

Elite Athletes' Characteristics in Esthetic Sports Related to Body Composition, Physiology, Bone Mineral Density and Nutrition

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Abstract

Aim: Nutritional deficiencies occur in elite athletes in aesthetic branches who suffer from intensive training programs and strict weight control. Increased disability, the weakening of the immune system, menstrual disorders and increased risk of bone fracture due to abnormal bone mineralization impair the quality of life and threaten the health of athletes. The purpose of this study was to determine body composition, nutrition and hydration status, bone mineral density levels and some physiological parameters in athletes interested in aesthetic sports.

Material and Methods: The study was participated by a total of 15 healthy artistic gymnasts, ice skaters and ballet dancers aged 18 and over and 10 individuals of similar age and physical qualities as the control group. The body composition, resting metabolic rate, hydration status, bone mineral density, nutritional habit and menstruation period of the athletes were assessed and some health parameters in blood about bone metabolism, anaemia and infection were evaluated.

Results: It was found that the athletes' daily energy consumption and dietary intake of vitamin-mineral levels, vitamin D, Ca and Fe, are inadequate for especially female athletes. Fat ratio was higher and carbohydrate ratio was lower than the recommended daily energy distribution of athletes, 2/3 of athletes were dehydrated. The athletes did not have menstrual irregularities and eating disorder behaviours. The highest bone mineral density was in athletes, especially in gymnastics, while the lowest was in the control group.

Conclusion: Although the athletes have higher values than the controls, due to insufficient energy, low carbohydrate and calcium intake and low bone density of female athletes, especially female athletes are suggested keeping under control for risk of female athlete triad.

Keywords

Bone mineral density
Female athlete triad
Ice skating
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INTRODUCTION

Aesthetic visuality and low body weight are required as well as speed, endurance and power in some sport branches such as gymnastics, ballet, ice skating (IS), aerobic dance, and weight sports (Di Cagno, Baldari, Guidetti and Piazza, 2008; Soric, Misigoj-Durakovic and Pedisic, 2008). These elite level athletes are exposed to extremely intensive training programs and strict attitudes in weight control since their childhoods, which may results in insufficient nutrition (D'Alessandro, Morelli, Evangelisti, Galetta, Franzoni, Lazzeri and Cupisti, 2007; Soric et al.). Failure to provide the required energy for athletes bring about the risk of disease, injury and sportive inefficacy (Sundgot-Borgen & Torstveit, 2004).

Malnutrition leads to increased risk of injury, menstrual irregularities, delayed pubertal development and skeletal maturation, as well as decreased resting metabolic rate, increased fat tissue and stress fractures and osteoporosis due to abnormal bone mineralization (Georgopoulos, Roupas, Theodoropoulou, Tsekouras, Vagenakis and Markou, 2010; Michopoulou, Avloniti, Kambas, Leontsini, Michalopoulou, Tournis and Fatouros, 2011). Many studies have reported insufficient intake of energy and various vitamins and minerals such as Ca, Fe and B complex, particularly in rhythmic gymnasts, artistic gymnasts (AG) (Jonnalagadda, Bernadot, & Nelson, 1998), ballet dancers (Weimann, 2002), and IS (Voelker, Gould and Reel, 2014) athletes. It has been shown that especially female athletes have more aesthetic concerns than males, so that they are under the risk of "female athlete triad" which is characterized by low energy intake, menstrual irregularities and low bone mineral density (BMD) (Kouloutbani, Efstathiou and Apostolos, 2012; Michopoulou et al.). Moreover, it has also been reported that long term low energy intake may result in more fat storage in the body and might damage the athletes' body compositions and performance (Deutz, Benardot, Martin and Cody, 2000).

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Studies have revealed controversial results concerning the statistical relations between the BMD level as an indicator of bone health and such parameters as protein rich diet, calcium and vitamin D intake, menstrual irregularity, menstruation age, menopause and puberty, body weight, fat-free mass and exercise type, which are considered to result from particularly genetic susceptibility, other environmental factors and the difference in the areas of measurement in body (Burekhardt, Wynn, Krieg, Bagutti and Faouzi, 2011; Lichtenbelt, Fogelholm, Otteenheijm and Westerterp, 1995; Amorim, Wyon, Maia, Machado, Marques, Metsios and Koutedakis, 2015). On the other hand, other studies which have investigated the relationship between BMD and exercise, have found that especially athletes who regularly do weight bearing and high impact exercises have a better advantage than the sedentary, and athletes who started sports before menarche are more advantageous than those who started after menarche, and that BMD is correlated with strength, muscle mass and oxygen consumption capacity (Amorim et al.,).

In addition to its generally known positive roles in bone health and certain chronic diseases, vitamin D has great importance for athletes due to its positive effects protecting muscular power, physical performance and immune system (Constantini, Arieli, Chodick and Dubnov-Raz, 2010). For example, it has been found that vitamin D is correlated with muscular power, strength, and speed in adolescent female athletes (Ward, Das, Berry, Roberts, Rawer, Adams and Mughal, 2009). Although there are limited number of studies examining the lack of vitamin D on active individuals (Ginde, Liu and Camargo, 2009) vitamin D insufficiency was observed in approximately 80% of the gymnast population in Australia and in 44% of adolescent male dancers (Ducher, Kukuljan, Hill, Garnham, Nowson, Kimlin and Cook, 2011; Lovell, 2008). In addition, it is reported that deficiency of serum 25-hydroxyvitamin D, a significant hormone, impairs muscle movements and bone mineralization (Houston, Tooze, Hausman, Johnson, Nicklas, Miller and Kritchevsky, 2011).

In different sports such as gymnastics which require being slim, calorie limitations and intensive training programs risk hydration state (Filho, Guiramand, Sehl and Leites, 2014; Gibson, Gunn and Maughan, 2012). Young athletes usually start training and competitions in a state of insufficient hydration and restrict fluid intake in order to maintain low body weight (Bergeron, Laird, Marinik, Brenner and Waller, 2009; Meyer, Volterman, Timmons and Wilk, 2012). Continuous dehydration state has been reported to possibly lower performance, motivation, and physical effort during training sessions and competitions (Sawka, Burke, Eichner, Maughan, Montain and Stachenfeld, 2007), and may even be trouble in terms of health (Filho et al., 2014).

As a result of the review of the related literature, no study has been found on the evaluation of both nutrition and hydration states and certain physiological parameters of Turkish male and female elite athletes doing aesthetic sports. Hence, the aim of the present study was to determine the body compositions, nutrition and hydration states, BMD levels, and certain physiological parameters of elite Turkish athletes in aesthetic sports. The present study was initiated with the hypotheses that (1) the required hydration and nutrition balance cannot be maintained in high level athletes in aesthetic sports, (2) the male athletes would be less affected by the possible negative results of intensive exercise and aesthetic concerns in comparison to female athletes, and (3) the female athletes may go under the risk of female athlete triad due to the pressure of being aesthetic.

METHOD

Participants

Fifteen elite athletes (EAG; 9 females, 6 male) who were trained in different sport branches (AG, n=6; ballet, n=6; IS, n=3) and 10 healthy sedentary individuals (CG; 6 females, 4 male) at a similar mean age volunteered to participate in the present study.

Inclusion criteria were: being healthy, being 18-30 years old, and for EAG to have been engaged in aesthetic sports (*e.g.* AG, ballet, and IS) for at least 5 years, doing regular training for at least 7-8 hours a week, and at least 3 days a week. Inclusion criteria for CG were being at a similar age of EAG, and weekly number of activities ≤ 2 . The participants were informed about the nature of the study, and signed informed consent according to the Helsinki Declaration Principles and those of the local ethical committee (20478486-40).

Evaluation of the General Nutrition Habits: After the participants were informed about the portion definitions, a 3-day (2 weekdays and 1 day on weekend) food consumption record was taken in writing

and photographs and also, they were given a food consumption frequency questionnaire. The amounts of the food included in the individuals' diets were calculated in numbers and size. The distribution of energy intake and nutritional elements were analyzed on the Nutritional Information System (BEBIS 7.1, Istanbul, Turkey) program and were compared with the values that are required to be taken.

Anthropometric Measurements: The height and body mass of the participants were measured through standard methods (Seca 769, Hamburg, Germany), and their body mass indexes (BMI) were calculated. Body composition analysis was carried out with the body analysis device (Tanita BC 418, ABD) which is operated through bioelectrical impedance method after overnight fasting. The participants were asked to avoid rigorous exercise, alcohol and caffeine consumption on the day before measurements.

Resting Metabolic Rate Measurement and Daily Energy Requirement Estimation: Resting metabolic rate (RMR) measurements were taken after overnight fasting using a gas analyzer (Cosmed Quark b², Rome, Italy) at sitting position for ten minutes. Additionally, daily energy requirements were estimated using the physical activity factor (D'Alessandro et al., 2007).

Evaluation of the Hydration State: The athletes' body weight was measured before and after morning (9.00-11.00) training sessions, routine technical development training during their season, using an electronic scale. Urine densities were determined from the mid-stream urine samples on a refractometer (Atago Master-Urc/Nm, Tokyo, Japan), and urine color was assessed using the Armstrong color scale. Water and other drinks consumptions (except for caffeine) during training were recorded. Ambient humidity and temperature was measured with a digital thermo-hygrometer and recorded.

Bone Mineral Density Measurement: BMD was measured through standard methods using a dual-energy x-ray absorptiometry (DEXA) (XR-800, Norland) along the total lumbar region (L1-L4), femoral neck, trochanter and Ward's triangle.

Blood Analyses: Using the morning fasting blood samples, total hemogram analyses were counted in EDTA-collected whole blood on a hemacounter (Beckman Coulter, Gen-S). Serum fasting blood glucose (FBG), triglyceride (TG), total cholesterol (TC), HDL-C, blood urea nitrogen, total protein, albumin, creatinine, alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma glutamil transferase (GGT), ionized calcium (Ca), alkaline phosphatase (ALP), Fe levels were measured on the chemistry analyzer (Beckman Coulter, DXC). LDL-C level was calculated by the Friedewald equation. Folate, B12 and ferritin levels were measured with an immunechemiluminescence (Siemens, Immulite 2000) method on auto analyzers. 25- hydroxyvitamin D levels were measured by HPLC (Thermo-Finnigan, Waltham, USA) using Vitamin D3 ClinRep HPLC kits (RECIPE Chemicals+Instruments GmbH, Munich, Germany).

Questionnaires: The participants were given a questionnaire (Hasbay, 2005) to specify their personal and sporting qualities (training frequency, type, history, total number of years, achievements, previous injuries etc.) as well as eating behavior disorders, amenorrhea and osteoporosis states.

Statistical Analysis

Statistical analyses were conducted on the SPSS (version 15.0, SPSS Inc, Chicago, IL, USA) statistical package program. The Shapiro-Wilk W test and the Levene test showed that the obtained data did meet the assumptions of normality and variance homogeneity. Differences between groups were determined using Independent Samples t Test, between pre and post-tests data were determined using Paired Samples t test. Furthermore, differences between genders were evaluated with Mann Whitney U test. The data for EAG and CG were represented as mean and standard deviation (SD). However, the related data of AG, Ballet, and IS athletes were represented in median and 25-75 percentile values. Value of statistical significance was accepted as $p < 0.05$.

RESULTS

The body composition and some physiological data of the groups are presented in Table 1, no significant difference was found between EAG and CG, except body fat ($p=0.042$). The lowest BMI value was recorded in the ballet group, additionally, the highest fat ratio, the lowest body fat free mass (FFM), body water amount and RMR were observed in this group as well. Furthermore, comparing the groups in terms of gender, no significant difference was found between the EAG and CG ($p > 0.05$) (Table 1).

Table 1. Body composition and some physiological variables of elite athlete and control groups

VARIABLES	AG (1F, 5M)	Ballet (6F)	IS (2F, 1M)	EAG (9F, 6M)	CG (6F, 4M)
	Median (25-75 P)	Median (25-75 P)	Median (25-75 P)	X±SD	X±SD
Age (year)	20.0 (18.8-21.5)	25.0 (21.3-27.3)	19.0 (18.0-22.0)	21.7±3.26	22.2±2.30
Body mass (kg)	62.2 (52.9-67.3)	51.0 (48.8-58.6)	53.8 (50.4-74.5)	57.1±8.44	59.8±7.97
BMI (kg/m ²)	21.9 (21.7-23.8)	18.6 (18.0-20.5)	20.2 (19.7-24.0)	20.9±2.17	21.3±2.00
Body Fat Ratio	6.15 (4.93-9.63)	21.0 (16.3-22.4)	17.8 (14.3-18.6)	13.0±6.60	19.1±9.27
Body Fat (kg)	4.10 (3.08-5.30)	10.2 (8.40-12.3)	10.0 (9.00-10.7)	7.20±3.34	11.2±5.14*
FFM (kg)	57.8 (49.0-63.6)	43.1 (35.2-46.4)	43.8 (41.4-63.8)	50.9±10.4	48.6±10.3
Total body water (kg)	42.0 (33.9-46.6)	31.6 (25.8-34.0)	32.1 (30.3-46.7)	37.0±7.56	35.6±7.51
Resting RER	0.80 (0.74-0.85)	0.78 (0.76-0.85)	0.82 (0.82-0.83)	0.80±0.04	0.78±0.04
RMR (kcal)	1657 (1524-1753)	1232 (1193-1366)	1764 (1312-1941)	1554±243	1513±190

AG: artistic gymnastics; IS: ice skate; EAG: elite athlete group; CG: control group; F: female; M: male; BMI: body mass index; FFM: fat free mass; RER: respiratory exchange ratio; RMR: resting metabolic rate; *p<0.05: significantly different from EAG (Independent Samples *t* test result).

The EAG were found to have statistically lower body mass ($p=0.021$) and higher urine specific gravity (USG) ($p=0.046$), and urine color ($p=0.010$) in the post-exercise examination of the hydration status (Table 2). The group with the highest fluid consumption amounts during training occurred as the ballet dancers while the least fluid consumption was observed in ice skaters. Moreover, considering the 500 gr mass lost during training and the 500 ml fluid consumed by the gymnasts, it was observed that they lost an approximately 1 L of fluid through sweating. In addition, 2 athletes has a 1% loss in their body weight due to training, and 10 individuals were dehydrated (1020 g/ml) according to urine density before training while 13 individuals were found to be dehydrated after training. Urine color assessment (based on >3 color scale) confirmed these findings.

Table 2. Hydration parameters of the elite athletes

HYDRATION STATUS	AG (1F, 5M)	Ballet (6F)	IS (2F, 1M)	EAG (9F, 6M)
	Median (25-75 P)	Median (25-75 P)	Median (25-75 P)	X±SD
Pre-training body mass (kg)	62.3 (53.0-67.4)	50.3 (48.8-56.1)	53.2 (50.4-71.2)	56.6±8.11
Post-training mass (kg)	61.9 (52.6-67.0)	50.5 (48.7-56.3)	53.0 (50.4-70.5)	56.3±7.91*
Pre- training USG (g/ml)	1022 (1012-1026)	1024 (1023-1028)	1015 (1010-1022)	1021±7.47
Post- training USG (g/ml)	1025 (1022-1025)	1025 (1021-1032)	1020 (1018-1031)	1025±4.50*
Pre- training urine color	5.00 (1.75-6.25)	5.50 (4.75-6.25)	3.00 (1.00-4.00)	4.47±2.00
Post- training urine color	6.00 (4.75-6.00)	6.00 (5.75-7.00)	3.00 (3.00-6.00)	5.47±1.25**
Fluid intake (ml)	538 (407-593)	915 (645-1075)	100 (0-180)	555±355

AG: artistic gymnastics; IS: ice skate; EAG: elite athlete group; F: female; M: male; USG: urine specific gravity, *p<0.05: significantly different from pre-training values; **p≤0.01: significantly different from pre-training values (Paired Samples *t* test results)

The values of the blood bone metabolism markers fall within normal limits and were found no difference between EAG and CG ($p>0.05$; Table 3). While ALP was found to be higher in gymnasts than the other athletes, mild vitamin D deficiency (<20 µg/L) was seen in 2 male gymnasts, 2 female ballet dancers, and 2 male ice skaters. In addition, ALP values of male athletes were significantly higher than males in CG ($p=0.011$).

Table 3. Bone metabolism parameters of elite athlete and control groups

BONE METABOLISM	AG (1F, 5M)	Ballet (6F)	IS (2F, 1M)	EAG (9F, 6M)	CG (6F, 4M)
	Median (25-75 P)	Median (25-75 P)	Median (25-75 P)	X±SD	X±SD
Vitamin D (µg/L)	20.1 (17.2-23.3)	24.1 (18.4-34.9)	20.2 (13.5-30.9)	22.8±7.14	20.3±7.42
Ca (mg/dL)	9.50 (9.45-9.78)	9.35 (9.13-9.53)	9.40 (9.20-9.50)	9.43±0.26	9.47±0.22
P (mg/dL)	3.65 (3.43-4.08)	3.95 (3.68-4.40)	3.50 (3.40-3.80)	3.79±0.45	3.77±0.35
Mg (mg/dL)	2.11 (2.04-2.15)	1.97 (1.88-2.13)	1.92 (1.90-2.02)	2.03±0.13	1.99±0.13
ALP (U/L)	87.0 (74.5-104)	54.0 (43.5-59.0)	60.0 (55.0-70.0)	67.1±19.9	59.2±14.1

AG: artistic gymnastics; IS: ice skate; EAG: elite athlete group; CG: control group; F: female; M: male; Ca: calcium; P: phosphorus; Mg: magnesium; ALP: alkaline phosphatase.

The values of anemia markers were found to be within the specified limits and no significant difference was recorded between EAG and CG ($p>0.05$; Table 4). In addition, it was seen that the lowest iron binding capacity (IBC) and the highest ferritin levels were recorded in gymnasts; the lowest ferrum (Fe), hemoglobin, hematocrit and erythrocyte levels were recorded in ballet dancers and the highest vitamin B12 and lowest folate levels were found in IS group. IBC values of 2 ballerinas and 2 female participants in the CG were over reference values (228-425 µg/dL), whereas Fe levels of 2 ballerinas, 1

ice skater and 4 women in the CG were found to be under the reference limits (50-170 ug/dL). It was found that ferritin, hemoglobin and hematocrit levels were under the normal reference limits in 1 ballerina and 1 woman in the CG (5-148 ng/mL; 11-16 g/dL; 37-54%, respectively), additionally, folate levels were recorded >5.38 ng/mL in 1 woman and 1 man from IS, and mean corpuscular volume (MCV) levels were determined between 80-100 fL in 1 male gymnast, 1 ballerina, 1 ice skater and 3 women from CG. Moreover, no significant difference was found between EAG and CG in terms of gender ($p>0.05$).

Table 4. Anemia markers of elite athlete and control groups

ANEMIA	AG (1F, 5M)	Ballet (6F)	IS (2F, 1M)	EAG (9F, 6M)	CG (6F, 4M)
	Median (25-75 P)	Median (25-75 P)	Median (25-75 P)	X±SD	X±SD
IBC (ug/dL)	313 (307-329)	380 (351-461)	366 (365-381)	360±50.8	374±38.2
Fe (ug/dL)	105 (86.5-117)	60.5 (23.3-79.3)	119 (36.0-154)	84.8±39.8	81.2±51.4
Ferritin (ng/mL)	73.0 (39.5-130)	14.5 (7.75-27.3)	24.0 (7.00-31.0)	44.0±45.6	37.8±43.0
Vitamin B12 (pg/mL)	459 (267-622)	409 (358-492)	425 (253-806)	445±161	364±120
Folate (ng/mL)	12.3 (10.9-15.5)	8.95 (5.90-11.9)	4.30 (4.10-6.60)	9.33±3.92	7.89±1.96
Erythrocyte (M/uL)	5.48 (4.985-8.2)	4.61 (4.31-4.70)	5.21 (4.73-5.27)	4.96±0.51	5.02±0.48
Hemoglobin (g/dL)	15.6 (14.5-16.4)	12.9 (11.5-13.9)	14.6 (12.7-15.2)	13.9±1.94	13.5±2.22
Hematocrit (%)	47.0 (43.3-49.0)	40.0 (36.2-42.6)	44.1 (40.0-46.2)	42.7±4.86	41.3±5.31
MCV (fL)	84.6 (65.4-87.0)	88.3 (79.0-94.1)	87.6 (76.8-93.3)	83.3±12.15	82.3±8.11

AG: artistic gymnastics; IS: ice skate; EAG: elite athlete group; CG: control group; F: female; M: male; IBC: iron binding capacity; Fe: ferrum; MCV: mean corpuscular volume.

FBG, urea, creatinine, AST, ALT and GGT levels examined in the participating groups were observed to fall within the normal limits. Only AST level was seen to be significantly higher in EAG than CG (22.4±2.05 vs 16.1±3.92 U/L, respectively; $p=0.038$), especially in gymnasts (30.0±6.51 U/L). In addition, no significant difference was found between EAG and CG in terms of gender ($p>0.05$).

Blood Na, K and Cl levels of the groups were found to be within normal limits (136-145 mmol/L; 3.5-5.1 mmol/L; 98-107 mmol/L respectively) and no significant difference was observed between groups. Also, Cl values of male athletes were significantly higher than those found for males in CG ($p=0.037$).

The groups were evaluated for blood lipids, all parameters were found within the specified normal limits and no significant difference was observed between EAG and CG. In addition, no significant difference was found between groups in terms of gender ($p>0.05$).

Energy and macro-nutrient intakes of athlete and control groups are presented in Table 5. The findings demonstrated that, there were no significant differences between EAG and CG on energy and macro-nutrient intakes ($p>0.05$; Table 5). The lowest daily energy intake and the least consumed fat (38%), the most protein (15.5%) and carbohydrate (CHO) (48%) values were recorded in the ballet dancers in comparison with the other athletes. Those who consume the least saturated and monounsaturated fats were the ballet group while the highest consumption was in the AG. Similarly those in the AG group consume Omega-3 and cholesterol rich fat. The group whose diet was mainly based on high fiber food was found in ice skaters. Also, fat% and monounsaturated fat consumption of male athletes was found to be significantly different from those in the CG; and female athletes' energy ($p=0.045$), saturated fat ($p=0.005$) and omega 3 ($p=0.011$) consumption was different from the women in the CG.

Table 5. Energy and macro-nutrient intakes of elite athlete and control groups

MACRO-NUTRIENT	RDA [‡]	AG (1F, 5M)	Ballet (6F)	IS (2F, 1M)	EAG	CG
		Median (25-75 P)	Median (25-75 P)	Median (25-75 P)	(9F, 6M)	(6F, 4M)
Energy (kcal)	--	2429 (1572-2826)	1184 (1161-1369)	2017 (1360-2425)	1759±693	2050±624
Energy (kcal/kg)	--	36.1 (27.8-45.3)	24.2 (20.1-27.2)	32.6 (27.0-37.5)	30.3±9.76	34.0±7.83
CHO (g/kg BM)	6-10g	3.85 (2.90-4.75)	2.59 (1.77-3.10)	3.90 (2.35-3.95)	3.18±1.11	3.59±1.25
CHO (%)	55-60%	42.5 (41.8-46.8)	48.0 (34.5-50.3)	43.0 (42.0-49.0)	44.4±5.94	43.0±8.54
Protein (g/kg BM)	0.8-1.4g	1.21 (0.85-1.73)	0.90 (0.77-1.03)	0.94 (0.80-1.16)	1.04±0.40	1.27±0.40
Protein (%)	12-15%	14.0 (10.8-16.3)	15.5 (14.5-18.3)	13.0 (12.0-14.0)	14.6±2.90	15.4±3.13
Fat (g/kg BM)	--	1.65 (1.37-2.14)	1.06 (0.82-1.16)	1.41 (1.11-1.87)	1.36±0.52	1.55±0.42
Fat (%)	20-30%	43.0 (40.8-44.0)	38.0 (33.5-46.0)	43.0 (39.0-44.0)	41.0±4.81	41.6±8.11
Saturated fat (g)	--	42.3 (30.6-55.1)	17.1 (13.8-19.4)	30.9 (20.1-37.1)	29.4±16.0	35.9±14.3
Monounsaturated(g)	--	40.1 (30.1-48.1)	21.5 (15.5-26.2)	35.6 (20.1-37.1)	29.8±11.87	31.1±7.28

Polyunsaturated (g)	--	15.7 (11.2-21.9)	8.16 (6.02-14.5)	22.4 (10.4-29.5)	14.6±7.84	16.6±7.86
Omega-3 (g)	--	2.30 (1.85-3.92)	0.98 (0.65-1.55)	1.66 (1.34-3.04)	1.87±1.12	2.12±0.59
Omega-6 (g)	--	12.6 (9.40-16.2)	7.25 (5.30-11.1)	15.5 (9.05-26.3)	11.6±6.29	14.3±7.83
Cholesterol (mg)	--	346 (175-698)	142 (69.8-266)	169 (117-297)	271.4±205	395.7±225
Fiber (g)	--	19.5 (14.8-30.1)	13.1 (11.9-16.8)	21.7 (6.85-25.0)	17.5±7.53	16.9±9.89

RDA: recommended dietary allowance; ¥: According to Soric et al., 2008; AG: artistic gymnastics; IS: ice skate; EAG: elite athlete group; CG: control group; F: female; M: male; BM: body mass; CHO: carbohydrate.

The percentages of meeting daily energy consumptions and essential nutrients according to the Nutrition Guide for Turkey (2015) are presented in Table 6. Percentages of meeting daily energy consumptions were estimated (Cupisti et al., 2000; Mielgo-Ayuso, Maroto-Sánchez, Luzardo-Socorro, Palacios, Gil-Antuñano and González-Gross, 2015) over the value obtained by multiplying RMR with the physical activity coefficient 1.6 in AG, 1.5 in ballet dancers and IS and 1.2 in CG.

Table 6. The percentages of meeting daily energy consumptions and essential nutrients according to the Nutrition Guide for Turkey (2015) (Nutrition Guide for Turkey, 2015)

Macro-nutrients	Elite Athlete Group				Control Group				Male	Female
	Male		Female		Male		Female			
	Intake	RDA (%)	Intake	RDA (%)	Intake	RDA (%)	Intake	RDA (%)		
Energy (kcal)	2472	94.6	1284	62.5	2547	123	1718	104	-	-
Carbohydrate (%)	44.3	80.5	44.4	80.7	47.2	85.8	40.2	73.0	55-60	55-60
Protein (%)	83.7	116	44.6	75.6	99.5	138	62.3	106	10-15	10-15
Fat (%)	1.31	131	0.85	85.0	1.45	145	1.15	115	20-30	20-30
Omega-3 (g)	14.0	93.3	15.0	100	16.0	107	15.0	100	1.6	1.1
Omega-6 (g)	41.7	139	40.6	135	36.7	122	44.8	149	17	12
Fiber (g)	2.97	186	1.14	104	2.28	143	2.02	184	29	25

RDA: recommended dietary allowance.

Vitamin (A, E, D, K, B1, B2, B3, B6, B12, folic acid, C) and mineral (K, P, Ca, Mg, Fe, Zn) contents of daily diets of the elite athlete and the control groups were evaluated and the percentages of meeting this content according to the Nutrition Guide for Turkey (2015) ('Nutrition Guide for Turkey.', 2015) are revealed in Figure 1. Accordingly, all the values fell within normal limits and no significant difference was found between groups and genders ($p>0.05$).

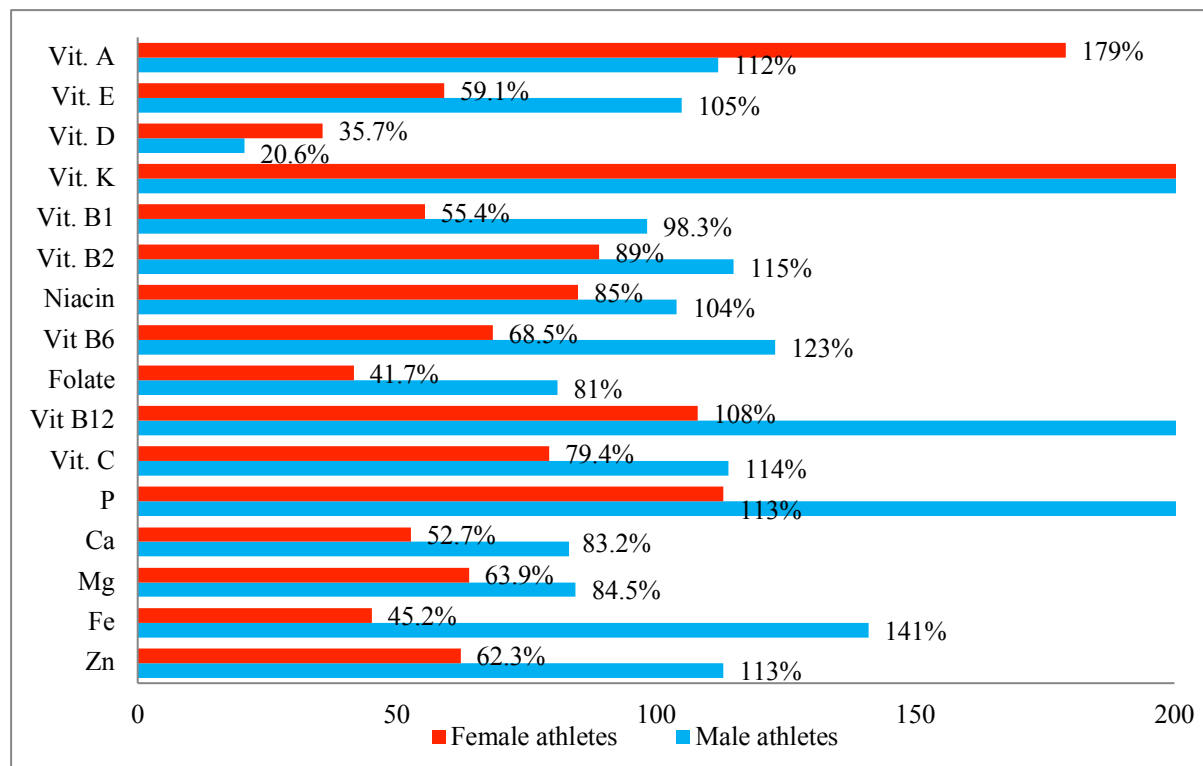


Figure 1. Micro-nutrient intake percentages of athletes and control groups to dietary guidelines for Turkey (2015)

BMD measurements carried out using DEXA on the total lumbar region (L1-L4), femoral neck, trochanter and Ward’s triangle were compared with T and Z score measurement results of the athletes and control group and there were no significant differences between EAG and CG ($p>0.05$; Figure 2A, B, C, and D), which fell within acceptable limits. The highest values of BMD and T- score for the femoral neck were obtained in AG, ballet and IS groups, with similar results while the lowest values were found in CG.

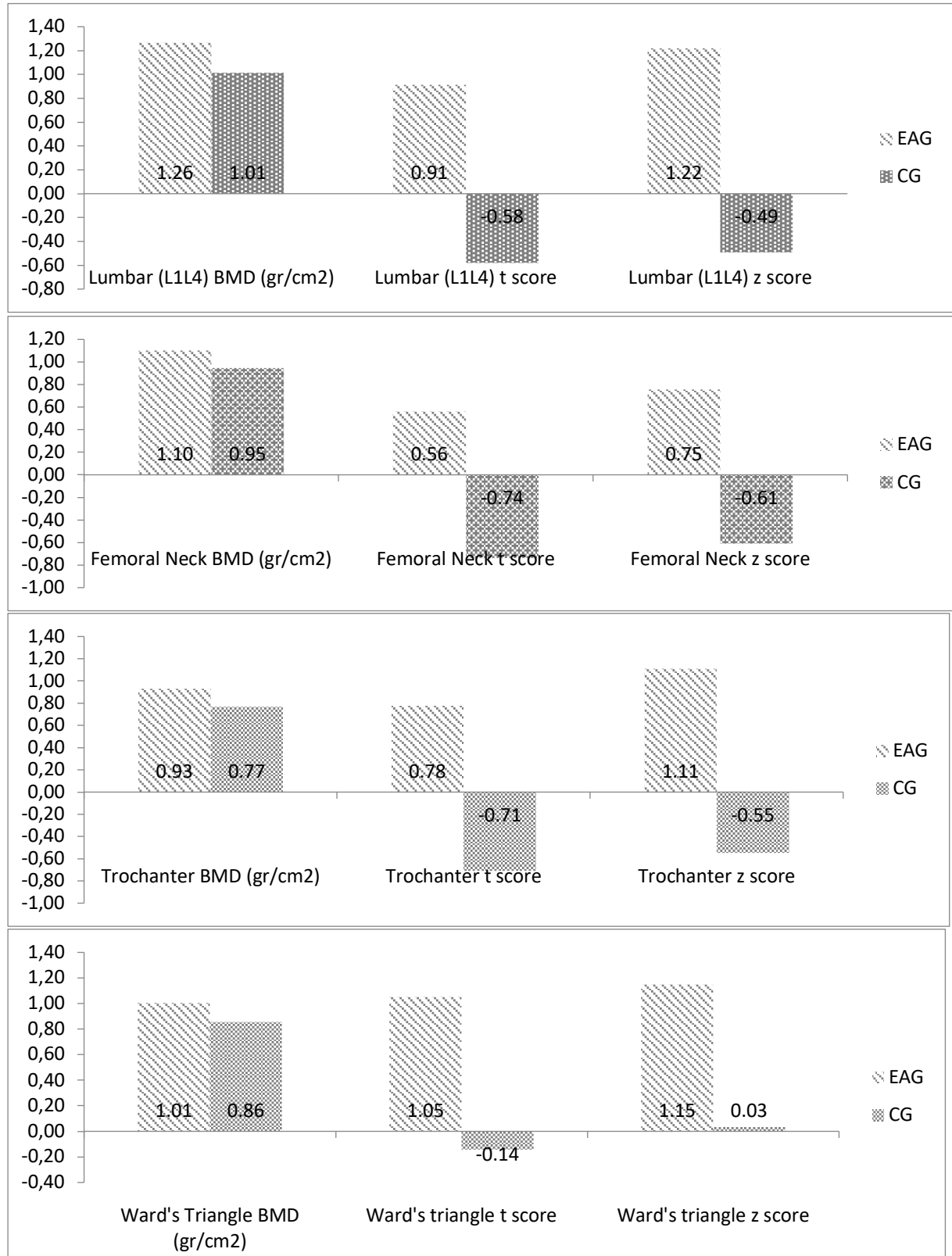


Figure 2. Lumbar region bone mineral density parameters (A), Femoral neck region bone mineral density parameters (B), Trochanter region bone mineral density parameters (C), and Ward's triangle region bone mineral density parameters (D) of elite athlete and control groups.

DISCUSSION

The aim of the present study was to determine the body compositions, BMD, nutrition behaviors, hydration and menstruation states and certain physiological parameters of elite competing athletes in aesthetic sports such as AG, IS and ballet.

The literature point to USG, urine color and body weight are the best techniques to evaluate hydration state and reports that these methods can be successfully used in clinical settings and the field of sports (Armstrong, 2005; Casa, Armstrong, Hillman, Montain, Reiff, Rich and Stone, 2000). Studies have found that insufficient hydration leads to increased body temperature and heart rate and decreased cardiac output, and adversely affects thermoregulation, metabolism, cardiovascular and cognitive function due to serum electrolyte imbalance (Armstrong, Ganio, Casa, Lee, McDermott, Klau and Lieberman, 2012; Magal, Cain, Long and Thomas, 2015) The common conclusion of the previous studies is that a great majority of the competing athletes doing regular training cannot maintain their body fluid balance and continue their lives in dehydration, which is also parallel with the findings of our study (Arnaoutis, Kavouras, Angelopoulou, Skoulariki and Bismikou, 2015; Castro-Sepúlveda, Astudillo, Álvarez, Zapata-Lamana, Zbinden-Fonca, Ramírez-Campillo & Jorquera, 2015; Osterberg, Horswill and Baker, 2009; Thigpen, Green and O'Neal, 2014). Urine color and density of 59 male elite athletes from basketball, swimming, canoeing, running and 10 gymnasts were assessed before and after an approximately 90-minute training session and it was found that 76.3% of the athletes start training in insufficient hydration (USG \geq 1.020 mg/dl) and 74.5% fail to maintain hydration during training. Although they have fluid with them during training, a majority of the athletes had body weight loss (-1.1 ± 0.07 %) and the greatest loss was observed in gymnasts (-1.7 ± 0.07 %) (Arnaoutis et al., 2015). In our study, 67% of the athletes were found to be in dehydration prior to training while this value increased to 87% after training; and it was found that those losing the greatest body weight were gymnasts (avg. 500g) despite taking fluid during training (avg. 538 ml). The group least fluid intake during exercise was ice skaters due to their training ambient temperature (14°C) and humidity (33%). Similarly, athletes in the university basketball team were assessed for hydration states according to gender through urine density measurements, fluid intake and sweat loss percentage during training. While the athletes' urine densities were really high (17% > USG 1.030 mg/dl), no significant difference was found between female (1.022 mg/dl) and male (1.026 mg/dl) athletes (Thigpen et al.).

It was seen that the female athletes in our study fail to fully meet their suggested daily nourishment needs in comparison to men and take their daily Fe, Ca, Zn, Mg, fiber, vitamins E, B1, B2, niacin, folic acid, vitamins B6, C, omega-6 at insufficient amounts. The amount of vitamin D, Ca, Mg, folic acid and fibers consumed by male athletes were found to be under the recommended daily intakes. Fat percentages from the individuals' daily energy intake are over the recommended values while CHO percentages are low. The fact that the athletes whose food consumption records were taken consume high protein food increased the amount of fat taken in the diet at the same time. It is considered that since athletes reduce their complex CHO consumption, which has an indispensable role for their performance, in order to avoid weight gain, they meet the energy deficiency through protein and therefore high fat food.

It is seen that the overall energy intake of foreign athletes is also insufficient; however, the distribution of essential nutrients in energy intake is more balanced. In a study which assessed energy and nutrient intakes of 122 elite female synchronized skaters at national level (mean age 15.7 ± 2.4 years and BMI 21.0 ± 2.0 kg/m²), it was found that daily energy intake of the athletes was average 1658 kcal, with a distribution of 67% CHO, 16% protein and 29% fat. It was determined that dietary vitamin E and K, Ca, Mg and K intakes of these athletes, who also use nutritional supplements, were less than 2/3 of the recommended amounts (Ziegler & Jonnalagadda, 2006). Likewise, 3-day food consumptions of 80 male (mean age 18.4 year) and 81 female (mean age 15.9 year) elite level ice skaters were evaluated. Energy intakes of the athletes were under the recommended daily levels and it occurred as 2329 kcal in men and 1545 kcal in women. Energy distribution was 57% CHO, 30% fat, 15% protein on average in male athletes while it was 60% CHO, 16% protein and 25% fat in females. Protein intake per kg of the

athletes was calculated as 1.3 g. Measured body fat ratio was 6.6% in men and 14.1% in women. Moreover, blood glucose, TC, TG, ferritin and albumin levels were observed to be within normal range (Ziegler, Jonnalagadda and Lawrence, 2001). In another study, 3-day food consumption records of 7 male (mean age 23.0) and 7 female (mean age 21.1) figure skaters who train for 25-30 hours a week were assessed and it was seen that energy intake (1416 kcal/day) was lower than the recommended levels in female athletes whereas male athletes managed to supply the required energy (2837 kcal/day). CHO intake was lower than the recommended levels both in male (44%) and female athletes (51%) and the amounts of fat (38%) and protein (18%) coming from the energy were found to be higher than recommended. All micro nutrient elements, except for folate and Zn, supplied 2/3 of the recommended amounts in all the dancers. In addition, body fat ratio was found to be 8% in men (BMI: 22.7 kg/m²) and 17.6% in women (BMI: 20.5 kg/m²) (Ziegler, Nelson, Barratt-Fornell, Fiveash and Drewnowski, 2001). Different from the results of our study, it is seen that the ice skaters evaluated in the referred three studies have insufficient but balanced nutrition and their body fat ratios are lower. It is known that the athletes' training history and weekly hours of training are also effective on body fat ratio as well as nutrition. The 3 ice skaters aged 18.0-22.0 in our study have 4.3 years of training experience and training programs of 10 hours a week.

It is generally accepted that young female gymnasts are at risk of malnutrition due to their behaviors of being slim and weight loss tendencies. In one study carried out on rhythmic gymnasts, 55 competing female athletes aged between 13 and 19 were evaluated for their 3-day food consumption records and diets and their body compositions were assessed. They were observed to have better nutrition habits in comparison to CG. Their daily energy distributions showed that they had a CHO (54.9%) rich diet, their daily protein intake was 1.21g/kg and daily energy intake was 28.8kcal/kg. Comparing the nutritional elements consumed by both gymnasts and CG with recommended dietary allowance (RDA) values, it was seen that Ca, Fe, K and Zn intakes and their daily energy intake according to the estimated energy consumption were insufficient. Moreover, it was reported that the gymnasts' average body fat ratio was 16.5% and mean menarche age was 13.3 (D'Alessandro et al., 2007). The results of the evaluation of 77 Turkish rhythmic and artistic gymnastics show that gymnasts aged 7-15 intake CHO and energy at lower amounts than recommended and that their vitamin E, niacin, thiamin, folic acid, K, Ca, Fe intakes are insufficient as well (Karabudak, Koksak, Ertas and Kucukerdonmez, 2016). It was also seen that daily dietary energy consumption of 20 young female rhythmic gymnasts was under the recommended value and the estimated requirement and their vitamin A, Ca, Fe and Zn intakes were also insufficient (Cupisti, D'Alessandro, Castrogiovanni, Barale and Morelli, 2000). The main reason behind the lack of dietary vitamins and minerals, which is seen in almost all athletes in aesthetic sports, is considered to be their insufficient energy intakes and the fact that they do not consume enough amounts of nutrients from each food group.

In such sports as ballet, which highlight low body weight to reach optimal performance, the prevalence of female athlete triad is known to be increasing. Therefore, evaluations have to be carried out at certain intervals. One study carried out on 15 elite female ballet dancers aged 18-35 and training for over 27 hours a week found their mean BMI as 18.9 kg/m², FFM 44.3 kg, fat percentage as 15.5%, RMR as 1367 kcal, respiratory exchange ratio (RER) 0.87, daily energy intake as 1557 kcal and the energy consisted of 56% CHO, 17% protein and 26% fat. Vitamin D, Fe and Ca intake was found to be insufficient. The dancers total Z- scores pertaining to waist and hips measured with DEXA was 0.99 and total BMD was 1.16g/cm² (Doyle-Lucas, Akers and Davy, 2010). It could be asserted that the ballet dancers in our study have a similar profile: age range 19-28, weekly hours of training 32, BMI 19.1 kg/m², FFM 41.6 kg, fat 19.9%, RMR 1349 kcal, RER 0.80, daily energy intake 1240 kcal consisting of 45% CHO, 16.3% protein and 39% fat. It was found that their diet is poor in Ca, Fe and vitamin D and Z score for total lumbar region is 0.93 and 0.94 for total hips.

In another study conducted for similar purposes, adult female ballet dancers have significantly lower BMI and body fat ratio than the CG. Except for vitamin C, all other nutrition intakes are significantly insufficient according to the RDA. While TG values of dancers are low in comparison to the CG, their HDL-C levels are higher, TC, hemoglobin and hematocrit values are similar. The results are interpreted as the dancers need to take nutritional education so as to develop their nutrition states and improve dancing performances (Kim, N.Y., H.K., S.J., Park, Kim and Lee, 2005).

Fe deficiency and anemia due to Fe deficiency may be seen particularly in female athletes as a result of nutrition associated insufficient intake, loss because of sweating and menstruation, and blood cell lysis due to muscle damage in weight bearing and high impact sports. Lack of Fe affects an athlete's performance and immune functions negatively. In order to detect Fe deficiency anemia, ferritin, hematocrit and hemoglobin levels must be checked (Ersoy, 2011). In our study, lack of Fe was found in 3 female athletes and 4 women in CG and 1 female athlete had Fe deficiency anemia. One study found that dietary Fe intakes of 43 female AG athletes and 40 sedentary individuals were low while the athletes' hemoglobin levels, several blood findings and serum Fe values were higher than those in the CG (Sureira, Amancio and Pellegrini Braga, 2012). Serum Fe levels of the ballerinas in our study, on the other hand, are significantly low. One study reported adolescent ballet dancers' body fat ratios as average 23.5, distribution of daily energy intakes as 48.9% CHO, 16.9% protein, 33.8% fat; average CHO intake as 4.8 g/kg/day and protein as 1.6 g/kg/day. Their Ca, Folate, Mg and selenium intake was 60% lower than their requirement. Fe deficiency was seen in 4 athletes and 1 athlete was found to have Fe deficiency anemia (Beck, Mitchell, Foskett, Conlon and Von Hurst, 2015).

In our study, in terms of the L1-L4, femoral neck, Ward's triangle and trochanter regions over which BMD evaluations were carried out, the highest values were obtained in AG athletes, this was followed by ballet and IS and the lowest values occurred in the CG. When interpreting this order, it should be considered that the gymnasts consist of 5 mesomorphic male and 1 female athletes and they have the lowest age of starting sport (6.7 years) and a training background of 13.7 years; while all the ballet dancers are ectomorphic women but they are still the most trained group both because of their starting age (7.5 years) and sporting history (17.2 years) and their weekly hours of training. In one study, elite couples of dancers competing at international level, the athletes' femoral neck BMDs evaluated with DEXA are higher than the CG and male athletes have significantly higher values than females. A positive correlation was found between BMD levels and training experience in dancers (Kruusamäe, Maasalu and Jurimäe, 2016). In a study which examined the effects of nutritional states together with puberty and the average weekly dancing exercise of 22 hours on bone mineral content (BMC) in 127 female ballet dancers, it was found that ballet dancers have low BMC, high risk of fracture, low BMI for age, low energy intake and delayed menarche (Burckhardt et al., 2011).

There is a strong correlation between the age of involving in the sport prior to menarche and menarche age in adolescent ballet dancers, but no correlation was found with menstruation cycle (Sabbour & El-Deeb, 2011). In comparison to CG, total BMDs and body fat masses of ballet dancers with menstruation irregularities are lower than CG. Dancers who have regular menstrual cycles also have a higher BMD on the body parts exposed to resistance and regional FFM thanks to regular training. A strong positive correlation was found between total fat free mass and femoral neck, ward's triangle and trochanter BMD (Sabbour & El-Deeb).

Although the athletes participating in the study had no low BMD, menstrual irregularities and eating disorders; early age of starting sport, low fat and thin body structures and long hours of training and insufficient and unbalanced nutrition bring about the need for raising their awareness of nutrition and following them regularly.

CONCLUSION

Although the elite athletes have better body composition and BMD values than the controls, especially all female athletes have the risk of dehydration, Fe deficiency anemia, lower BMD when compared to male athletes because of their insufficient daily total energy, CHO, water, vitamins and mineral intakes.

PRACTICAL APPLICATIONS

Elite competing athletes in aesthetic sports who suffer from intensive training programs and strict weight control and especially female athletes are suggested keeping under control in terms of risk of female athlete triad because of impairment the quality of life and threaten the health of athletes.

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