energy, Macro- and Micronutrient Intake

The energy and macronutrient intakes of collegiate American football players by position groups were shown in Table 1. The average energy (kg/kcal/day), carbohydrate (g/kg/day), and protein intakes (g/kg/day) of R were significantly high compared to DL and OL. The other macronutrient intakes of collegiate American football players were not significantly different between position groups ($p>0.05$).

Table 2 shows micronutrient intakes of collegiate American football players by position groups. Micronutrient intakes of position groups were not significantly different from each other.

The numbers and percentages of collegiate American football players consuming macro-and micronutrients below or above EAR/AI/RDA or sports nutrition recommendations were reported in Table 3. Most players were found to consume carbohydrate (g/kg/day) below the recommended range for athletes. Accordingly, carbohydrate intakes (%) of most players were found below AMDR. Almost all players were found to consume fiber below AI. Only a small percentage of players consumed protein below RDA, but as for sports nutrition recommendations, especially for American football players, more than half of them consumed protein below that recommended range. Protein intakes (%) of only a very small percentage of players were found below AMDR. Fat intakes (%) of most players were above AMDR. Saturated fatty acids (SFAs) intakes (%) of all players were above the recommended amount, and the omega-6/omega-3 (ω-6/ω-3) ratios in the diets of almost all players were above the recommended ratio. Approximately half of them were found to consume vitamin A below RDA. More than half of players consumed vitamin E and C at a level above EAR. Also, most players were found to consume vitamin B_1, B_2, B_3, B_6, and B_{12} above EAR, but more than half of them consumed vitamin B_9 below EAR. Iron, phosphorus, and zinc intakes of most players were above EAR. Calcium intakes of more than half of the players were above EAR. Almost half of these players were found to consume a low amount of magnesium compared to EAR. Almost all players were found to consume sodium above RDA, and most players were found to consume potassium below RDA.

Table 1. Energy and Macronutrient Intakes of Collegiate American Football Players by Position Group

Energy and Macronutrients	DL (n=22)	OL (n=23)	DB (n=71)	OB (n=34)	R (n=35)	Total (n=185)	F	P
	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$		
Energy (kcal)	2817.14±1172.50	2787.99±806.39	2630.60±627.70	2639.02±813.24	3035.16±1221.47	2750.43±896.00	1.385	0.241
Energy (kcal/kg/day)	27.84±12.85 **(a)**	25.98±9.17 **(a)**	33.45±8.63 **(ab)**	34.03±11.61 **(ab)**	41.49±20.12 **(b)**	33.48±13.39	6.655	**<0.001**
Carbohydrate (g/day)	275.37±118.19	265.57±82.00	259.88±75.46	256.02±88.51	310.37±138.19	271.27±99.44	1.847	0.122
Carbohydrate (%)	39.91±7.37	39.26±8.84	40.51±8.12	40.00±8.45	41.91±8.72	40.45±8.25	0.439	0.780
Carbohydrate (g/kg/day)	2.73±1.35 **(a)**	2.47±0.85 **(a)**	3.32±1.11 **(ab)**	3.33±1.31 **(ab)**	4.31±2.34 **(b)**	3.33±1.55	6.678	**<0.001**
Protein (g/day)	130.78±63.17	129.46±55.93	125.38±42.24	126.39±52.98	133.37±59.55	128.23±51.73	0.165	0.956
Protein (%)	19.14±3.94	18.65±4.00	19.52±4.71	19.74±6.01	18.00±4.17	19.12±4.71	0.822	0.513
Protein (g/kg/day)	1.29±0.68 **(a)**	1.21±0.61 **(a)**	1.60±0.50 **(ab)**	1.61±0.68 **(ab)**	1.81±0.91 **(b)**	1.55±0.69	3.631	**0.007**
Fat (g/day)	130.63±60.99	130.21±45.64	117.75±38.90	118.53±45.53	135.25±62.23	124.29±48.90	1.052	0.382
Fat (%)	40.73±6.36	41.30±7.36	39.39±6.97	39.53±7.14	39.29±6.97	39.79±6.94	0.484	0.748
MUFAs (g/day)	48.02±21.03	47.46±20.76	42.53±14.61	43.29±16.87	51.10±26.46	45.55±19.37	1.425	0.228
MUFAs (%)	15.62±3.99	15.10±3.86	14.43±3.06	14.77±3.02	14.90±3.56	14.81±3.36	0.585	0.674
PUFAs (g/day)	27.39±17.19	26.33±10.80	23.43±11.52	21.89±11.69	25.43±13.74	24.36±12.68	0.932	0.447
PUFAs (%)	8.64±3.55	8.50±2.62	7.92±2.70	7.25±2.76	7.42±2.59	7.86±2.81	1.370	0.246
SFAs (g/day)	43.36±22.59	40.99±16.53	39.37±13.78	41.76±18.76	43.50±21.80	41.27±17.80	0.416	0.797
SFAs (%)	13.75±4.34	13.14±3.80	13.41±3.09	14.12±4.20	12.91±2.84	13.45±3.51	0.600	0.663
Omega-3 (g/day)	2.52±2.11	2.33±2.87	2.11±1.83	1.82±0.96	2.14±1.29	2.14±1.81	0.567	0.687
Omega-6 (g/day)	19.78±14.93	17.02±8.50	16.54±9.36	14.75±9.45	16.77±10.85	16.70±10.35	0.796	0.529
Omega-6/Omega-3 (g/day)	8.85±5.15	11.34±7.73	10.17±6.94	8.50±4.10	8.74±5.84	9.58±6.22	1.114	0.352
Fibre (g/day)	19.79±7.28	20.36±10.12	21.01±8.55	21.23±10.59	24.15±11.34	21.42±9.59	0.973	0.423
Cholesterol (mg/day)	583.81±315.02	577.50±315.24	589.78±319.77	597.58±380.21	564.26±304.23	584.15±324.45	0.054	0.995

F: One-way analysis of variance; a–b: There is no difference between position groups who have the same letter; MUFAs: Monounsaturated fatty acids; PUFA: Polyunsaturated fatty acids; SFAs: Saturated fatty acids.

Table 2. Micronutrient Intakes of Collegiate American Football Players by Position Groups

Micronutrients	DL (n=22)	OL (n=23)	DB (n=71)	OB (n=34)	R (n=35)	Total (n=185)	F	P
	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$		
Vitamin A (mcg/day)	1011.48±524.20	894.60±480.15	1085.71±790.02	1058.22±751.71	895.46±589.28	1012.08±684.71	0.662	0.619
Vitamin E (mg/day)	23.22±16.60	21.61±12.82	19.25±9.88	17.35±11.24	20.74±13.63	19.95±12.18	0.987	0.416
Vitamin K (mcg/day)	111.76±116.24	102.46±108.42	99.12±100.23	118.97±98.28	80.13±67.60	101.09±97.49	0.761	0.552
Vitamin C (mg/day)	94.68±56.98	105.15±66.64	103.71±67.34	97.43±59.65	93.13±68.41	99.66±64.43	0.241	0.915
Vitamin B_1 (mg/day)	1.18±0.50	1.19±0.54	1.24±0.45	1.31±0.61	1.29±0.60	1.25±0.53	0.314	0.869
Vitamin B_2 (mg/day)	2.38±1.14	2.36±1.10	2.28±0.92	2.34±1.23	2.17±1.11	2.29±1.06	0.190	0.943
Vitamin B_3 (mg/day)	29.83±20.90	31.21±16.59	28.99±12.68	26.63±13.51	29.26±17.74	28.99±15.38	0.334	0.855
Vitamin B_6 (mg/day)	2.09±1.38	2.25±1.65	2.37±1.15	2.19±1.18	2.46±1.52	2.31±1.32	0.373	0.828
Vitamin B_9 (mcg/day)	303.76±165.09	300.67±173.21	310.50±108.80	330.31±144.98	298.35±122.13	309.82±133.59	0.299	0.879
Vitamin B_{12} (mcg/day)	11.09±6.59	8.79±4.96	11.26±10.42	8.99±5.27	8.61±4.70	10.01±7.73	1.150	0.335
Calcium (mg/day)	1067.13±605.90	1040.81±508.44	972.32±406.57	1086.54±558.90	1065.02±515.37	1030.64±493.03	0.427	0.789
Iron (mg/day)	13.49±4.03	13.72±5.82	13.92±4.22	14.01±5.28	15.35±5.90	14.13±4.95	0.698	0.594
Magnesium (mg/day)	353.69±169.73	355.33±192.35	361.17±120.00	377.80±168.20	379.58±175.38	366.09±155.08	0.192	0.942
Phosphorus (mg/day)	1746.83±795.78	1749.17±688.75	1741.62±539.78	1793.04±736.81	1843.26±720.90	1771.86±659.38	0.160	0.958
Potassium (mg/day)	2814.92±1138.77	3042.89±1473.16	3015.21±885.32	3044.53±1092.62	3130.68±1191.27	3022.07±1090.66	0.287	0.886
Sodium (mg/day)	4871.10±1507.33	4828.90±2233.58	4604.00±1697.27	4561.30±2060.31	5609.47±2689.70	4846.10±2049.01	1.651	0.163
Zinc (mg/day)	15.31±5.78	14.80±6.93	15.03±4.61	15.63±5.79	16.27±6.81	15.38±5.70	0.350	0.844

F: One-way analysis of variance.

Table 3. The Numbers and Percentages of Collegiate American Football Players Consuming Macro- And Micronutrient Below or Above The EAR/AI/RDA or Sports Nutrition Recommendation

Nutrients	EAR/AI/RDA or Sports Nutrition Recommendation	DL		OL		DB		OB		R		General	
		n	%	n	%	N	%	n	%	n	%	n	%
Carbohydrate													
g/kg/day	5–7[a]	19	86.4	23	100	67	94.4	30	88.2	24	68.6	163	88.1
% total energy intake	45–65[b]	15	68.2	19	82.6	53	74.6	24	70.6	19	54.3	130	70.3
Fiber (g/day)	38 [c]	21	95.5	22	95.7	69	97.2	32	94.1	32	91.4	176	95.1
Protein													
g/kg/day	0.8[d]	5	22.7	6	26.1	0	0	3	8.8	1	2.9	15	8.1
g/kg/day	1.6–1.7[e]	17	77.3	19	82.6	40	56.3	19	55.9	17	48.6	112	60.5
% total energy intake	15–25[b]	3	13.6	2	8.7	7	9.9	4	11.8	6	17.1	22	11.9
Fat													
% total energy intake	20–35[f]	16	72.7	22	95.7	50	70.4	23	67.6	27	77.1	138	74.6
SFAs (% total energy)	<10% total energy[g]	22	100	23	100	71	100	34	100	35	100	185	100
ω-6/ω-3 (g/day)	3/1[h]	21	95.5	22	95.7	70	98.6	33	97.1	34	97.1	180	97.3
Vitamins													
Vit. A (mcg/day)	900[d]	11	50	12	52.2	36	50.7	13	38.2	23	65.7	95	51.4
Vit. E (mg/day)	12[i]	2	22.2	2	13.3	9	24.3	9	39.1	6	35.3	28	27.7
Vit. K (mcg/day)	120[c]	16	72.7	18	78.3	60	84.5	21	61.8	29	82.9	144	77.8
Vit. C (mg/day)	75[i]	9	40.9	7	30.4	28	39.4	11	32.4	17	48.6	72	38.9
Vit. B_1 (mg/day)	1[i]	11	50	11	47.8	26	36.6	13	38.2	11	31.4	72	38.9
Vit. B_2 (mg/day)	1.1[i]	2	9.1	1	4.3	2	2.8	5	14.7	4	11.4	14	7.6
Vit. B_3 (mg/day)	12[i]	0	0	0	0	2	2.8	3	8.8	3	8.6	8	4.3
Vit. B_6 (mg/day)	1.1[i]	3	13.6	4	17.4	4	5.6	6	17.6	5	14.3	22	11.9
Vit. B_9 (mcg/day)	320[i]	16	72.7	17	73.9	40	56.3	19	55.9	21	60	113	61.1
Vit. B_{12} (mcg/day)	2[i]	0	0	0	0	0	0	3	8.8	1	2.9	4	2.2
Minerals													
Calcium (mg/day)	800[i]	9	40.9	8	34.8	27	38	10	29.4	12	34.3	66	35.7
Iron (mg/day)	6[i]	1	4.5	0	0	1	1.4	2	5.9	0	0	4	2.2
Magnesium (mg/day)	330[i]	14	63.6	13	56.5	33	46.5	14	41.2	18	51.4	92	49.7
Phosphorus (mg/day)	580[i]	0	0	0	0	0	0	2	5.9	1	2.9	3	1.6
Potassium (mg/day)	4700[j]	20	90.9	20	87	68	95.8	31	91.2	31	88.6	170	91.9
Sodium (mg/day)	1500[k]	22	100	23	100	71	100	33	97.1	35	100	184	99.5
Zinc (mg/day)	9.4[i]	4	18.2	2	8.7	10	14.1	6	17.6	3	8.6	25	13.5

AMDR: Acceptable Macronutrient Distribution Range; EAR: Estimated Average Requirement; AI: Adequate Intake; RDA: Recommended Dietary Allowance; SFAs: Saturated fatty acids; [a] Participants consuming carbohydrate below sports nutrition recommendation (18, 20); [b] Participants consuming carbohydrate and protein below AMDR (16); [c] Participants consuming fiber and vitamin K below AI (16); [d] Participants consuming protein and vitamin A below RDA (16); [e] Participants consuming protein below recommendations for American football players (19, 20); [f] Participants consuming fat above AMDR (16); [g] Participants consuming SFA above 10% of total energy (21); [h] Participants whose omega-6/omega-3 ratio above 3/1 (17); [i] Participants consuming micronutrients below EAR (16); [j] Participants consuming potassium below RDA (16); [k] Participants consuming sodium above RDA (16).

Body Composition

Anthropometric measurements. Anthropometric measurements of collegiate American football players by position groups were shown in Table 4. Average body weights, BMIs, WCs, and WHtRs of both DL and OL were significantly higher than other position groups. Even if the average heights of both DL and OL were similar to each other and with R, their average heights were significantly higher than DB and OB. The average WC of DB was significantly higher than R but similar to OB. The average WHR of OL was similar to DL but significantly high compared to DB, OB, and R. Adversely, the average WHR of DL was similar to DB, OB, and R. The average WHtRs of both DB and OB were similar to each other but significantly higher than R.

The status of collegiate American football players by position groups in the BMI classification of WHO (13) was shown in Figure 1. According to this, more than half of DL and OL were obese in various degrees. As for other players, while more than half of DB were overweight, most of R and a half of OB had healthy body weight.

Figure 2 shows the WC classification of players by position groups according to WHO (14). While a majority of DB, OB, and R were within the recommended range (<94 cm), more than half of DL and OL were within the range where health risks are available.

The WHR classification (14) of collegiate American football players by position groups were shown in Figure 3. Accordingly, while WHR of almost half of OL and approximately one-third of DL were found ≥0.90 cm, WHR of a majority of DB, OB, and R were <0.90 cm.

The WHtR classification (15) of collegiate American football players by position groups was given in Figure 4. More than half of DL and OL was in the risky range. In addition, while most of DB, OB, and R were in the normal range, some of DL and OL were in the range that action must be taken and requires treatment.

BIA measurements. The results of the BIA measurements of players by position groups are also indicated in Table 4. Accordingly, the average BFPs, BFMs, LBMs, TBWs, and BMRs of both DL and OL were found significantly higher than other position groups. Although the average BFP and BFM of DB were similar to OB, these values of DB were significantly higher than R. Besides, the average LBMs, TBWs, and BMRs of DB, OB, and R were not significantly different from each other.

Discussion

The findings of this study were compared with other studies. However, the published studies on dietary intakes of collegiate American football players have been limited, and a direct comparison of dietary intakes is difficult due to playing positions have not been categorized in the same way.

The average total energy intake of players in this study was similar to the study of Cole et al. (23), while it was lower compared to the study of Kirwan et al. (8). Regarding the position groups, the average total energy intakes of DL and OL in this study were found very low compared to the average total energy intake of linemen (5225.4±1693.6 kcal/day) in a study by Abbey et al. (4).

The carbohydrate intake of American football players is extremely important in terms of meeting their energy needs for the training and recovery process (20). Inadequate carbohydrate intake may lead to depleted glycogen stores and impaired performance (18). It was suggested that these players may need 5-7 g/kg/day carbohydrate for the preservation and regeneration of muscle and liver glycogen stores because they sometimes have high intensity and strength training of more than 1 hour per day (20). In this study, almost all players (especially OL) were found to consume carbohydrates below that recommended range (5–7 g/kg/day). Thus, these players may have a greater risk for lower than optimal carbohydrate intakes to support the most intense training effort possible. Also, almost all players consumed fiber less than AI (16). In this context, meeting the carbohydrate needs of collegiate American football players from fruits, vegetables, and whole grain foods, especially during intensive training and competition periods,

Table 4. Body Composition of Collegiate American Football Players by Position Groups

Body Composition	DL (n=22)	OL (n=23)	DB (n=71)	OB (n=34)	R (n=35)	Total (n=185)	F	P
	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$	$\bar{X} \pm S$		
Anthropometric Measurements								
Body weight (kg)	103.61±11.75 **(b)**	110.13±13.39 **(b)**	79.31±7.31 **(a)**	78.53±9.67 **(a)**	75.39±9.94 **(a)**	85.14±15.83	76.926	**<0.001**
Height (cm)	182.11±6.25 **(b)**	183.17±6.69 **(b)**	176.58±4.41 **(a)**	175.96±7.47 **(a)**	179.99±6.41 **(ab)**	178.59±6.49	9.453	**<0.001**
BMI (kg/m²)	31.38±4.43 **(c)**	32.95±4.77 **(c)**	25.46±2.50 **(b)**	25.41±3.20 **(b)**	23.21±2.26 **(a)**	26.66±4.56	47.652	**<0.001**
WC (cm)	97.09±9.39 **(c)**	102.52±11.36 **(c)**	82.69±5.57 **(b)**	83.00±6.07 **(ab)**	79.31±5.15 **(a)**	86.29±10.58	58.215	**<0.001**
HC (cm)	110.41±8.92 **(b)**	113.83±8.93 **(b)**	96.75±5.63 **(a)**	96.44±6.10 **(a)**	94.46±5.93 **(a)**	100.01±9.64	50.402	**<0.001**
WHR (cm)	0.88±0.03 **(bc)**	0.90±0.05 **(b)**	0.85±0.04 **(ac)**	0.86±0.03 **(ac)**	0.84±0.03 **(a)**	0.86±0.04	10.639	**<0.001**
WHtR (cm)	0.53±0.06 **(c)**	0.56±0.07 **(c)**	0.47±0.04 **(b)**	0.47±0.04 **(b)**	0.44±0.03 **(a)**	0.48±0.06	35.498	**<0.001**
BIA Measurements								
BFP (%)	26.13±8.79 **(c)**	30.06±7.33 **(c)**	16.81±5.50 **(b)**	15.69±6.73 **(ab)**	12.79±4.91 **(a)**	18.60±8.47	37.058	**<0.001**
BFM (kg)	27.89±11.98 **(d)**	33.67±11.19 **(d)**	13.56±5.10 **(b)**	12.62±6.48 **(ab)**	9.91±4.49 **(a)**	16.90±10.91	57.015	**<0.001**
LBM (kg)	75.73±5.59 **(b)**	76.46±7.46 **(b)**	65.75±5.23 **(a)**	65.90±7.48 **(a)**	65.48±7.31 **(a)**	68.24±7.78	22.210	**<0.001**
TBW (L)	55.21±3.97 **(b)**	55.89±5.43 **(b)**	48.06±3.82 **(a)**	48.19±5.42 **(a)**	47.87±5.25 **(a)**	49.87±5.63	22.188	**<0.001**
BMR (kcal)	2005.82±120.64 **(b)**	2021.39±161.24 **(b)**	1790.32±112.85 **(a)**	1793.47±161.53 **(a)**	1784.29±158.04 **(a)**	1844.11±168.03	22.194	**<0.001**

F: One-way analysis of variance; a-b: There is no difference between position groups who have the same letter.

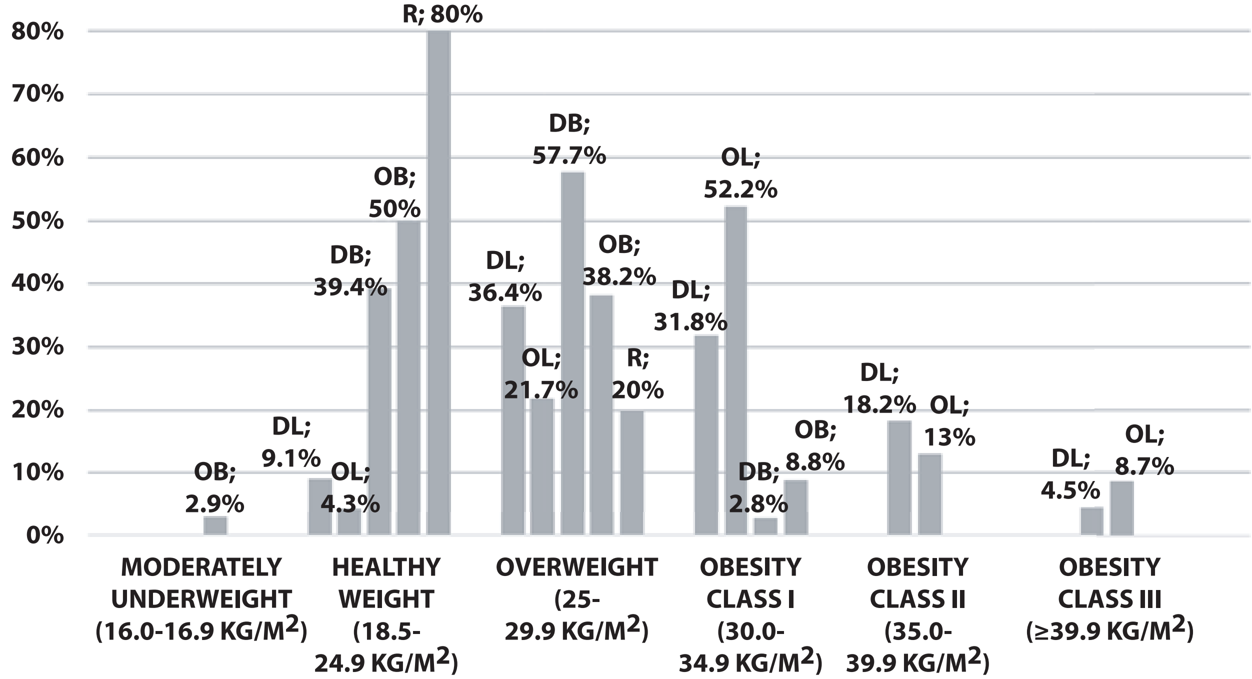

Figure 1. BMI Classification of Collegiate American football Players by Position Groups

would not only improve their athletic performance but also increase their fiber intake and thus reduce the risk of developing cardiovascular disease (CVD) (4).

The protein requirement of athletes may vary depending on the type of sport. It was recommended that these players could consume protein in the range of 1.6–1.7 g/kg/day (19,20). Kirwan et al. (8) found that the average protein intake of collegiate American football players was 1.8 g/kg/day. Abbey et al. (4) reported that the average protein intake of linemen was 2 g/kg/day. Protein intakes of players in this study were low compared to a study by Kirwan et al. (8). In comparison with a study by Abbey et al. (4), it was found that DL and OL of the present study consumed quite low amounts of protein. Although it seems that most players in this study consumed excessive amounts of protein compared to RDA, they consumed a very low amount of protein compared to other studies (4, 8). Besides, the average protein intakes of DL and OL were below the recommended range for American football players (1.6–1.7 g/kg/day) (19, 20). American football is a kind of full-contact sport that includes both endurance training and strength training. Accordingly, DL and OL are typically stronger than other players due to their roles in the game. Therefore, if these players want to gain lean mass and to be stronger, they probably need to increase their protein intake at least to the recommended range or the amount consumed by counterparts in the other studies. Thus, they also may benefit more from increased protein intake to stimulate muscle protein synthesis, repair muscle damage, and cover oxidative protein losses (19). The key point is that the increase in protein intakes should have to displace another dietary macronutrient unless weight gain is the desired target. In the case of displacement of dietary fat, then both health and performance benefits may be provided (19). However, if the increased protein intake led to a lower carbohydrate intake, performance may be impaired (19).

Average fat intakes of most players (% total energy) were found high compared to AMDR (20–35%) (16). Besides, the average fat intake (% total energy) of players in this study was more than reported (24%) by Cole

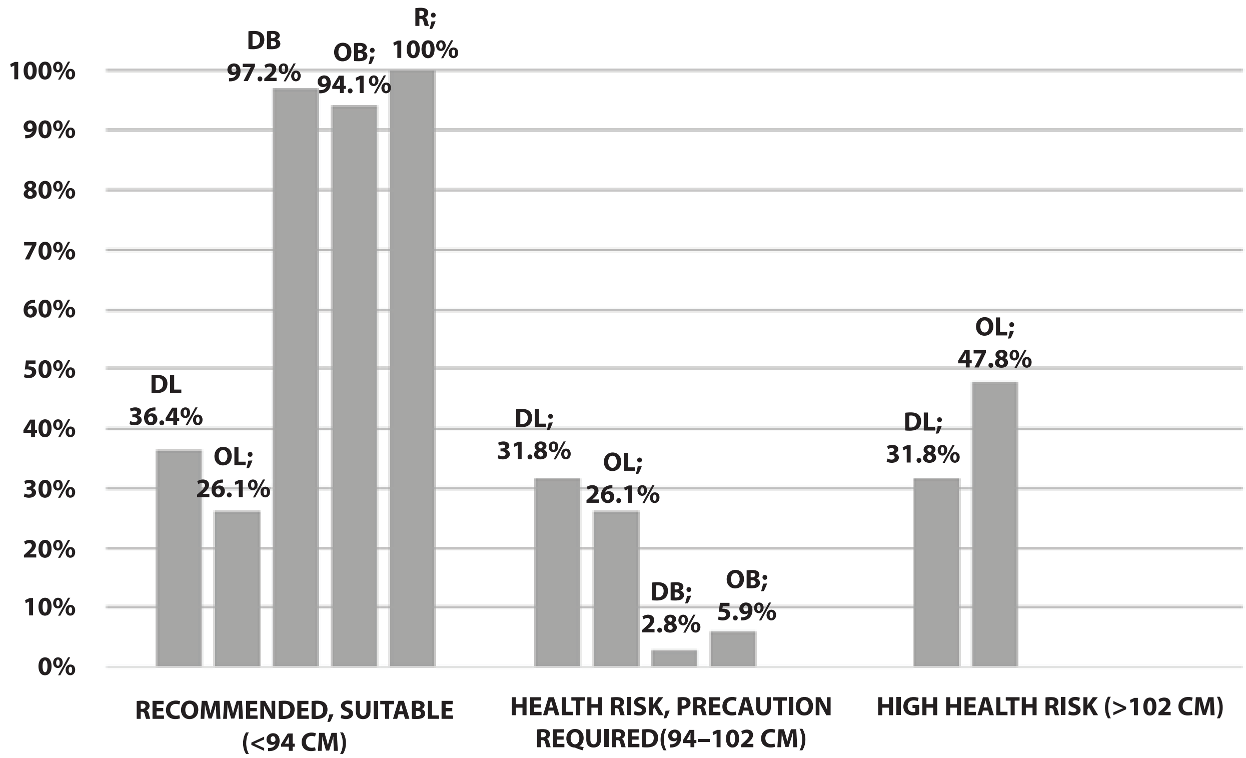

Figure 2. WC Classification of Collegiate American Football Players by Position Groups of DB were similar to OB, these values of DB were significantly higher than R. Besides, the average LBMs, TBWs, and BMRs of DB, OB, and R were not significantly different from each other.

et al. (23). This would lead to not only an imbalance in the diet but also cause a decrease in performance, as carbohydrates are the major source of energy. Moreover, the average SFAs intake of players in this study was also high compared to a study by Cole et al. (23) in terms of both amount and percentage. Also, the average SFAs intake (% total energy) of players was higher than the percentage (<10%) recommended by the American College of Sport Medicine (ACSM) (21). SFAs have been primarily linked to CVD risk due to their potential to increase blood levels of LDL cholesterol (24-26). So, it is suggested that instead of foods with high SFAs content (processed meats, full-fat dairy products, butter, etc.), these players should consume more fruits, vegetables, and whole-grain foods, which are cardiovascular protective thanks to their high amounts of MUFAs and PUFAs content (27–30). The average ω-6/ω-3 ratio in the diets of players was higher than the rate (3/1) recommended for athletes (17). The studies have shown that lowering the rate of ω-6/ω-3 in a diet has beneficial effects on various diseases (31–33). In this context, it is thought that it will be beneficial for players to decrease their consumption of foods such as vegetable oil and margarine rich in ω-6 fatty acids and to increase the consumption of foods such as fish, walnuts, and green leafy vegetables rich in ω-3 fatty acids. Even if the most recent Dietary Guidelines (34) no longer include the previous recommendation (<300 mg/day), they still emphasize that dietary patterns, including lower intake of dietary cholesterol, are associated with a lower risk of CVD (35). Therefore, avoiding the consumption of foods high in cholesterol, such as fast foods, would be beneficial for these players.

Vitamin A supports the normal vision (17). Besides, it helps keep bones, skin, and red blood cells healthy and is also needed for the immune system to function normally (17). It also may, as an antioxidant, be effective in reducing post-exercise muscle soreness

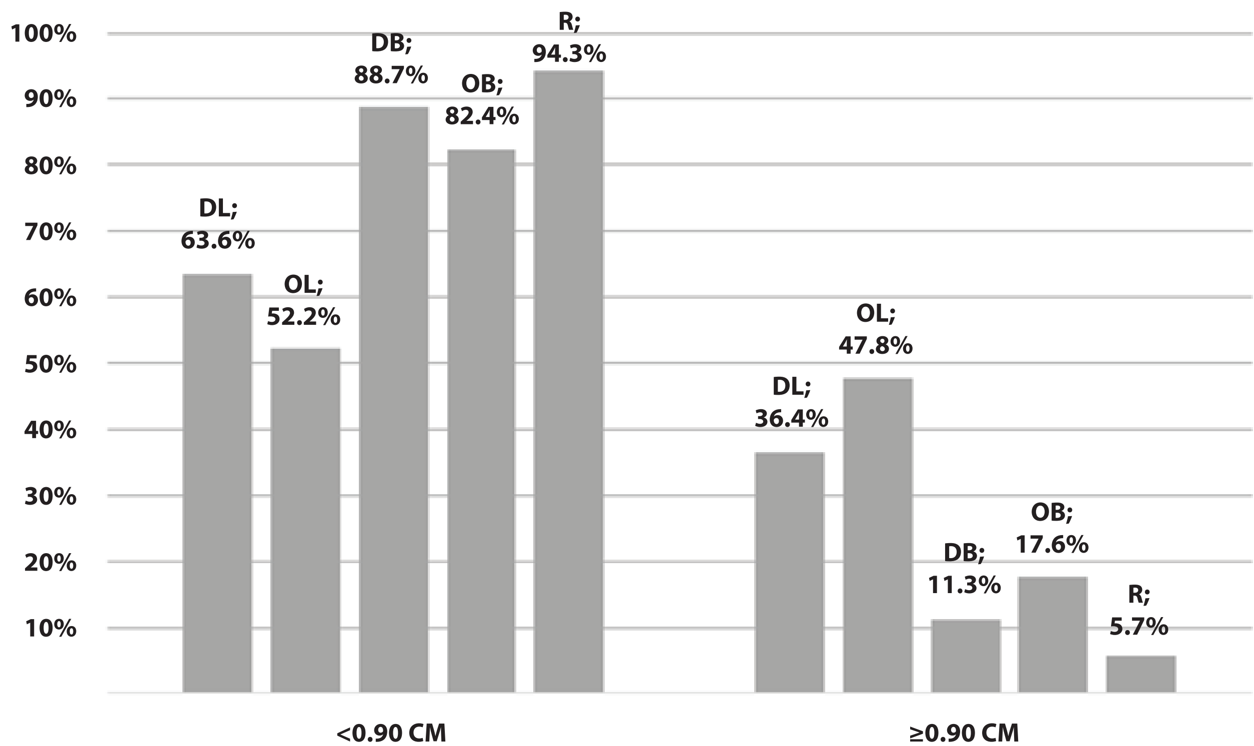

Figure 3. WHR Classification of Collegiate American Football Players by Position Groups

(17, 36). However, approximately half of the players were found to consume vitamin A below EAR. Therefore, these players should consume foods rich in this vitamin, such as liver, butter, cheese, egg, yolks, fish liver oils, dark green, and brightly pigmented fruits and vegetables more. Vitamin B_9 (folic acid) is necessary for many enzymes that are critical for DNA synthesis and amino acid metabolism (37). Besides, it has a role in assisting with cell division, which makes it a critical nutrient for growth, the synthesis of new cells, such as red blood cells, and the repair of damaged cells and tissues (37). Therefore, vitamin B_9 requirements might be higher with exercise because damaged muscle tissue needs to be repaired (37). Unfortunately, more than half of players consumed vitamin B_9 under EAR. So, it will be beneficial for these players to increase their dietary vitamin B_9 intake by consuming foods rich in this vitamin, such as dark green leafy vegetables, beans, peanuts, fresh fruits, whole grains, liver, seafood, and eggs. Although it is seen that vitamin B_{12} intakes of players were excessive, the high intake of this vitamin does not have any negative and toxic effects.

Calcium is an important mineral that participates in the structure of bones and increases its durability (17). However, it was found that calcium intakes of more than one-third of players were below EAR. While most players consumed potassium below RDA, almost all of them consumed sodium above RDA. The players' average sodium intake was more than three times RDA but may be suitable depending on their individual sweat rates. However, consuming a diet high in sodium during off-season lasting for months could result in adverse cardiovascular effects through a rise in blood pressure (38). Both a dietary decrease in sodium and an increase in potassium have been reported to help moderate blood pressure (38). As well as being high in potassium, diets rich in fruits and vegetables may be beneficial for cardiovascular health because of their high antioxidant content, which could reduce inflammation and oxidative stress (39, 40).

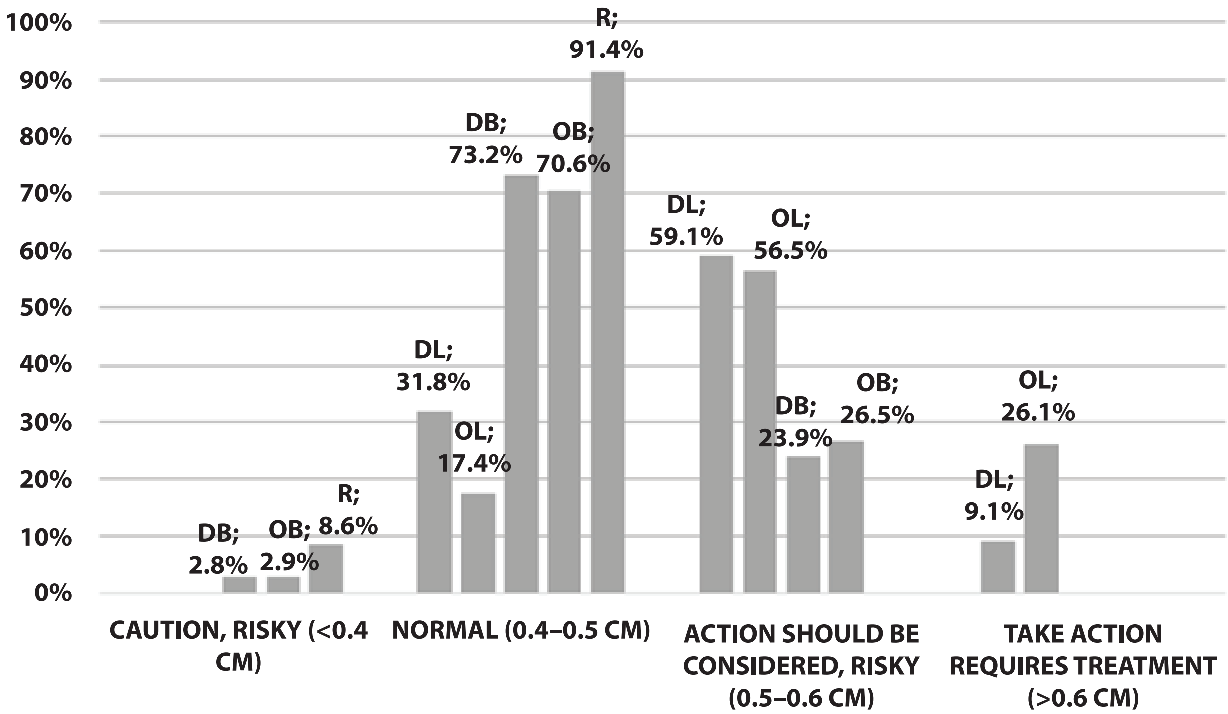

Figure 4. WHtR Classification of Collegiate American Football Players by Position Groups

With respect to the anthropometric measurements, the average BMIs of DL and OL in this study were low compared to the studies by Abbey et al. (4) (34.2±4.3 kg/m² for linemen), Cole et al. (23) (36.43 kg/m² for linemen), Turnagöl (12) (DL: 30.80±3.55 kg/m² and OL: 34.06±3.73 kg/m²) and Mathews & Wagner (6) (DL: 31.9±3.5 kg/m² and OL: 34.4±4.0 kg/m²). Besides, the average BMIs of DB, OB, and R were similar to a study by Turnagöl (12). According to BMI classification, most DL and OL were found obese in various degrees (see Figure 1). However, BMI has its own limitations in athletic populations and should therefore be considered along with the other anthropometric measurements when assessing cardiometabolic disease risk. Average WCs of DL and OL in the present study were lower than average WCs of DL (99.3±16.0 cm) and OL (105.9±10.9 cm) in the study of Mathews & Wagner (6). Nonetheless, it was found that most of these players were in the region that indicates health risk in terms of WC and WHtR (see Figure 2 and Figure 4). Therefore, the cardiometabolic disease risks of these players were higher than other position groups. So, BMIs, WCs, and WHtRs of DL and OL should be reduced and monitored regularly.

However, the anthropometric measurements may not always accurately demonstrate the health status of the athletic population. Therefore, it was also evaluated the BIA measurements of collegiate American football players. Mathews & Wagner (6) found that the average BFPs of DL and OL were 22±1.3% and 27.6±1.3%, respectively. Melvin et al. (41) reported that the average LBMs of DL and OL were 96.2±4.8 kg and 96.6±6.8 kg, respectively; the average BFMs of them were 29.1±4.8 kg and 32.7±4.6 kg, respectively; and the average BFPs of them were 22.3±2.3% and 24.4±2.2%, respectively. Turnagöl (12) reported that the average LBMs of the DL and OL were 73.40±5.26 kg and 71.46±5.32 kg, respectively; the average BFMs of them were 30.38±12.66 kg and 40.94±9.23 kg, respectively; and the average BFPs of them were 28.40±7.32% and

36.17±6.44%, respectively. Average LBMs of DL and OL in the present study were quite low compared to a study by Melvin et al. (41) but higher than reported by Turnagöl (12). On the other hand, average BFMs of DL and OL were similar to a study by Melvin et al. (41), whereas quite low compared to a study by Turnagöl (12). Besides, average BFPs of DL and OL were high compared to the other two studies (6, 41) but lower than reported by Turnagöl (12). While only OL was found to have significantly higher BFP than other position groups in a study by Turnagöl (12), it was found that the BFPs of both DL and OL were significantly higher than other position groups in this study. Also, it was determined that DB, OB, and R had high LBMs and low BFMs and BFPs, compared to a study by Turnagöl (12). In addition, the average BFP of R was within the ideal range for athletes (6–13%); the average BFPs of DB and OB were in the ideal range recommended for those who live actively (14–17%); the average BFPs of DL and OL were located in the region indicating obesity (≥25%), according to the BFP classification of American Council on Exercise (ACE) (42). In the light of these data, the establishment of regular exercise and nutrition programs to reduce the BFPs of DL and OL at least to the acceptable range (18–24%) indicated by ACE has great importance.

In this study, collegiate American football players were found to follow an unbalanced diet in terms of many nutrients. Besides, it was determined that most DL and OL were obese. In conclusion, it would be useful to provide nutritional education for collegiate American football players, and specific nutritional strategies should be developed to reduce the risk of obesity-related diseases in both DL and OL.

To our knowledge, this is the first study, which examined the dietary intake of collegiate American football players by position groups in Turkey. Furthermore, the body composition profiles of collegiate American football players of the present study were different compared to a previous study in Turkey (12). This difference may be due to the large sample size of our study. However, this study has some limitations. First, we did not take daily activity records of participants, so this is the reason why we could not be able to calculate their energy requirements. Second, data on diet records were self-reported by the participants. Since the participants were constrained by their tight schedules during mid-season, more direct assessments such as observations of dietary intake were not feasible. Although participants were instructed on how to estimate portion sizes and their diet records were rechecked by a registered dietitian, there may have been inaccuracies in their reports. In this context, investigating whether collegiate American football players meet their energy requirements and determining their dietary intake by more direct measurements will provide more comprehensive data. Besides, most studies on the dietary intake and body composition of collegiate American football players conducted in the USA, so future studies in different parts of the world, especially in Europe, in which this sport becomes more popular, may enable researchers to enlarge the database on dietary intake and body composition of these players.

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Conflict of Interest: The authors declare no conflict of interest. The results of this study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

Ethical Standards: This study was approved by the Acıbadem Mehmet Ali Aydınlar University and Acıbadem Health Institutions Medical Research Ethics Committee (2017–13/31). All participants provided written informed consent.

Data Availability Statement: The datasets generated for this study are available on request to the corresponding author.

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