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The Status of Micronutrient Elements in Adolescent Athletes: A Gastronomy City Example

Adolesan Sporcularda Mikrobesin Öğelerinin Durumu: Bir Gastronomi Şehri Örneği

Sabriye Ercan

Sports Medicine Department, Dr. Ersin Arslan Training and Research Hospital, Gaziantep, Turkey

ABSTRACT

Objective: Adolescent athletes are individuals who require special attention. Health problems related to nutritional deficiencies and associated loss of performance must be prevented in this group who are still continuing to grow and develop. The aim of this study was to make a retrospective examination of the micronutrient element status of adolescent athletes.

Materials and Methods: The hospital records of adolescent athletes aged between 12 and 17 who were admitted for pre-participation examinations were collected. The time frame was designated as twelve months. The athletes were separated into 2 groups; according to the time of admission. Group 1: 1st April -31st August, Group 2: 1st September -31st March. The test results of micronutrient elements were selected from the blood analysis of the athletes.

Results: The test results of 166 athletes were retrieved from the digital archives of the hospital. 111 (67%) of them were belonging to male athletes and 55 (33%) were to females. There were no significant differences between the groups in terms of demographic data and duration of training ($p>0.05$). Hemogram results revealed no significant difference between two groups. Iron deficiency anemia was determined in 10 (18%) female athletes and in 1 (1%) male athlete. Serum ferritin levels were low in 20 (15%) athletes; 15 (33%) were belonging to females and 5 (6%) to males. Anemia due to vitamin B_{12} or folic acid deficiency was not detected, but 10 (7%) athletes had severe vitamin B_{12} deficiency and 6 (4%) had severe folic acid deficiency. A statistically significant difference was determined between the groups in respect of serum 25 (OH) vitamin D concentration ($p<0.05$). In both of the groups, the female athletes and those who trained indoors had lower serum 25 (OH) vitamin D levels. Age showed a negative correlation with Vitamin B_{12} levels and folate levels, whereas a positive correlation detected with ferritin levels ($p<0.05$) in male athletes.

Conclusions: Factors such as age and gender, the training area and seasonal factors can affect the micronutrient element status during adolescence. All athletes should be evaluated in terms of personal risk factors and adolescent athletes should be closely monitored to prevent micronutrient deficiencies.

Keywords: micronutrients, season, gender, training area.

S. Ercan
0000-0001-9500-698X

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Yazışma Adresi / Corresponding Author:
Sabriye Ercan
Dr. Ersin Arslan Eğitim ve Araştırma Hastanesi, Spor Hekimliği Bölümü, Gaziantep, Türkiye
E-mail: *sabriyeercan@gmail.com*

ÖZ

Amaç: Adolesan sporcular, özel önem gösterilmesi gereken bireylerdir. Büyüme ve gelişmenin devam ettiği bu grupta besin eksikliğinden kaynaklı sağlık sorunları ve performans kayıpları önlenmelidir. Bu çalışmanın amacı, adolesan sporculardaki mikrobesin düzeylerinin retrospektif olarak incelenmesidir.

Gereç ve Yöntemler: Spor Hekimliği Bölümü'ne spora katılım öncesi sağlık değerlendirmesi için başvuran, 12-17 yaş arasındaki adolesan sporcuların hastane kayıtları incelenmiştir. Bu kayıtlar içinden mikrobesin öğelerini belirlemeye yönelik yapılan biyokimyasal tetkik sonuçları toplanmıştır. Sporcular, on iki ay boyunca başvurdukları zamana göre; Grup 1: 1 Nisan -31 Ağustos, Grup 2: 1 Eylül -31 Mart olarak iki gruba ayrılmıştır.

Bulgular: Çalışmaya dahil edilen 166 sporcunun 55'i (%33) kadın, 111'i (%67) erkekti. Gruplar arasında demografik veriler ve antrenman süreleri açısından fark görülmedi (p>0.05). Hemogram sonuçlarında gruplar arasında fark bulunmadı (p>0.05). Tüm katılımcıların %6.6'sında (10 kadın, %18; 1 erkek, %1) demir eksikliği anemisi mevcuttu. Serum ferritin düzeyi incelendiğinde, demir eksikliği bulunan 20 (%15) sporcunun 15'inin (%33) kadın, 5'inin (%6) erkek olduğu saptandı. Sporcularda B_{12} vitamini ve folik asit eksikliğine bağlı anemi saptanmadı. Fakat, B_{12} vitamini ciddi düzeyde eksik olan 10 (%7) sporcu, ciddi folik asit eksikliği olan 6 (%4) sporcu belirlendi. Serum 25(OH) D vitamini konsantrasyonu açısından gruplar arasında istatistiksel anlamlı fark olduğu saptandı (p<0.05). Kadınların ve kapalı alanda antrenman yapan sporcuların daha düşük serum 25(OH) D vitamini konsantrasyonuna sahip oldukları görüldü. Yaşın, B_{12} vitamini düzeyleri ve folat düzeyleri ile negatif korelasyonu gözlenirken, erkek sporcuların ferritin düzeyleri ile pozitif korelasyonu belirlendi (p<0.05).

Sonuçlar: Adolesan dönemde; sporcuların antrenman alanları, mevsimsel faktörler, yaş ve cinsiyet gibi değişkenler mikrobesin öğelerinin durumunu etkileyebilmektedir. Tüm sporcular, kişisel risk faktörlerine göre değerlendirilmeli ve adolesan sporcular mikrobesin öğelerinde eksiklik oluşmaması için yakından izlenmelidir.

Anahtar sözcükler: mikrobesinler, mevsim, cinsiyet, antrenman alanı.

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INTRODUCTION

Adolescence is a time of intense physiological, psychological and social change. Globally, 85% of the adolescents who will be the adults of tomorrow live in developed countries. Individuals in this age group are accepted as healthier compared to those at other stages of the life cycle, irrespective of living in developed or undeveloped countries (1). In developed countries, health services are struggling with chronic diseases in the increasing elderly population and in developing countries, pre-school children and women of reproductive age are evaluated as requiring nutritional support. Thus adolescents, squeezed between the paediatric and adult groups, are not shown the necessary care for some problems such as malnutrition and micronutrient deficits related to adolescent nutrition (1).

However, there is an increased need for nutrition and energy in the adolescent period to be able to achieve healthy growth and development. In particular, adolescent athletes must pay attention to the intake of additional energy required by physical activity. Because, adequate food and fluid help to maintain blood glucose concentration during exercise, maximize exercise performance, and improve recovery time. In nutritional guidelines, the main focus for athletes is on the need for energy, micronutrients and fluid. In most of these guidelines, less importance is given to micronutrient elements (2). Various studies have reported that the intake of fluid, fibre, iron, calcium, potassium, magnesium, folate, and vitamins A, D, E and B_{12} is insufficient in adolescent athletes in different branches (2-5). Each of these micronutrient elements has indispensable benefits for the provision of muscle contractions, nerve transmission, oxygen transport, enzyme activation, immune functions, antioxidant activity, bone health and acid-based balance in the blood for adolescent athletes (6).

Anemia is a health problem that develops as a result of nutrition-related deficiencies and is often seen in adolescents. When the causes of anemia are examined, the development of iron deficiency-related microcytic anemia has been often reported. In iron deficiency, insufficiencies in nutritional intake result in chronic urinary/gastrointestinal blood loss or intravascular hemolysis associated with intense exercise. Anemia not only affects physical performance but also cognitive functions. Findings start in the early stage of iron deficiency and complaints emerge without development of anemia (1). Serum iron is critical for hemoglobin production demonstrating its importance for performance and oxygen transportation needed during exercise (6). Although 3% of athletes are known to be affected by iron-deficiency anemia, there are insufficient data about the prevalence of folate and vitamin B_{12} deficiency, which are important in hemopoiesis (3, 7, 8).

Folate and vitamin B_{12} are co-factors funtioning in the methionine pathway. Substrates, such as catecholamines, creatinine and DNA, which have a central role in physical exercise, are obtained from this pathway (9). However, the daily intake of folate and vitamin B_{12} of adolescent athletes remains well below the amounts recommended by the World Health Organisation (3).

Adolescence is the stage when bone remodelling is highest. Calcium, phosphorus and vitamin D have a key role in skeletal development and protection. By increasing calcium absorption in the intestines, vitamin D provides the continuation of normal calcium metabolism (7, 10). It must not be forgotten that in addition to calcium and phosphorus, magnesium is indispensible for healthy bone structure (11). It is known that regular exercise has the effect of increasing bone mineral density in adolescents (7). However, athletes have the same risk as the non-sporting population of vitamin D deficiency and seasonal changes in vitamin D (12). In particularly, athletes who practice and compete indoors while avoiding sun exposure are at risk for vitamin D deficiency any time of the year. Low vitamin D concentrations observed in athletes result in the majority of cases in a predisposition to bone pathologies such as stress fractures. To prevent these pathologies developing, optimal vitamin D, calcium and phosphorus levels must be protected in athletes (13).

Magnesium is an important mineral for cellular reactions with a physiological regulatory function in the human body. This mineral has a role in fat oxidation and protein synthesis and glycogen destruction especially during exercise. Magnesium depletion manifests as muscle fatigue, an increased need for energy and an effect on cardiopulmonary functions in submaximal exercise (6). Sudden changes in the magnesium level are not expected provided there is no change in the hydroelectric balance (14, 15). On the other hand, the serum magnesium level can be currently evaluated as a marker of the training level of athletes (16).

Each micronutrient element has a critical function in the body. There is lack of knowledge in Turkey about nutrition of young athletes. Attention to nutrition must be increased in both physicians and the athletes. Performance losses and health problems related to nutritional deficiencies must be prevented in adolescent athletes whose growth phase have not been completed. The aim of this study was to determine micronutrient status in adolescent athletes according to gender, sports branches (indoors and outdoors) and seasonal change.

MATERIAL AND METHODS

A retrospective investigation has been carried on the files of athletes who had admitted to Sports Medicine. The study included athletes aged between 12-17 years who were attending a regular training schedule (at least 1 hr per day, 3 times per week) for the last year and were not taking any nutritional supplements or medical treatment. All the athletes were living in a provincial centre, geographically located 38º 28' and 38º 01' East; 36º 38' and 37º 32' North at an altitude of 850 m above sea-level.

The biochemical tests of the athletes, including hemogram, ferritin, serum iron, total iron binding capacity, total iron saturation, folate, vitamin B_{12}, 25 (OH) D vitamin, serum calcium, serum phosphorus and serum magnesium levels were taken into consideration. Patients were excluded if they were aged <12 years or >17 years, if they had any systemic disease, if the hemogram results showed findings of infection, if they had taken any nutritional supplement or medical treatment containing micronutrients in the last 6 months, or if they had admitted to polyclinic due to a sports injury.

The demographic data of the athletes and information related to the sports branch (indoor or outdoor), the training area, the duration of training and smoking status were retrieved from the digital archives. *Indoor sports* (aikido, artistic gymnastics, badminton, basketball, body-building, handball, indoor football, karate, kick-boxing, swimming, taekwondo, volleyball, weight-lifting, wrestling) are competitive physical activities trained and played indoors. *Outdoor sports* (amputee football, athletics, football) are competitive physical activities trained and played outdoors. The athletes were separated into 2 groups according to the time of presentation as, Group 1; who admitted to hospital between 1st of April and 31st of August and Group 2; who admitted between 1st of September and 31st of March.

Blood samples

Blood samples were taken at 09:00-15:00 from the antecubital vein.

Hemogram, Ferritin, Vitamin B_{12}, Folate and Vitamin D cutoff values

Hemogram

For female athletes and males aged 12-14 years, the hemoglobin level accepted for the diagnosis of anemia was 12 g/dL, and for males aged 15-17 years, it was 13 g/dL (4,17,18).

Serum Ferritin

Serum ferritin concentration <12 μg/L was accepted as iron deficiency, a value in the range of 12-30 μg/L was considered as second-degree depletion, and 30-50 μg/L as first-degree depletion (8).

Serum vitamin B_{12}

Serum vitamin B_{12} concentration of >201 pg/mL was accepted as normal, 150-200 pg/mL as deficiency, and <150 pg/mL as severe deficiency (8).

Serum Folate

Serum folate concentration of >6 ng/mL was accepted as normal, 3-5.9 ng/mL as deficiency, and < 3 ng/mL as severe deficiency (8).

Serum 25 (OH) vitamin D

Serum 25 (OH) D vitamin concentration >30 ng/mL was accepted as normal, 20-30 ng/mL as insufficiency, 10-20 ng/mL as deficiency, and <10 ng/mL as severe deficiency (19).

Body mass index and percentile curve

Body mass index (kg/m^2) was calculated using the method determined by the World Health Organization. Body mass index percentile values were calculated using the lists determined by the World Health Organization according to age and gender.

Ethics

The study was approved by the Ethics Committee of Gaziantep University (decision no 2018/44, dated 26/01/2018).

Statistical analyses

Analyses of the study data were performed using SPSS 22.0 software. Conformity of the data to normal distribution was assessed with the Kolmogorov-Smirnov test or the Shapiro-Wilk test. The Skewness-Kurtosis test was applied. With descriptive statistical analysis, the frequency, mean and standard deviation values were determined. Data were expressed as mean ± standard deviation (SD) values. In different analyses of independent groups, the T-test was applied to parameters with normal distribution and the Mann Whitney U-test to parameters showing abnormal distribution. Correlation analysis was applied using the Pearson Correlation test or the Spearman Correlation test according to the distribution pattern of data. Statistical significance was accepted as $p<0.05$.

RESULTS

166 athletes included in the study; 111 (67%) of them were males and 55 (33%) were females. Group 1 composed of 68 athletes who admitted between April and August (45 males, 23 females) and Group 2 included 98 athletes admitted between September and March (66 males, 32 females).

Group 1 included 23 athletes (13 females (56%), 10 males, (44%)) who were participating in outdoor sports (amputee football (n:2) and athletics (n:21)), and 45 (10 females, 35 males) were participating in indoor sports (aikido (n:1), basketball (n:2), weight-lifting (n:19), karate (n:6), taekwondo (n:14), volleyball (n:2), and body-building (n:1)).

Group 2 included 44 athletes (11 females, 33 males) who were participating outdoor sports (athletics (n:34) and football (n:10)). 54 (21 females, 33 males) were participating in indoor sports (artistic gymnastics (n:1), badminton (n:1), basketball (n:6), indoor football (n:1), wrestling (n:9), weight-lifting (n:13), handball (n:1), kick-boxing (n:1), taekwondo (n:18), volleyball (n:2), and swimming (n:1)). No statistically significant difference was determined between the groups in terms of demographic data, the training area, the duration of sports participation, the weekly training periods, the duration of training and smoking status (Table 1).

Table 1. Sociodemographic and exercise related characteristics (mean values±SD)

	Group 1 (n:68)	Group 2 (n:98)	p value
Age (years)	15.5±1.6	15.1±1.7	0.2
Body height (cm)	168.8±9.3	166±9.8	0.06
Body weight (kg)	59.7±15	55.4±13.3	**0.03***
Percentile of BMI (%)	45.4± 30.9	39.1 ± 26.9	0.2
Sports participation (years)	3.7±2.7	3.3±2	0.8
Weekly training time (hour/week)	11.8±3.4	11±4.2	0.3
Yearly training time (month/year)	10.5±1.5	10.6±1.3	0.8
Cigarette smoking (packet-years)	0.3±0.8	0.1±0.5	0.052

Group 1: from April to August, Group 2: from September to March.

*BMI: body mass index, *: significant difference (p <0.05).*

No statistically significant difference was determined between the groups in respect of the hemogram results (p>0.05), (Table 2). Iron deficiency anemia has been detected in 6.6% of the athletes (10 females, 18%; 1 male, 1%). 6 of them (5 females, 1 male) were in Group 1 and 5 (5 females) were in Group 2. Thalassemia minor was detected in 3% of the athletes (3 females, 2 males). Of those diagnosed with anemia, the mean hemoglobin level was determined as 10.3±1.5 g/dL in 6 female athletes who were between 12-14 years, as 10.6±1 g/dL in 7 female athletes aged between 15-17 years and as 11.8±1.5 g/dL in 3 male athletes aged between 15-17 years. Serum ferritin levels of the athletes were found as such; iron deficiency (n:20; 15 females, 5 males): 8.1±2.9 µg/L; second-degree iron insufficiency (n: 50; 17 females, 33 males): 21.3±6 µg/L; first-degree iron insufficiency (n:33; 8 females, 25 males): 38.4±5.2 µg/L; sufficient ferritin concentration (n:35; 6 females, 29 males): 91.3±56.5 µg/L. (Figure 1.)

Table 2. Hemogram, ferritin, folate, vitamin B12 status of the athletes (mean values ±SD)

	Group 1 (n:68)	Group 2 (n:98)	p value
Hemoglobin (g/dL)	14.1±1.7	14.2±1.5	0.9
Hematocrit (%)	41.8±4.2	41.7±3.7	0.7
RBC (10^12/L)	5.1±0.5	5±0.4	0.3
MCV (fL)	82.5±6.4	83.6±6.1	0.1
Serum ferritin (µg/L)	46.7±56.9	38.2±30.7	0.5
Transferrin saturation (%)	25.9±10.8	26.9±14.6	0.9
Serum vitamin B_{12} (pg/mL)	302.5±136.6	329.6±128.5	0.1
Serum folate (ng/mL)	6.7±2.7	6.6±2.8	0.8

RBC: Red blood cell count, MCV: mean corpuscular volume, Transferrin saturation =(Serum iron/total iron binding capacity) X 100. Significant difference is p <0.05.

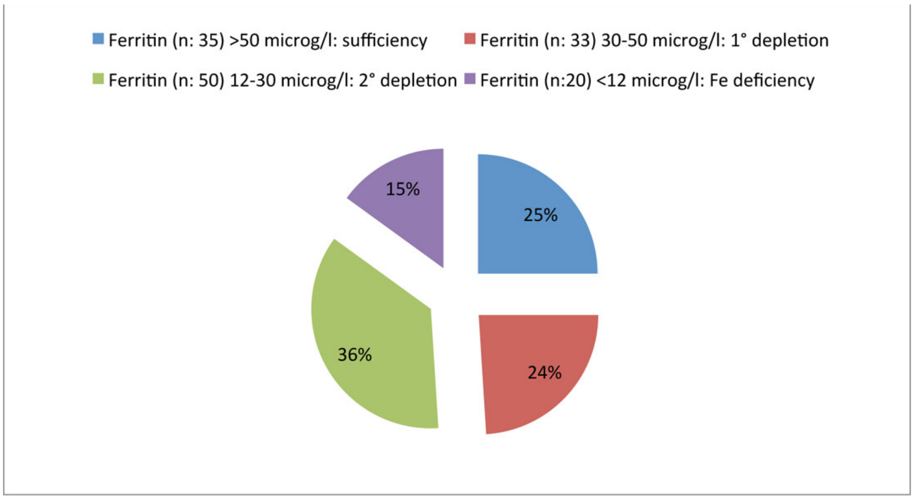

Figure 1. Percent of ferritin status in athletes

The serum vitamin B_{12} levels were found as such; severe vitamin B_{12} deficiency (n:10; 4 females, 6 males): 118.1±23.5 pg/mL; vitamin B_{12} deficiency (n:10; 5 females, 5 males): 181.5±16.7 pg/mL; sufficient levels of vitamin B_{12} (n:125; 42 females, 83 males): 345.8±121.1 pg/mL (Figure 2).

Serum folic acid levels were as such; severe folic acid deficiency (n:6; 1 female, 5 males): 2.5±0.5 ng/mL; folic acid deficiency (n:63; 20 females, 43 males): 4.6±0.7 ng/mL; normal folic acid concentration (n: 78; 28 females, 50 males): 8.6±2.4 ng/mL (Figure 3).

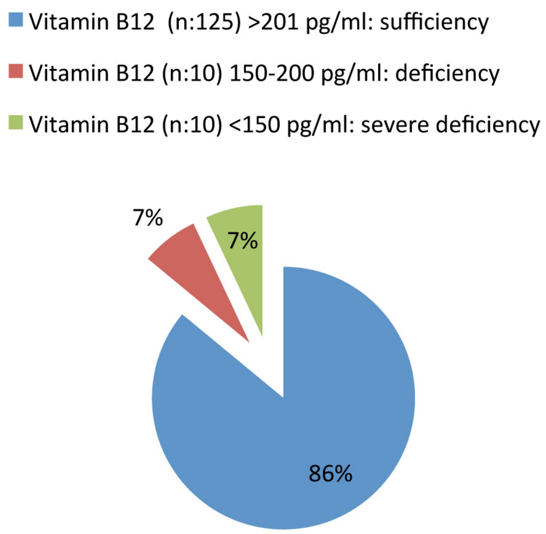

Figure 2. Vitamin B_{12} status of athletes

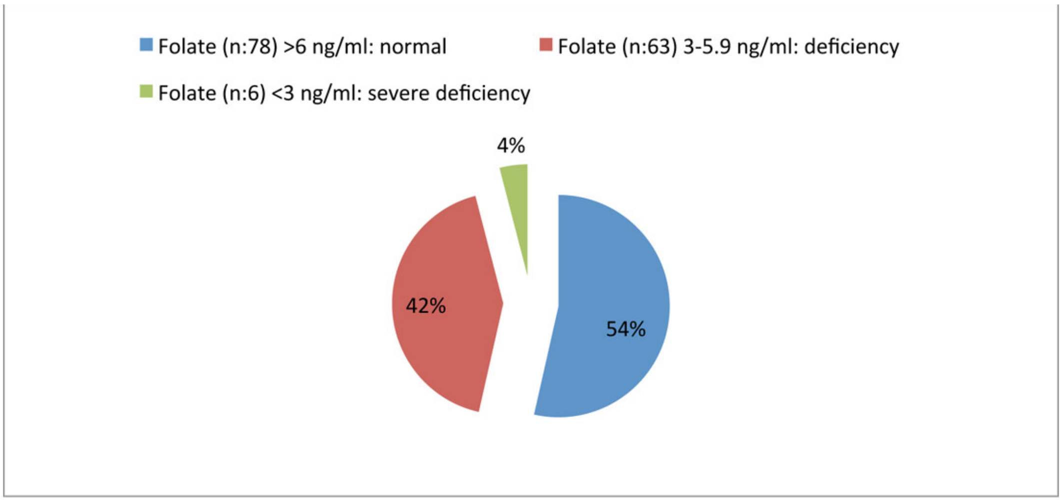

Figure 3. Folic acid status of athletes

In the analysis of the other micronutrient elements, a statistically significant difference was determined between the groups in respect of serum 25 (OH) vitamin D concentration ($p<0.05$). No difference was determined between the groups in respect of serum calcium, serum phosphorus and serum magnesium levels ($p>0.05$). There was a fluctuation in the 25 (OH) vitamin D levels according to the months (Figure 4). When the seasonal difference was analyzed in more detail in the sub-groups, all the females in both groups and athletes training indoors have been found with lower levels of serum 25 (OH) vitamin D (Table 3).

Vitamin D levels were as such; severe vitamin D deficiency (n: 17; 9 females, 8 males; 4 trained outdoors, 13 trained indoors; 5 in Group 1, 12 in Group 2): 8.3±1.6 ng/ml; vitamin D deficiency (n: 68; 31 females, 37 males; 26 trained outdoors, 42 trained indoors; 22 in Group 1, 46 in Group 2): 15±2.9 ng/ml; vitamin D insufficiency (n: 45;11 females, 34 males; 20 trained outdoors, 25 trained indoors; 23 in Group 1, 22 in Group 2):24.7±3.1 ng/ml; sufficient amounts of vitamin D (n:28; 3 females, 25 males; 14 trained outdoors, 14 trained indoors; 15 in Group 1, 13 in Group 2): 35.4±4.6 ng/ml (Figure 5).

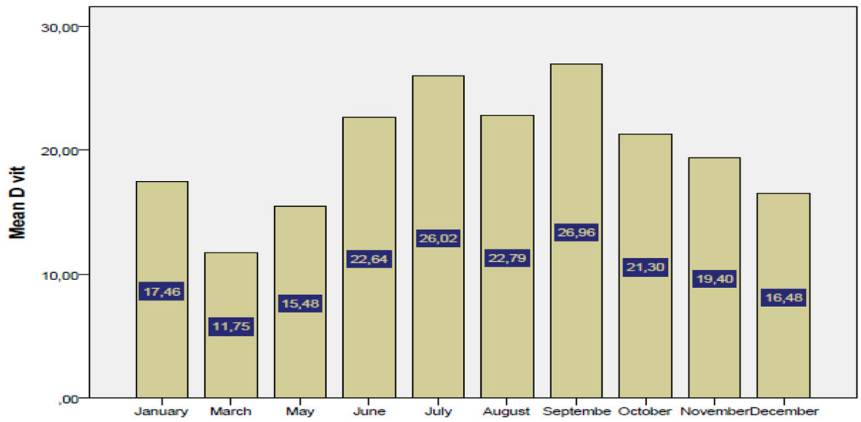

Figure 4. Distribution of serum 25 (OH) vitamin D level by month

D vit: 25 (OH) vitamin D

Table 3. Results of micronutrient effects on bone metabolism

	Group 1 (n:68)	**Group 2 (n:98)**	***p value*** (G)
25 (OH) vitamin D (ng/ml)	23.4±9.5	18.8±8.5	**0.002***
	Outdoor: 25.7±8.9	Outdoor: 20±8.9	**0.02***
	Indoor: 22.1±9.7	Indoor: 17.8±8	**0.03***
p value (sport location)	0.1	0.2	
	Female: 19.4±8.5	Female: 15.4±6.7	0.06
	Male: 25.5±9.4	Male: 20.5±8.8	**0.006***
p value (gender)	**0.01***	**0.003***	
Serum calcium (mg/dL)	9.4±0.3	9.5±0.5	0.2
Serum phosphorus (mg/dL)	4±0.7	4.2±0.7	0.4
Serum magnesium (mg/dL)	2±0.2	2±0.3	0.4

Group 1: from April to August, Group 2: from September to March.

*(G): Between Group 1-Group 2, *: significant difference (p <0.05).*

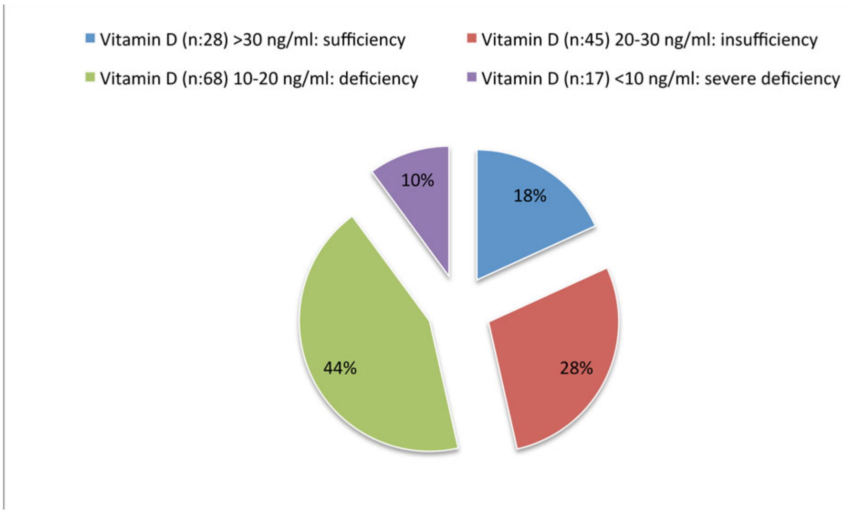

Figure 5. Percent of vitamin D status in athletes

When the micronutrient element status was analyzed according to gender, females were determined as at risk with lower hemogram parameters and lower serum vitamin D concentrations (Table 4).

A moderate negative correlation was determined with increasing age and vitamin B_{12} and folate levels in females. A mild negative correlation with increasing age in males was seen with vitamin B_{12} and folate and a moderate positive correlation was determined with ferritin level (Table 5).

Table 4. Hematological and micronutrient variables by gender

	Female (n:55)	Male (n:111)	p value
Hemoglobin (g/dL)	12.9±1.6	14.8±1.1	**0.001***
Hematocrit (%)	38.7±3.8	43.2±3	**0.001***
RBC (10^12/L)	4.7±0.4	5.2±0.4	**0.001***
MCV (fL)	83.3±7.5	83±5.5	0,1
Serum ferritin (µg/L)	33.9±55.8	44.9±32.7	**0.001***
Transferrin saturation (%)	21.9±12.3	28.9±13.4	**0.004***
Serum vitamin B12 (pg/mL)	305.9±129.1	325.8±133.7	0,3
Serum folate (ng/mL)	6.8±2.8	6.6±2.8	0,6
25 (OH) vitamin D (ng/ml)	17.1±7.7	22.5±9.3	**0.001***
Serum calcium (mg/dL)	9.3±0.5	9.5±0.4	**0.02***
Serum phosphorus (mg/dL)	4±0.6	4.2±0.7	0,1
Serum magnesium (mg/dL)	2.1±0.2	2±0.3	0,9

*RBC: Red blood cell, MCV: mean corpuscular volume, Transferrin saturation =(Serum iron/total iron binding capacity) X 100, *: significant difference (p <0.05).*

Table 5. Relationship of age progression to micronutrient elements

	25 (OH) vitamin D	**Vitamin B_{12}**	**Folate**	**Ferritin**
Age (years, female)	r: -0.2 p: 0.08	r: -0.4 **p: 0.007***	r: -0.4 **p: 0.01***	r: 0.2 p: 0.2
Age (years, male)	r: 0.1 p: 0.2	r: -0.2 **p: 0.02***	r: -0.2 **p: 0.04***	r: 0.4 **p: 0.001***

**: significant difference (p <0.05).*

DISCUSSION

According to the findings obtained in this study, the micronutrient elements of adolescent athletes are below the desired level. Female athletes in particular are a risk group for anemia and vitamin D deficiency. Vitamin D levels showed a seasonal difference and insufficiency has been detected in the athletes who trained indoors. Increasing age in both genders seemed to have a negative effect on vitamin B_{12} and folate levels.

Sports skills are acquired in adolescence, physical composition and hormonal changes occur that can directly affect the future health and healthy living habits of the individual, thereby making it a critical time of life (7). Iron, vitamin D and calcium deficiencies are often seen in adolescent athletes in this period. Therefore, dieticians involved in the nutrition of athletes recommend increasing the intake of these micronutrient elements in the food of adolescents (7). However, studies have shown that despite all the recommendations and warnings, the daily intake of macro and micronutrient elements of adolescent athletes remained below the desired amount (3, 20).

Christensen et al. examined the 24-hour nutrition records of 12 male adolescent athletes and reported that the intake of vitamin A, pyridoxine, folic acid, vitamin B_{12}, vitamin C, and vitamin E met the daily required intake at the rates of 17%, 82%, 56%, 55%, 95% and 65%, respectively (3). In the use of uncontrolled supplements of magnesium, iron and zinc, intake was 272%, 404% and 122% above the desired rate. Intake of calcium and selenium was reported to meet 47% and 49% of the required intake. The rates of these data were found to be very far from the recommendations of the Food and Agriculture Organization and the World Health Organization (3). Dwyer et al. examined the 3-day nutritional intake records of 36 female figure skaters and determined that they were far below the daily energy intake requirements and there was a moderate risk of eating disorders. It was also emphasized that female athletes should implement a prophylactic nutritional program to increase bone quality (20). Akabas et al. reported that female athletes were at risk of iron deficiency anemia as a result of blood loss during the menstrual cycle (17). Daily iron intake has been reported to be lower in individuals aged 15-18 years (21). This situation puts adolescent athletes at risk.

Although iron deficiency anemia is very widespread throughout the world in general, the prevalence of iron deficiency anemia in athletes has been reported to be similar to that of non-athletes at approximately 3%, and the prevalence of iron deficiency has been reported as 10%-20% (7, 22, 23). In a study by Habte et al. in athletes aged mean 21.3 years, with no use of supplements, anemia prevalence was reported as 3% (hemoglobin <12 g/dL), iron deficiency as 2% (ferritin <12 µg/L), first-degree iron depletion as 22% (ferritin <50 µg/L, but >30 µg/L) and second-degree iron depletion as 13% (ferritin < 30 µg/L, but >12 µg/L), (8). Ahmadi et al. examined female athletes with a mean age of 23.6 years and no use of supplements, and determined a low ferritin level (<30 ng mL^{-1}) in 33.3% of cases and a normal ferritin level in 12.5% (22). In another study in Turkey that examined adolescent athletes with a mean age of 13 years, iron deficiency anemia was determined in 14.3% of females, in 6.7% of males and in 11.1% of the whole group, and iron deficiency (ferritin <15 μg/L) was determined in 61.9% of females, in 26.7% of males and in 47.2% of the whole group. Gender seemed to make a difference in respect of hemogram parameters and ferritin levels, and a negative correlation was reported between age and ferritin levels (24). In the current study, the prevalence of iron deficiency anemia of the athletes was determined as 18% in females, 1% in males and as 6.6% in the whole group. When the cutoff value for serum ferritin concentration was accepted as 12 μg/L, iron deficiency was determined in 15% of the cases (females 33%, males 6%). A positive correlation was found between ferritin and age in male athletes. Compared to the findings of a study by Yüksel et al., the rates of anemia in the current study were lower, which could be considered to be due to regional differences in the nutritional habits and preferences of the athletes.

Although several studies have examined the serum iron levels of athletes, there were very few studies that have examined the levels of vitamin B_{12} and folate (9). Researchers who have examined these vitamins have stated that athletes who had western-type nutritional habits often used supplements and most of these supplements contained vitamin B_{12} and folate, but according to evidence-based recommendations, supplementation of these vitamins was not necessary (8). Fayet-Moore et al. reported a low vitamin B_{12} concentration (<120 pmol/L) at the rate of 11.3% in female university students aged 22.6±3.9 years and low serum folate concentration at 1.7% (23). In a study by Herrmann et al., levels of vitamin B_{12} (343 pg/mL) and folate (8.3 ng/mL) were reported to be similar with athletes aged 38±7 years compared to a non-athlete control group (9). Habte et al. determined serum folate concentration of mean 8.5±3.1 ng/mL in athletes, but folate deficiency (<5.9 ng/mL) was found in 20.8% of cases and no vitamin B_{12} deficiency was determined (8). In the current study, vitamin B_{12} was found to be at a sufficient level in 82% of females, in 88% of males and in 86% of the whole group of adolescent athletes. Although the serum folate concentration of the examined adolescent athletes was lower than rates reported in other studies, the normal serum folate concentration (>6 ng/mL) prevalence was determined as 54% (females 60%, males 49%). A negative correlation was seen between vitamin B_{12} and folate levels with advancing age in both genders. This demonstrated the necessity for closer monitoring of Turkish adolescent athletes in respect of folate deficiency and folate-rich food should be included in the diet.

Another micronutrient element that is seen to be deficient worldwide is vitamin D. Even though vitamin D deficiency is known to be widespread, data related to the status of this vitamin in active individuals are limited. Vitamin D is an extremely important vitamin for athletes with effects on bone mass, bone mineral density, the immune system and physical performance (25). Factors which can have an effect on vitamin D synthesis include ageing, skin pigmentation, regular use of protective sunscreen (SPF ≥15), style of dressing, cloud cover, atmospheric pollution, time of day, extended winter season, and distance from the equator (>35° N or S) (26). Due to the latitude of Turkey, there is a belt where vitamin D deficiency may often be seen. Data presented by Nayır et al. confirmed this information (27). Vitamin D levels in Turkey have been reported as 21.5 ng/mL in females and 23.1 ng/mL in males. Although engaging in sports did not create a statistically significant difference on levels of vitamin D, serum calcium, serum phosphorus, alkaline phosphatase and parathormone, training indoors were related with lower vitamin D levels (19.1±9.7 ng/mL) compared to those who trained outdoors (24.3±14.5 ng/mL). When athletes in all sports branches have been evaluated, only 18.7% have been reported to have a sufficient level of vitamin D (27). In a study conducted by Hamilton et al, athletes living in the Middle East had similar results; the vitamin D level of the 58% of the athletes were <10 ng/mL and 33% were <20 ng/mL (19). In a study in the UK, Close et al. reported a low vitamin D level in 62% of male athletes (28).

Lewis et al. monitored serum vitamin D levels in athletes over a period of 6 months from September to March and although all the athletes had sufficient levels of vitamin D at the beginning of this season, vitamin D deficiency was observed in 13% of the athletes at mid-season, and in 16% at the end of the season (29). Garcia et al. detected vitamin D deficiency in 57% of athletes after the winter season and reported that they were at risk at this time. A correlation between vitamin D level and daily vitamin D and calcium intake has been depicted (30). Villacis et al. examined athletes in the period of June to August and determined a mean vitamin D level of 40.1±14.9 ng/mL. A sufficient level of vitamin D was determined in 66.4% of the athletes. When the factors affecting vitamin D level were examined, it was reported that males and those with a dark skin had lower vitamin D levels (31). Constantini et al. found a mean concentration of vitamin D as 25.3±8.3 ng/mL in athletes with a mean age of 14.7±3 years and reported vitamin D insufficiency in 73%. Vitamin D insufficiency was detected in 48% of the athletes who trained outdoors, whereas 80% had insufficiency who trained indoors. A correlation was determined between vitamin D level and age, gender, season and serum ferritin level (25). In the current study, a sufficient level of vitamin D was determined in 6% of females and 24% of males, in 15% of those who trained indoors, in 22% of those who trained outdoors and in only 18% of the whole group. Although serum vitamin D showed a seasonal change, there was no such seasonal change in serum calcium, serum phosphorus and serum magnesium levels.

In this study, micronutrient element deficiencies were evaluated biochemically in adolescent athletes and important findings were presented. However, there were some limitations of this study. First, as the study was retrospective, the time of the biochemical analyses and the fasting status of the patients were not standardized. The analysis was made on the acceptance of verbal statements of the athletes in respect of height and weight, training programs and the use of supplements.

CONCLUSION

In the adolescent period, variables such as the training area of athletes, seasonal factors, age and gender can affect the status of micronutrient elements. All athletes should be evaluated according to personal risk factors and there must be close monitoring of adolescent athletes in respect of micronutrient element deficiencies. Extra supplementation of nutrients may help to alleviate deficiciency of micronutrients. Most importantly, maintaining a balanced nutrition and providing regular and appropriate education programs will eliminate the nutritional deficiencies.

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