Original article

Nutritional and Obesity Status of Children and Adolescents with ADHD: a case-control study

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Abstract

Objective**:* Due to their prone to obesity and unbalanced nutrient intake this study was carried out to evaluate the daily energy and nutrient intake and obesity status of children and adolescents with attention deficit hyperactivity disorder (ADHD). ***Methods: The study was conducted on a total of 390 children (169 ADHD and 221 control groups) between the ages of 6-17 years. Body weight and height were measured and height-for-age-z-score (HAZ), weight-for-age-z-score (WAZ) and BMI-z-score (BMIZ) were calculated. 24-hour dietary recalls of the participants were recorded, and energy and nutrients intake were analysed. The ratio of meeting daily energy and nutrients adequacy according to age and gender was calculated. ***Results:*** The HAZ values of the children with a mean age of 10±2 years were within the normal range in most of both groups. The ratio of overweight-obese children was 43.8% in the ADHD group and 39.8% in the control group, respectively. The ratio of energy from fat was high in both groups (ADHD: 39%, control: 41%) ($p < 0.05$). It was found that folic acid and thiamine were sufficient in both groups, pyridoxine was consumed in borderline excess, other vitamins were consumed in excess. All minerals except sodium were sufficient and sodium was consumed more. Folic acid and water consumption were found to be less in children with ADHD ($p < 0.05$). ***Conclusion*:** Overweight and obese rates are common among children and adolescents with ADHD, and their eating habits are similar to those of their healthy peers.

Keywords: attention deficit hyperactivity disorder; obese; children; adolescents; nutrients; energy

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Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders seen in childhood[1]. Although it is thought to be a heterogeneous, complex and multifactorial disorder affected by genetic and environmental factors, the pathophysiology of ADHD has not yet been fully proven[2]. Nutrition can be an environmental factor in the development of ADHD.

In studies investigating the effects of nutrients on

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ADHD and its symptoms, folate deficiency has been associated with an increased risk of behaviour such as hyperactivity, inattention, and aggression[3-5]. In a meta-analysis study conducted by Wang et al. Serum ferritin levels of children with ADHD were reported to be low; however, a correlation with iron levels was not found[6]. In a pilot study, it was observed that both dietary intake of zinc and copper minerals and serum levels of children with ADHD were low[7]. In a parallel study conducted by Viktorinova et al., It was found that plasma zinc levels were lower than the control group and were associated with inattention scores on parent-teacher scales[8].

It has been stated that ADHD may cause a disorder between energy intake and expenditure balance. In addition, it has been stated that poor impulsivity and behavioural control may cause changes in diet and consequently the development of obesity[9]. As a matter of fact, in studies in which the anthropometric measurements of children with ADHD were evaluated, it was observed that the number of overweight and obese children was higher[9-12]. On the other hand, it has been found that the body weight, height, and BMI values of 5-6 years old children with ADHD in Iran are similar to their peers[13]. Similarly, in a study conducted on 785 Asian healthy children, no significant relationship was found between ADHD symptoms and BMI[14].

Studies in the literature report that children with ADHD are rich in macronutrients, poor in micronutrients and prone to obesity. In line with the studies in the literature, this study was planned and conducted to evaluate the anthropometric measurements and energy and nutrient consumption of children and adolescents with ADHD.

Materials and methods

Research Place, Time and Sampling Selection

All procedures contributing to this work comply with the ethical standards of the relevant national and institutional committee on human experimentation with the Helsinki Declaration of 1975, as revised in 2008. This article was produced from the thesis entitled "Nutritional Status in Children with Attention Deficit and Hyperactivity Disorder". Another part of the thesis entitled "Processed Meat Products and Snacks Consumption in ADHD: A case-control study" is under the journal review process.

The case group of the study, which was planned and conducted as case-control, consisted of 169 children and adolescents between the ages of 6-17 with ADHD who applied to the Child Psychiatry Clinic of Health Sciences University Erenköy Mental and Neurology Hospital between October 2018 and April 2019. The parents of the children with ADHD were interviewed face to face and information was given about the study, and the parents and their children who agreed to participate were included in the study. The inclusion criteria were as follows: (1) normal intelligence based on either a WISC-R full-scale IQ score above 80 or the average/above average academic performance documented with the last year's final school grades (normal intelligence was confirmed by at least one faculty member of child psychiatry/paediatric neurology), (2) evaluation by a child and adolescent psychiatry clinic for behavioural/learning problems, (3) ADHD diagnosis and subtype according to the DSM-V by a structured psychiatric interview.

As the control group, the study was initiated with 400 children between the ages of 6-17 who were studying at Necmiye Güniz Primary School, Yıldırım Beyazıt Secondary School, and Şeyh Şamil Vocational Technical and Anatolian High School determined by Üsküdar District Directorate of National Education but 221 children who completed the questionnaire between April 2019 and May 2019 were included in the study. The parents were asked in writing, "Does your child have any psychiatric disorder?" and children with any psychiatric condition were not included in the study.

Written consent was obtained from parents.

Collection of Data

Demographic characteristics of children and families were obtained using a pre-prepared questionnaire. The questionnaires were filled in face-to-face interviews with the children with ADHD and their parents, and the control group's questionnaires were filled by the students themselves or by delivering them to the parents through teachers. As a demographic feature, the questionnaires included the questions of age, gender, parental education and being under treatment for ADHD.

In order to evaluate the growth and development of children, their body weight and height were measured and recorded in the questionnaire form. Body weight was measured using a 100 grams sensitive bamboo bathroom scale "GM-7173" without shoes and with minimum clothing. The same scale was used for all measurements. Height was measured with feet side by side, head on the Frankfurt plane (eye triangle and

auricle parallel to the floor) with a 0.01 cm sensitive non-stretch measuring tape.

A "24-hour dietary recall" was taken to determine the nutritional status of children. Dietary forms were used for the records based on the reminder method. The forms were completed in detail by interviewing face-to-face with children with ADHD and their parents. Dietary forms of the children in the control group were filled by themselves or by delivering them to the parents through teachers. The forms received from the parents were checked by the researcher, and the deficiencies, if any, were completed by confirming with the students. Parents of the children in the control group were informed about filling out the forms via teachers.

In determining the amount of food consumption, "Definition of standard measuring tools" under the chapter of "Determination of Standard Portion Sizes and Amounts of Food Groups" from Turkey Dietary Guidelines (TUBER) was utilized[15]. In these definitions, food consumption was recorded by questioning in detail the kitchen measurements (water glass, bowl, dinner plate, ladle, and tablespoon) and hand and finger measurements (fist, palm) from the parents. Photographs of foods and food models were used while writing their food consumption.

Evaluation of Data

Participants in the case and control groups were grouped as children (6-10 years old) and adolescents (11-17 years old), and analyses were made by comparing them between their age groups. The growth and development of children and adolescents were evaluated by measurements of body weight and height. Weight for height is determined by the body mass index (BMI). For this, BMI: Weight (kg) / height (m^2) formula is used. Height-for-age-z-score (HAZ), weight-for-age-z-score (WAZ) and BMI-z-score (BMIZ) were calculated. We calculated the *z*-score for each patient using AnthroPlus (http://www.who.int/growthref/tools/en), which calculates the exact *z*-score (the "absolute" *z*-score), not only its range[16].

In the z-score evaluation of anthropometric measurements, the z-score value is "0" in the child who fully fits the population average of height for age, body weight, and BMI. Values between +2 SD and -2 SD are considered normal. Height for age below -2SD was considered to be stunted, weight for age below -2SD was considered as low weight, height for age over + 2SD was too long, weight for age over + 2SD was considered as overweight[17]. Using BMI *z*-score curves and tables developed by the World Health Organization[18], we classified the children's BMIs according to

i. Severe thinness: *z*-score <-3 SD
ii. Thinness: *z*-score <-2 SD
iii. Normal weight (eutrophy): *z*-score ≥ -2 and <1 SD
iv. Overweight: *z*-score >1 SD
v. Obesity: *z*-score >2 SD

In the assessment of nutritional status, 24-hour recall records were used. Daily energy and nutrient consumption was determined using the NutriSurvey Turkish version 7.2[19]. The resulting values were compared with the energy and nutrient targets according to age and gender for evaluation of adequacy of diet patterns in TUBER [15]. Adequacy is accepted as ± 33% limit, consumption between 67-133% of the recommendations is sufficient, consumption below 67% of the recommendations is insufficient, and above 133% is considered excessive consumption[20].

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 17.0 was used for statistical evaluation of the data. The arithmetic means standard deviation, median, and upper and lower values of the data obtained from individuals were calculated. Nominal variables are given using frequency and percentages. Descriptive findings were given as mean and standard deviation for continuous data. Median and interquartile width values were given for sequential data. Independent Sample t-Test was used for the average comparison between binary groups. Chi-square tests were used to compare the classified data. The tests were determined in the 95% confidence interval and the significance level was $p < 0.05$.

Results

Demographic characteristics

The demographic characteristics of the children and adolescents participating in the study are shown in Table 1. In the study where there were many male participants, 22% of the ADHD group and 42% of the control group were determined to be female. The average age of the ADHD group was 9.76 2.45 years, and the control group was 10.25 ± 2.39 years. Of the ADHD group, 46.4% are children, 38.4% are adolescents; 53.5% of those in the control group are

in the age range of children and 61.6% of them are in the age range of adolescents. 68% of children with ADHD are under treatment.

It was determined that most of the mothers (61.4%) had primary education, the rest had high school (24.8%) and university (13.4%) education, and the education level of fathers was slightly higher than mothers. The education level of the mothers of children with ADHD is higher than that of the control group ($p < 0.05$).

Table 1: Demographic characteristics of children and parents

Characteristics	ADHD (n=169)	Control (n=221)	Total (n=390)	*p*
Gender				
Female	38.0 (22%)	93.0 (42%)	131.0 (33.5%)	**<0.001***
Male	131.0 (78%)	128.0 (58%)	259.0 (66.4 %)	
Total	169.0 (100%)	221.0 (100%)	390.0 (100%)	
Age (year)	9.76 ± 2.45	10.25 ± 2.39	10.04 ± 2.42	0.05
Age group				
6-10 (Child)	111.0 (65.7%)	128.0 (57.9%)	239.0 (61.3%)	0.11
11-17 (Adolescent)	58.0 (34.3%)	93.0 (42.1)	151.0 (38.7%)	
Total	169.0 (100%)	221.0 (100%)	390.0 (100%)	
Receiving Treatment				
New diagnosis	54.0 (32.0%)	-		-
Under treatment	115.0 (68%)	-		
Mother's Education				
Primary education	88.0 (52.4%)	151.0 (68.9%)	239.0 (61.8%)	**<0.001***
High school	49.0 (29.2%)	47.0 (21.5%)	96.0 (24.8%)	0.08
University	31.0 (18.4%)	21.0 (9.6%)	52.0 (13.4%)	**0.01***
Father's Education				
Primary education	84.0 (49.7%)	124.0 (56.1%)	208.0 (53.8%)	0.17
High school	58.0 (34.3%)	75.0 (33.9%)	133.0 (34.4%)	
University	25.0 (14.8%)	20.0 (9%)	45.0 (11.6%)	

p: Chi-Square test was used to compare the classified data, and Independent Sample t-Test was used to compare the means between groups

Anthropometric measurements

Information on the anthropometric measurements of the participants is given in Table 2. Average height, body weight, and BMIZ values were in the normal range in both groups. In terms of height z score, most of both groups (ADHD: 86.9%, control: 91%) were within the normal range, the proportion of too long children and adolescents in the ADHD and control group were 9.5%, 6.5%, respectively, and the stunted ones were similar: 3.6%, 2.2%. There was no statistically significant difference in height between both groups and all ages ($p > 0.05$).

According to the WAZ cut-points values, most of both groups (ADHD: 73.9%, Control: 84.4%) were in the normal range, the proportion of overweight children and adolescents in the ADHD and control groups were: 23.4%, 13.3%, respectively, and the low weight ones were similar sequentially: 1.8%, 1.6%. Body weights were similar in both groups and at all ages, as well as in height ($p > 0.05$).

According to BMIZ cut points, more than half of the children and adolescents in both groups (ADHD 53.8%, control 58.4%) were in normal weight, the ratio of underweight children and adolescents in ADHD and control groups were 2.4%, 1.4%, and overweight: 23.7%, 23.5%, respectively, and the obese ones were: 20.1%, 16.3%. The ratio of overweight and obese children and adolescents was 43.8% in the ADHD group and 39.8% in the control group. There was no statistically significant difference between BMIZ values in both groups and all ages ($p > 0.05$).

Table 2: Evaluation of anthropometric measurements in children

Anthropometric Measurements	ADHD			Control			p^a	p^b
	6-10 years	11-17 years	Total	6-10 years	11-17 years	Total		
	(n=110)	(n=58)	(n=168)	(n=127)	(n=93)	(n=220)		
Height (cm)	131.20±9.43	154.47±12.74	139.24□□□□□□	132.04±8.87	154.40±10.66	141.49□□□□□□	0.48	0.97
HAZ	0.38±1.23	0.30±1.25	0.36□□□□□	0.28±1.19	0.22±1.06	0.26□□□□□	0.52	0.66
HAZ cut-points								
<-2SD	5.0 (4.5%)	1.0 (1.7%)	6.0 (3.6%)	2.0 (1.6%)	2.0 (2.2%)	4.0 (1.8%)	0.22	1.00
-2SD and +2SD	93.0 (83.8%)	53.0 (91.4%)	146.0 (86.9%)	116.0 (90.6%)	85.0 (91.4%)	201.0 (91%)		
>+2SD	12.0 (10.8%)	4.0 (6.9%)	16.0 (9.5%)	9.0 (7%)	6.0 (6.5%)	15.0 (6.8%)		
Weight (kg)	31.63±9.34	49.55±13.97	37.83□□□□□□	31.56±7.80	49.30±11.53	□□□□□□□□□□□	0.07	0.90
WAZ	0.87±1.59	-	0.87□□□□□	0.72±1.31	-	0.72□1.31	0.42	-
WAZ cut-points								
<-2SD	2.0 (1.8%)	-	2.0 (1.8%)	2.0 (1.6%)	-	2.0 (1.6%)	0.13	-
-2SD and +2SD	82.0 (73.9%)	-	82.0 (73.9%)	108.0 (84.4%)	-	108.0 (84.4%)		
>+2SD	26.0 (23.4%)	-	26.0 (23.4%)	17.0 (13.3%)	-	17.0 (13.3%)		
BMI (kg/m²)	18.13±3.74	20.48±4.05	18.94□□□□□	17.88±3.01	20.48±3.45		0.57	0.99
BMIZ	0.88±1.64	0.69±1.21	0.82□□□□□	0.76±1.29	0.68±1.17	0.72□□□□□	0.52	0.98
BMIZ cut-points								
Severe thinness-Thinness	4.0 (3.6%)	0.0 (0.0%)	4.0 (2.4%)	1.0 (0.8%)	2.0 (1.4%)	3.0 (1.4%)	0.07	0.62
Normal weight	56.0 (50.5%)	35.0 (60.3%)	91.0 (53.8%)	78.0 (60.9%)	51.0 (54.8%)	129.0 (58.4%)		
Overweight	27.0 (24.3%)	13.0 (22.4%)	40.0 (23.7%)	23.0 (18%)	29.0 (31.2%)	52.0 (23.5%)		
Obese	24.0 (21.6%)	10.0 (17.2%)	34.0 (20.1%)	25.0 (19.5%)	11.0 (11.8%)	36.0 (16.3%)		

p: Chi-Square test was used to compare the classified data, and Independent Sample t Test was used to compare the means between groups; a: 6-10 years, b: 11-17 years.

Energy and Nutrient Intakes

In Table 3, the amount of energy and nutrients consumed by ADHD and the control group with their daily diet and the status of meeting the recommendations are given.

It has been observed that daily energy intake is adequate for almost all children and adolescents. The ratio of energy from carbohydrate, which is one of the macronutrients, was at the lower limit (47%) in the ADHD group and low (44%) in the control group, whereas the ratio of energy from fat was higher in both groups (ADHD: 39%, control: 41%) and the ratio of energy from the protein was found to comply with the recommendations in both groups ($p < 0.05$) (Figure 1). It was determined that cholesterol was consumed more (326.3 ± 162.4 mg) in the control group compared to the ADHD group (274.2 176.8 mg) as seen in the fat ($p < 0.05$). Folic acid and water consumption was found to be lower in the ADHD group compared to the control group, and the difference was statistically significant ($p < 0.05$).

In all groups, it was determined that folic acid and thiamine were sufficient, pyridoxine was borderline excess, and other vitamins were consumed in excess. It has been observed that all minerals except sodium are sufficient and sodium is consumed in excess (Figure 2, Table 3).

Table 3: Daily energy and nutrient intakes and evaluation of adequacy in children.

Energy and macronutrients		ADHD (n=169)		Control (n=221)		p^c
	Recommended[a]	Intake (X±SS)	Adequacy (%)[b]	Intake (X±SS)	Adequacy (%)[b]	
Energy (kcal)	1600.0-3200.0	1880.4±731.4	90.4±32.1	1781.6±611.1	95.2±30.2	0.15
Carbohydrate (%)	45.0-60.0	46.8±9.67	-	44.0±8.48	-	**0.003***
Protein (%)	5.0-20.0	14.2±5.15	-	14.6±3.84	-	0.37
Fat (%)	20.0-35.0	38.0±8.97	-	40.5±7.7	-	**0.004***
Fiber (g)	14.0-21.0	17.8±10.4	103.8±55.6	18.2±8.34	104.3±46.8	0.70
Cholesterol (mg)	<300.0	274.2±176.8	91.40±58.96	326.3±162.4	108±54.13	**0.003***
Vitamins						
Vitamin A (mcg)	300.0-750.0	821.0 ± 897.8	179.0±194.7	979.3±1610.4	203.2±237.4	0.25
Vitamin C (mg)	30.0-100.0	79.0±78.7	172.0±166.7	89.3±78.3	195.2±172.0	0.19
Vitamin E (mg)	9.0-13.0	18.7±12.3	172.5±91.9	20.4±9.5	184.6±103.4	0.13
Tiamin (mg)	0.6-1.2	0.72±0.34	90.2±42.4	0.70±0.27	84.6±35.3	0.65
Riboflavine (mg)	0.6-1.3	1.27±0.68	160.8±86.1	1.31±0.60	158.3±73.7	0.60
Pyridoxine (mg)	0.6-1.3	1.14±0.74	135.7±86.1	1.16±0.52	132.6±66.6	0.73
Folate (mcg)	140.0-330.0	199.6±99.4	90.6±39.5	227.5±91.0	100.6±38.7	**0.01***
Minerals						
Sodium (mg)	1900.0-2300.0	3476.7±2201.9	164.0±99.6	3675.66±1596.4	172±73.2	0.38
Calcium (mg)	800.0-1150.0	762.6±433.8	84.1±45.2	798.5±363.5	87.4±41.6	0.44
Iron (mg)	7.0-11.0	9.95±4.42	93.4±42.6	9.94±3.72	90.4±34.3	0.45
Zinc (mg)	5.5-14.2	9.89±4.17	120.0±49.0	10.3±3.7	120.88±44.3	0.86
Magnesium (mg)	230.0-300.0	252.1±110.3	97.8±41.3	259.3±103.0	101.8±39.6	0.32
Water (ml)	2137.7±767.7			2356.4 ± 860.4		**0.01***

a: In order to evaluate the adequacy of nutritional patterns in TUBER 2015, reference values in energy and nutrient targets according to age and gender were taken into consideration.

b: Adequacy (%) was calculated and averaged separately according to the purchases of girls and boys in cases where recommendations were varying according to gender and age.

c: Average amounts of energy and nutrients taken were analysed by independent sample t-test; *: p <0.05.

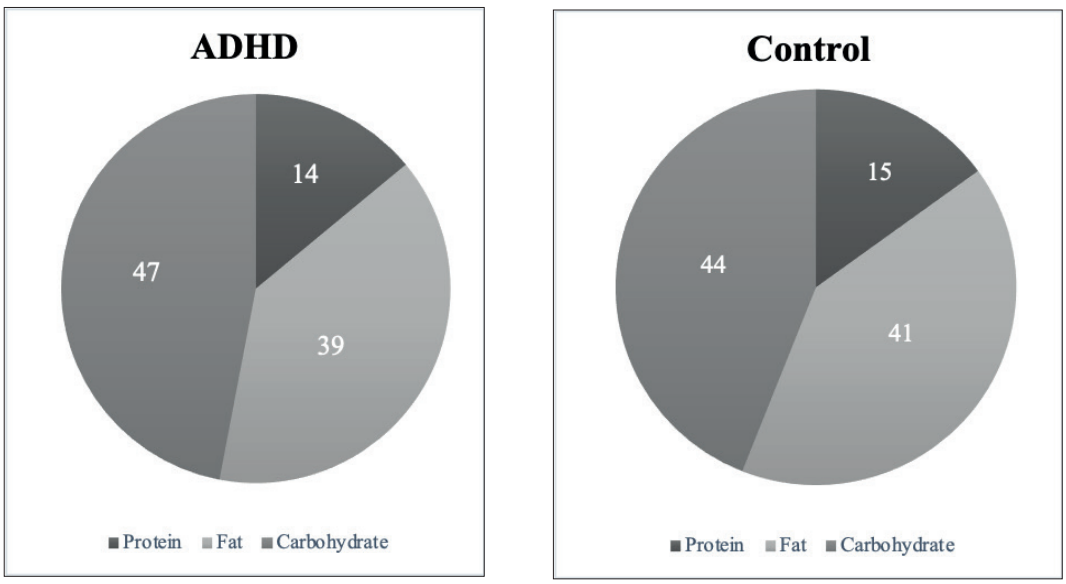

Figure 1: Contribution of children's macronutrient intake to total energy intake

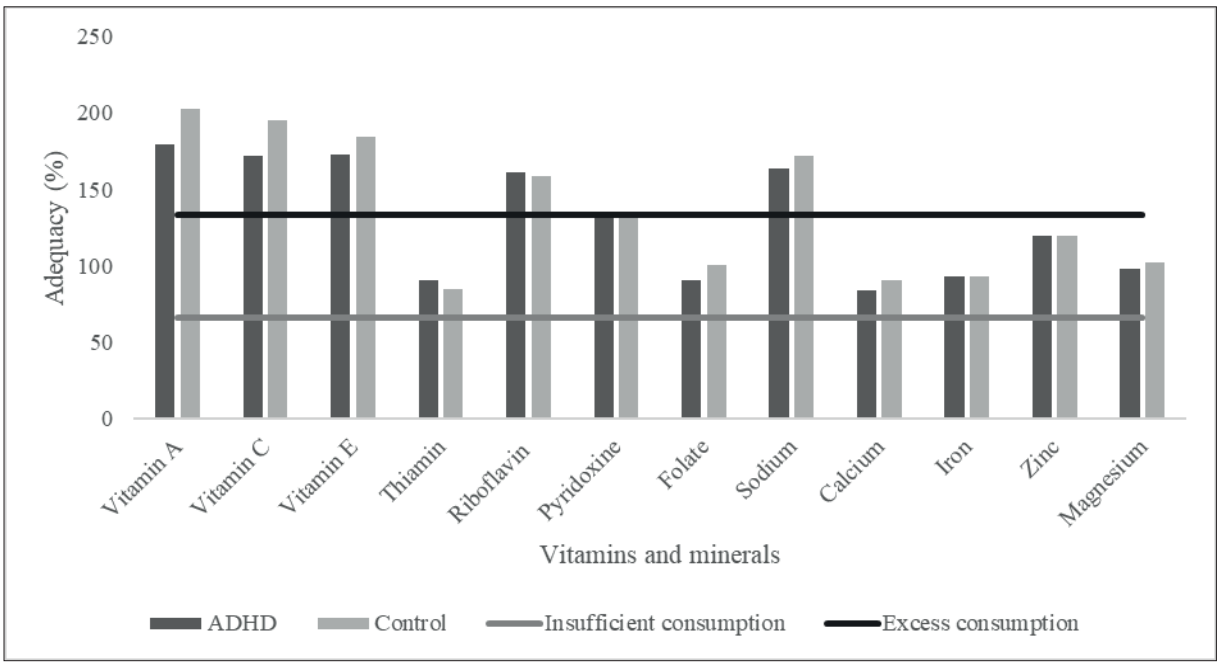

Figure 2: The ratio of meeting daily vitamins and minerals adequacy

Discussion

ADHD is a multifactorial disease and is associated with a high rate of energy intake and obesity[9-12]. In addition, the deficiency of some nutrients may play a role in the aetiology of ADHD[3-5]. In this study, in which nutritional status was evaluated, it was found that the anthropometric measurement values of children and adolescents with ADHD were similar to their peers, and the rate of overweight-obese was common in both groups. Vitamin and mineral consumption did not differ between groups.

Height for age, weight for age and BMI are markers that are frequently used in the evaluation of various conditions such as growth and development, obesity and malnutrition. In our study, height, weight and BMI values were examined between children with ADHD and the control group, and no statistically significant difference was found between the two groups. In another study conducted on children with Thai ADHD like our findings, it was stated that the mean weight and height z scores were within the normal range[21]. In another study conducted in 5-6 years old children with ADHD in Iran, it was shown that height, weight, and BMI values were similar to their peers with non-ADHD[13]. Similarly, Tong et al. did not find a statistically significant relationship between ADHD symptoms and BMI in a study they conducted on 785 healthy children[14].

Unlike our findings, Güngör et al. reported that malnutrition and overweight-obesity are more common in children with ADHD compared to their healthy peers[9]. According to these results, it was stated that ADHD may cause a disorder between energy intake and expenditure balance. Türkoğlu et al. showed that the rate of overweight and obesity is higher in children with ADHD and this situation is associated with ADHD symptoms[10]. According to these findings, the authors commented that poor impulsivity and behavioural control in ADHD may lead to changes in dietary patterns and consequently to the development of obesity. Similarly, it has been reported that children with ADHD are more likely to be overweight and obese in the Brazilian[11] and Chinese [12] samples.

Consumption of energy and nutrients is important in evaluating nutritional status. It has been reported that children with ADHD tend to develop risks in terms of undesirable dietary habits and consequently health problems[22]. In our study, it was observed that the energy from carbohydrates was at the lower limit in the ADHD group and low in the control group, while the ratio from fat was higher in both groups and higher in the control group ($p < 0.05$). Folic acid and water consumption was found to be less in children with ADHD ($p < 0.05$). There was no statistically significant relationship between the energy and nutrient consumption between the groups.

Although folate intake varied between groups, both groups were found to meet the recommended intakes

for folate and no further evaluation was needed. In line with our findings, Chou et al. showed that children with ADHD's intake of other nutrients except calcium and vitamin B2 were similar to the control group[23]. In another study, dietary nutrient intakes of children (7-12 years old) and college student (18-25 years) with ADHD diagnosis were evaluated using a 24 hour recall. There is no evidence that nutrient intake is low in ADHD patients compared to control. It was observed that the nutritional intake of children complied with the guidelines, whereas college students did not[24]. Similarly, Kiddie et al. showed that the macronutrient intake of ADHD patients was similar to their healthy peers[7].

Despite these findings, Sha'ari et al reported in their study by taking a 3-day diet record that the energy and carbohydrate intake of children with ADHD was higher than the control[25]. However, in a study conducted as a 100-person case-control group in Spain, ADHD patients' energy, protein, carbohydrate, fat, fiber, calcium, iron, magnesium, zinc, selenium, phosphorus, thiamine, niacin, vitamin B6 and folate intake was found to be less compared to their healthy peers[26]. In this study, all the group with ADHD are under methylphenidate treatment, which can reduce food intake. Therefore, the results were attributed to the appetite suppressing properties of the drug.

As a result, studies are showing that children with ADHD are more prone to obesity and various micronutrient deficiencies due to their diagnosis. However, our findings did not support these results. There is no difference in ADHD patients compared to their healthy peers in terms of growth and development. The rate of overweight-obesity is high in both groups. No significant nutritional deficiency was found in either group. There is a need for studies in which nutrient consumption is repeated and biochemical markers are evaluated to reveal macro and micronutrient deficiency/excess.

Limitations of the study:

The limitations of this study are that the parents of the control group could not be reached individually, the nutritional status was taken in one day with the recall method, and no laboratory measurements were made to evaluate biochemical markers.

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Authorship Contribution:

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