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Overweight and obese adolescents: A risk group for vitamin B12 deficiency and anemia?

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Ethics Committee Approval
The study was approved by the Ethics Committee of Ankara Education and Research Hospital (Approval number: E-19-195).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Obesity is a major clinical and public health problem for adolescents. It leads to various nutritional problems as well as adult diseases such as cancer, cardiovascular diseases, and diabetes. Some studies have found that dietary intakes of some micronutrients were inadequate among adolescents. The aim of this study was to investigate anemia and vitamin B12 deficiency in obese children and adolescents and to determine whether obesity has a role in vitamin B12 deficiency. Additionally, we aimed to assess ferritin levels and their relationship with body mass index in obese children and adolescents.

Methods: This retrospective cross-sectional study group consisted of 1574 patients between 10 and 18 years old who were admitted to the pediatrics department of the hospital, some for a weight problem and some, who constitute a control group, for other issues. Those excluded included patients with missing data, those with co-morbidities situations, patients taking vitamin supplements, children whose obesity was the result of a syndromic condition, and those whose obesity had endocrinal causes. Finally, 436 patients remained in the study. Vitamin B12 deficiency was defined as a serum level <200 ng/L. We defined anemia as a hemoglobin concentration under 12.5g/dl in males or 12g/dl in females according to depleted iron store, which is defined as a plasma ferritin level <12ug/L.

Results: 252 (57.8%) of 436 patients were normal weight, 51 (11.7%) were overweight, and 133 (30.5%) were obese. The overweight/obesity group had a significantly higher level of plasma ferritin compared to the normal group. No relationship was found between weight and anemia (P=0.95). Vitamin B12 levels negatively correlated with increasing age (P<0.001, Spearman's rho = -0,185). Obese and overweight adolescents had lower vitamin B12 concentrations than normal weight adolescents (P=0.01).

Conclusion: Serum ferritin concentrations are higher in obese and overweight adolescents than in those with normal weight. Obese and overweight adolescents are at high risk for low serum vitamin B12 concentrations, but not for anemia.

Keywords: Vitamin B12, Obesity, Adolescent, Anemia, Ferritin

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Introduction

Children's nutrition has a remarkable impact on lifelong health [1]. Adolescence is an intense growth period, second only to infancy. Therefore, as in infancy, general nutritional needs to support optimal growth and development are high in adolescence [2]. Food habits of adolescents are usually characterized by an irregular meal pattern with skipped meals [3]. In some studies, dietary intakes of certain micronutrients were found to be inadequate among adolescents [4, 5].

Iron deficiency is one of the micronutrient deficiencies for obese children and adolescents [6, 7], and it may lead to adverse effects, including lower cognitive or behavioral function, delayed mental and physical development, impaired sensorimotor function, and decreased work capacity [8].

Vitamin B12 is an essential vitamin found in foods of animal origin [3, 9]. Hematologic, psychiatric, and neurologic manifestations are seen because of vitamin B12 deficiency, which can cause irreversible neurological damage despite treatment [10]. In some studies, obesity in children and adolescents has been associated with an increased risk of low vitamin B12 concentrations [3, 9]. On the other hand, Gunanti et al. [11] reported that higher serum concentrations of vitamin B12 were associated with a reduced risk of obesity.

Our study aimed to assess whether obese children and adolescents are at increased risk for anemia and vitamin B12 deficiency.

Materials and methods

Study design and participants

This retrospective cross-sectional study was carried out by examining the data of 1574 patients between 10 and 18 years old who were admitted to the pediatrics department of the hospital between December 2018 and February 2019 for weight problems or who served as part of a control group. Patients whose serum vitamin B12, hemoglobin concentration, and plasma ferritin had been measured were included. Patients with missing data, having co-morbid situations, or using vitamin supplements were omitted. Also excluded were children whose obesity was the result of syndromic conditions and those whose obesity had endocrinal causes. Finally, 436 (27.7%) adolescent patients (268 female), 252 (57.8%) with normal weight, 51 (11.7%) overweight, and 133 (30.5%) obese remained in the study. The study proposal was approved by the Ethics Committee of Ankara Education and Research Hospital (approval number: E-19-195). There are no conflicts of interest; thus, the researchers do not have biases.

Anthropometry and body composition

Weight (measured by a digital electronic scale) and height (measured by a portable stadiometer) were recorded in digital patient files. Nutritional status was assessed using the body mass index (BMI)—the ratio of body weight (kg) and the square of the height (m^2)—according to World Health Organization recommendations. BMI categories were classified as obese (>95th percentile), overweight (85–95th percentile), and normal weight (<85th percentile), considering age and specific to gender [12].

Biochemical and clinical assessment

All blood analyses were performed at the Ankara Education and Research Hospital biochemical laboratory. The serum vitamin B12 levels were determined using the electro-chemiluminescence immunoassay method. Vitamin B12 deficiency was defined as a serum level <200 ng/L [13]. We defined anemia as a hemoglobin concentration under 12.5g/dl in males or 12g/dl in females, according to depleted iron store, which is defined as a plasma ferritin level <12ug/L [14, 15].

Statistical analysis

Statistical analyses were performed using SPSS version 15.0. Mean, standard deviation, median, range, and minimum and maximum values were shown as the descriptive statistics for age, BMI, hemoglobin, plasma ferritin, and vitamin B12. Percentages were given for groups of categorical variables. Differences between the groups for categorical data were analyzed using Pearson's chi-square or Fisher's exact test, as appropriate. The Shapiro-Wilk test was used for the test of normality. Continuous variables were compared using the Mann-Whitney U test. The relationship between age and B12 was evaluated using Spearman's rho correlation coefficient. A *P*-value <0.05 was considered statistically significant.

Results

In the study, the average age of patients was 13.7 (1.34) years. Laboratory characteristics of the patients are presented in Table 1.

Table 1: Laboratory characteristics of study population

	N	Minimum	Maximum	Mean	SD
Age (years)	436	10	18	13.7	1.34
BMI	436	13.6	44.4	23.4	5.82
Hemoglobin (g/dL)	434	7.9	17.6	13.8	1.34
Plasma Ferritin (ug/L)	427	0.9	166.3	39.7	26.71
Vitamin B12 (ng/L)	428	111.5	830.8	302.2	117.81

SD: Standard deviation, BMI: Body Mass Index

Normal weight and overweight/obesity groups, hemoglobin, and plasma ferritin levels are presented in Table 2 for both female and male adolescent participants. There was no gender difference between weight groups. Adolescent girls had significantly higher prevalence of anemia and lower plasma ferritin than boys (P<0.001 for each). The normal weight group had a significantly lower level of plasma ferritin compared to the overweight/obesity group (P=0.005) (Table 3). No relationship was found between weight and anemia (P=0.483).

Table 2: Distributions of adolescents according to weight groups, the hemoglobin level, anemia presence and plasma ferritin levels in both genders

	Female	Male	P-value
Weight group			
Normal weight	155 (57.7%)	97 (57.7%)	0.984
Overweight/Obesity	113 (42.2%)	71 (42.3%)	
Hemoglobin level (g/dL) Mean+ SD	13.31+1.15	14.49+1.39	0.483
Anemia			
No	241 (90.6%)	160 (95.2%)	<0.001
Yes	25 (9.4%)	8 (4.8%)	
Plasma ferritin level			
≤12 (ug/L)	50 (18.9%)	1 (0.6%)	<0.001
>12 (ug/L)	215 (81.1%)	161 (99.4%)	

SD: Standard deviation

Table 3: Anemia and plasma ferritin level according to weight status

		Normal weight	Overweight/ Obesity	Total	*P*-value
Anemia	No	230 (91.6)	171 (93.4)	401 (92.4)	0.483
n (%)	Yes	21 (8.4)	12 (6.6)	33 (7.6)	
Plasma ferritin level	Normal	210 (84.3)	166 (93.3)	376 (88.1)	0.005
n (%)	Low	39 (15.7)	12 (6.7)	51 (11.9)	

Vitamin B12 deficiency was seen in 68 of 428 (15.8%) patients. Also, 19% of male patients and 13.5% of female patients had a vitamin B12 deficiency. This difference was statistically insignificant (P=0.28). There was a correlation between age and vitamin B12 deficiency (P<0.001, Spearman's rho = -0,185). Vitamin B12 levels decreased with increasing age.

Obese and overweight adolescents had lower vitamin B12 concentrations than normal weight adolescents (P=0.019) (Table 4).

Table 4: Relationship between BMIP and Vitamin B12

		Vitamin B12		Total
		Deficiency n (%)	Normal n (%)	
BMIP	<85	31 (12.4)	219 (87.6)	250
	>85	37 (20.8)	141 (79.2)	178
Total		68 (15.9)	360 (87.6)	428

BMIP: Body Mass Index Percentile

Discussion

The prevalence of anemia in Turkey is 1.5–12.5%, and adolescence is considered as a risky age group for anemia [16]. In this study, the prevalence of anemia was found to be 7.6%. That broke down to 9.4% of girls and 4.8% of boys. A study by Huang et al. [8] compared 2099 adolescents and found that adolescent girls had significantly lower plasma ferritin and hemoglobin concentrations and a greater prevalence of anemia compared with boys. As seen in other studies, in our study, too, iron deficiency was higher in girls than in boys [8, 16–18]. Adolescent girls are vulnerable to anemia because their overall iron requirement increases two to three times during adolescence due to high growth and 12.5–15 mg iron loss in each menstrual cycle [2, 19].

Although some studies have found iron deficiency anemia to be more common in obese adolescents [7, 20], we couldn't find any significant relationship between BMI and anemia. Huang et al. [8] found a positive correlation between BMI and hemoglobin. Scheer and Guthrie [21], investigating whether hemoglobin criteria should be adjusted according to weight status, observed iron deficiency but no anemia, as in our study. Again, a study by Simsek et al. [22] in Turkey showed that hemoglobin levels were similar in both obese and control groups; in addition, ferritin levels were higher in the obese than in the control group.

We found that plasma ferritin levels increased as children's BMIs increased from normal weight to obesity. In this study, as in previous studies [8, 22, 23], higher ferritin levels were observed in children with overweight and obesity. These findings are consistent with the observation that obesity is an inflammatory condition that increases acute phase reactants [23, 24]. Ferritin functions not only as a parameter of iron storage but also as an acute phase protein; hence, its level in plasma increases in response to inflammation due to obesity [6, 23, 25]. However, in a study done in the Iranian population by Ghadiri et al. [6, 26], there was no difference in serum iron and ferritin among normal weight, overweight, and obese people. In several studies, children with higher BMIs had lower serum iron levels; however, ferritin concentrations were similar in both normal weight and obese children [6, 27].

Our study indicates that 20.8% of overweight and obese adolescents had B12 deficiency, while 12.4% of normal weight adolescents had B12 deficiency. In a study by Ho et al. [9] in Australia, the rate of obese adolescents with a serum vitamin B12 concentration ≤221pmol/L was reported to be 32.1%. In a study by MacFarlane et al. [28], this percentage was 20.4% in obese children and adolescents in Canada.

Our results show that obese and overweight adolescents had significantly lower vitamin B12 concentrations than normal weight adolescents. Pinhas-Hamiel and his colleagues [3] reported that obesity was associated with a greater than four times risk for low vitamin B12 concentrations. Gunanti et al. [11] also supported our results, finding that normal weight children's vitamin B12 mean serum concentrations were higher than those of overweight and obese children. In contrast, in a case control study in Brazil by Brasileiro et al. [3, 11], lower serum concentrations were detected in overweight adolescents compared with normal weight adolescents, but no significant difference was shown. Also, no significant difference was found in another study in adults [29]. Vitamin B12 deficiency is caused by decreased intake, abnormal nutrient absorption, or a rare congenital defect of vitamin B12 metabolism [3, 30]. Because obese children gain weight easily, there is no reason to suspect they have a problem with absorption [3]. Nutrition of obese and overweight children may consist of foods low in vitamin B12. In addition, it is also possible that obese children may have increased need for vitamin B12 compared to non-obese children due to increased growth and body surface area [3].

We found that the frequency of vitamin B12 deficiency increases with increasing age. A study evaluating the serum B12 levels of 3766 children (aged 4 to 19 years) in the USA found that the greatest proportion of children with levels <200 pg/mL was in the 12- to 19- year age category, with a rate of one in 112 [30]. Additionally, Pinhas-Hamiel et al. [3] reported that each increase of one year of age decreased vitamin B12 concentration by 22pg/mL.

There was no relationship between gender and vitamin B12 level. Pinhas-Hamiel et al. [3] also supported this finding. In contrast to our study, Gunanti et al. [11] observed higher mean concentrations of serum vitamin B12 among girls.

Limitations

We conducted a retrospective cross-sectional study, and the data were obtained by scanning patient files. Since only patients with complete data were included in the study, the number of patients included was limited.

In future studies, vitamin B12 levels can be measured in obese and normal weight adolescents, and their response to treatment can be evaluated prospectively by administering B12 therapy to those with low vitamin B12 levels.

Conclusion

Our findings show that serum ferritin concentrations were higher in obese and overweight adolescents due to the inflammatory state caused by obesity. Obese and overweight adolescents are at high risk for low serum vitamin B12 concentrations but not for anemia. We recommend including vitamin B12 intake in the dietary evaluation of obese and overweight adolescents. Clinicians should be careful about this.

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