Original Article

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Comparison of the Nutritional Status of Boys with and without Attention Deficit Hyperactivity Disorder

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ABSTRACT

BACKGROUND AND OBJECTIVE: Attention deficit hyperactivity disorder (ADHD) is one of the most common mental disorders in children. Nutritional deficiency may play a role in the etiology of this disorder. The purpose of this study was to determine and compare the nutritional status (dietary intake and anthropometric indices) of boys with and without ADHD.

METHODS: This case-control study was conducted on 36 boys with ADHD (case group) and 37 normal children (control group), aged 6-12 years. The case subjects were assesssed by an expert psychiatrist via clinical evaluations and psychiatric questionnaires. Height, weight, and body mass index (BMI) of the subjects were measured. Dietary intake was recorded, using a three-day food record (three non-consecutive days including one holiday and two weekdays) and analyzed using Nutritionist IV software.

FINDINGS: The mean weight, height, and BMI values were higher in children with ADHD, compared to the control group ($p<0.05$); the mean±SD of BMI was 17.28±2.44 in the case group and 15.14±2.34 in the control group ($p<0.001$). There was no significant difference in terms of energy, macronutrient, or micronutrient intake between the two groups. However, folate and selenium intake in the two groups was lower than the recommended dietary allowance.

CONCLUSION: The results showed no signifcant difference between the energy intake of children with ADHD and healthy boys. However, boys with ADHD were taller and heavier than healthy subjects, and their BMI was higher.

KEY WORDS: Attention Deficit Hyperactivity Disorder, Nutritional Status, Anthropometric Indices.

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Introduction

Attention deficit hyperactivity disorder (ADHD) is a psychiatric condition in children (1). This term is used to describe hyperactive, irritable children with attention deficit (2, 3). In fact, ADHD is the most common psychiatric disorder in children and adolescents (4). The onset of ADHD symptoms leads to developmental problems, attention deficiet, educational issues, and impulsivity in children with hyperactivity (5). Moreover, this disorder may cause difficulties in interpersonal relationships with peers, family members, and tearchers (6). Although ADHD seems to mainly affect children and adolescents, if left untreated, this disorder can affect one's life in family, school, and society, and the consequent problems may even continue into adulthood (7).

The American Psychological Association estimated the incidence of ADHD to be 3-5% in school-aged children, based on the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV), while other sources have reported a higher prevalence of 13.5% (8-11). Many studies have also shown that the incidence of ADHD is 9.2 times higher in boys than girls (12-15). In Iran, various studies have indicated the high prevalence of ADHD in preschool and school-aged children (5.8-16.3%) (16-19). As a study by Amiri et al. indicated, the prevalence of ADHD among elementary school students was 9.7% in Tabriz (20). Although the etiology of ADHD is unknown, multifactorial and biological factors seem to be involved. Moreover, the role of genetic factors has been noted in many studies (21-23).

In some studies, environmental pollutants, neurotransmitter imbalance, food coloring agents and preservatives, food allergies, and malnutrition have been shown to be associated with ADHD (24-26). Nutritional factors including the impaired metabolism of glucose or fatty acids (i.e., deficiencies of tryptophan, vitamins, and minerals) have been shown to affect brain function (27-30). Moreover, children with ADHD are prone to many types of nutritional deficiets, given the therapeutic effects of medications on their appetite and their inattention while sitting at the table or eating (31). Studies on school-aged children and adults have shown that ADHD can be also caused by malnutrition (32). According to a study conducted in Taiwan, no difference was observed between the dietary intake of children with ADHD and normal children, with the exception of vitamin C and iron intake (33). In a study by Antalis et al., the percentage of energy intake from saturated fatty acids (SFA) in children with ADHD was 30% higher than the control group; however, the intake of other nutrients showed no significant difference (34). In another study by Ng et al., the dietary intake of arachidonic acids was lower in children with ADHD, and the dietary intake of linolenic acid was higher in ADHD children, compared to the control group (of the same age) (35).

Based on a study by Colter and colleagues, it was concluded that hyperactive adolescents receive more energy and fat, compared to healthy children. However, no significant difference was observed in omega-3 and omega-6 inatake between hyperactive children and healthy subjects (15). In a study by Kiddie and colleagues, children with ADHD recieved lower amounts of zinc and copper than the standard values reported by the Canadian Community Health Survey (CCHS).

However, no signficant differencce was reported in the energy intake or the percentage of received energy from calories, proteins, fats, or carbohydrates (31). In a study by Dura'-Trave et al., the intake of energy and nutrients in children with ADHD was lower than normal children; however, both groups received the Recommended Dietary Allowances (RDA). The mean weight, height, and BMI values in the ADHD group were significantly lower than those reported in the control group (36). By reveiwing previous research, which aimed to evaluate the nutritional status of children with ADHD, it can be

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said that the reported results are inconsistent and insuffeceint.

Considering the limited number of studies in our country, the high prevalence of ADHD, and the subsequent problems of this condition, we aimed to assess and compare the dietary intake and anthropometric indices of ADHD boys and healthy subjects. Considering the higher incidence of ADHD in boys and for eliminating the factor of gender, only male subjects were evaluated in this study.

Methods

This case-control study was performed on 36 boys with ADHD (case group) and 37 boys without ADHD (control group), selected via easy accessible sampling. The case group included ADHD children, referring to psychiatric clinics. They were assessed by an expert psychiatrist via clinical evaluations, a semi-structured diagnostic interview (K-SADS-PL) (37), Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) criteria (6), and ADHD rating scale questionnaire (parent version) (38).

The control subjects were selected among children, referring to the otolaryngology clinic of Tabriz Children's Hospital. They were selected after evaluation by Strengths and Difficulties Questionnaire (SDQ) (39) and ADHD rating scale (parent version). Finally, 6-12-year-old boys were included in the study in case they did not have ADHD or other psychopatic disorders. The exclusion criteria were as follows: 1) <6 years of age or>12 years; 2) being a female; 3) concurrent mental diseases; 4) endocrine disorders (e.g., thyroid disorders and diabetes); 5) hypertension, 6) inherited metabolic disorders (familial hyperlipidemia or hyperchylomicronemia); 7) use of anti-inflammatory medications; 8) following a special diet (high-fat diets such as ketogenic diet); 9) use of dietary supplements including dietary fatty acids and antioxidant vitamins; and 10) prior history of fatty acid consumption over the past 6 months. The objectives of the study were explained to the parents and written consents were obtained. For each subject, after completing the required forms, the demographic questionnaire was completed. Then, the three-day food record sheet was distributed among parents and children to be completed at home. Afterwards, the data gathered by the food record forms were analyzed, using Nutritionist IV software. The average daily intake of calories (mean of three days), macronutrients [carbohydrates, proteins, fats, SFA, monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), oleic acid, linoleic acid, linolenic acid, eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and cholesterol], and micronutrients (vitamin B12, A, E, C, and folate and minerals such as iron, zinc, magnesium, and selenium) was recorded. The dietary intake of micronutrients was compared with RDA values.

The subjects' weight was calculated, using Seca scale with 500 g accuracy (with clothes and without shoes). Also, the subjects' height was measured using a tape with 0.5 cm accuracy. Finally, BMI was calculated, using the following formula:

$$\text{BMI} = \frac{\text{weight (kg)}}{(\text{height (m)})^2}$$

Then, the children's BMI was compared with BMI-for-age percentile, suggested by the Center for Disease Control and Prevention (CDC). Based on CDC classification, $0\text{-}5^{th}$ percentile is regarded as underweight, $5^{th}\text{-}85^{th}$ percentile as normal weight, $85^{th}\text{-}95^{th}$ percentile as overweight, and $> 95^{th}$ percentile as obesity (40). Kolmogorov-Smirnov, independent sample t-test, Mann-Whitney U, and Chi-square tests were perfomred, using SPSS version 19. P-value < 0.05 was considered statistically significant.

Results

The mean weight, height, and BMI values were signifcantly different between the two groups (p<0.05); the mean BMI was 17.28±2.44 in the case group and 15.14±2.34 in the control group (p<0.001).Overall, 25% of ADHD children had begun using stimulant medications to control their disease one month before the study (table 1). As the results indicated, 19.7% and 8.1% of subejcts in the case and control groups were over the 85th percentile, respectively. Chi-square test results showed a significant difference in the percentage of obesity between the two groups (p=0.018) (table 2).

Table 1. Demographic characteristics and anthropometric measurements in the two groups

Group / Variable	WithADHD (n=36) Mean±SD	WithoutADHD (n=37) Mean±SD	p-value*
Age(years)	8.7±1.70	8±1.86	0.06**
Weight(kg)	31.0±8.43	24.68±8.33	0.002
Height(cm)	13.04±10.71	13.91±13.79	0.016
BMI(kg/m2)	44.28±2.17	15.14±2.34	<0.001

*Independent sample t-test, **Mann-Whitney U test

Table 2. Frequency distribution and percentage of subjects in the case and control groups, based on BMI Percentile

Group / BMI Percentile	With ADHD N(%)(n=36)	WithoutADHD N(%)(n=37)	p-value
Underweight (0-5th)	0(0)	6(16.2)	0.018
Normal (5th-85th)	29(80.6)	28(75.7)	
Overweight (85th-95th)	4(11.4)	2(5.4)	
Obese(>95th)	3(8.3)	1(2.7)	

The mean values of energy and macronutrient intake were not significantly different between the two groups. There was also no significant difference regarding the intake of the following nutrients between the two groups: the mean and standard deviation of fatty acids (SFA, MUFA, and PUFA), oleic acid, linoleic acid, linolenic acid, EPA, DHA, cholesterol, folate, B12, vitamin A, E, and C, iron, zinc, magnesium, and selenium. Also, the mean percentage of energy from macronutrients was not significantly different between the two grups (table 3).

Table 3. Mean and standard deviation of energy and macronutrient intake in the two groups

Groups / Variables	with ADHD (n=36) Mean±SD	WithouhtADHD (n=37) Mean±SD	p-value*
Energy (kcal/day)	1941.9±290.1	1936.1±361.6	0.95
Protein (g/day)	61.2±15.9	58.3±18.8	0.58
Percentage of protein intake	12.5±3.1	12.6±2.7	0.93
Carbohydrate (g/day)	260.2±60.4	263.6±52.3	0.84
Percentage of energy from carbohydrates	52.7±7.6	54.3±4.6	0.38
Fat (g/day)	75.5±19.3	73.2±19.6	0.68
Percentage of energy from fats	34.8±7.4	33.0±4.8	0.34
SFA (g/day)	21.1±7.8	18.3±5.3	0.17
MUFA (g/day)	23.9±8.6	22.3±9.3	0.54
PUFA (g/day)	20.1±9.4	20.6±8.6	0.88
Oleic acid (g/day)	19.5±8.04	17.5±8.2	0.43
Linoleic acid (g/day)	19.06±9.4	19.0±8.04	0.98
Linolenic acid (g/day)	0.27±0.22	0.35±0.28	**0.25
EPA (g/day)	0.003±0.005	0.009±0.003	**0.69
DHA (g/day)	0.02±0.016	0.023±0.09	**0.68
Cholesterol (mg/day)	243.5±113.06	197.1±77.4	0.09

*Independent sample t-test, **Mann-Whitney U test

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The mean folate, B12, vitamin A, E, and C, iron, zinc, magnesium, and selenium intake was not significantly different between the two groups (table 4). On the other hand, the amount of nutritional intake was lower than RDA values for folate intake and selenium in both groups; however, the intake of other nutrients was within the normal range.

Table 4. Mean and standard deviation of micronutrient intake in the two groups

Micronutrients \ Group	WithADHD (n=36) Mean±SD	WithoutADHD (n=37) Mean±SD	p-value*
Folate(µg/day)	150.8±76.3	166.1±74.6	0.5
B12(µg/day)	5.6±9.5	4.2±7.10	**0.6
Vitamin A(RE/day)	613.6±379.2	986.23±868.0	0.07
Vitamin E(mg/day)	11.03±7.5	11.04±9.3	0.99
Vitamin C(mg/day)	46.2±12.3	50.0±16.8	0.39
Iron(mg/day)	11.6±2.4	13.1±4.4	0.28
Zinc(mg/day)	5.7±1.9	6.5±2.6	0.27
Magnesium(mg/day)	150.7±36.5	163.7±26.6	0.1
Selenium(mg/day)	0.085±0.05	0.095±0.07	**0.83

*Independent sample t-test, **Mann-Whitney U test

Discussion

This study showed that the mean weight, height, and BMI values in children with ADHD were higher than those reported in the control group; the number of overweight children was also higher than the control group. Therefore, we can conclude that children with ADHD are probably more prone to obesity, compared to healthy children. The relationship between ADHD and weight, height, and BMI has been discussed in many studies. In a study by Kiddie et al., it was shown that ADHD children were heavier and taller than normal children (31).

In a study by Cortese et al., weight and BMI were higher in individuals with ADHD, which was consistent with our findings (41). However, Dura'-Trave et al. showed that the mean weight, height, and BMI values of ADHD children were significantly lower than those of the control group (36).

The prolonged use of drug therapy was mentioned as an effective factor for the appetite, food intake, and anthropometric indices of these children. Although it is not clear why ADHD children were taller than healthy subjects, three mechanisms have been proposed regarding the relationship between obesity and ADHD: 1) obesity and the associated factors may occur as ADHD symptoms; 2) ADHD and obesity may have common genetic and neurobiological functions that affect the dopaminergic system or other systems in the body; and 3) inattention and impulsivity in ADHD lead to obesity due to irregular eating patterns (41); also, differences in physical activity can affect energy consumption.

In this study, among micronutrients, the intake of folate, B12, iron, zinc, magnesium, selenium, vitamin A, vitamin E, and vitamin C was studied. The average amounts of protein, carbohydrate, fat, SFA, MUFA, PUFA, EPA, DHA, oleic acid, linoleic acid, linolenic acid, and cholesterol showed no significant difference between the groups.

Also, the percentage of calories from proteins, carbohydrates, and fats did not differ between the groups with and without ADHD. In relation to micronutrients, the mean intake of folate, B12, iron, zinc, magnesium, selenium, vitamin A, vitamin E, and vitamin C was similar in the two groups. In a previous cross-sectional study, no significant difference was observed between ADHD children and the controls in terms of the intake of energy, protein, carbohydrates, vitamins, or minerals. However, the group with ADHD consumed more fats and PUFA, compared to the control group (3). In another study, children with ADHD received more energy and fat than healthy children. However, the intake of omega-3 and omega-6 in children with ADHD and healthy children was of no significant difference (15).

Kiddie and colleagues in a study showed that children with ADHD recieved lower amounts of zinc

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and copper, compared to the standard values suggested by CCHS; however, the energy intake and the percentage of energy received from proteins, fats, and carbohydrates were almost similar (31). In a study by Chen and colleagues, children with ADHD had higher dietary intake of iron and vitamin C, compared to the control group, while the intake of other dietary nutrients was not significantly different between the two groups (33).

Moreover, Antalis and colleagues in their study concluded that the percentage of calories from SFA in the ADHD group was 30% higher than that of the control group; however, no significant difference was observed in the intake of other nutrients between the two groups (34).

In a study by Ng and colleagues, it was revealed that the dietary intake of arachidonic acids in ADHD is lower, while linolenic acid intake was higher than the general population of the same age (35). Also, Azadbakht and colleagues examined the dietary patterns of ADHD children. ADHD children had lower vitamin B1, B2, calcium, iron, and zinc intake, compared to normal children. In the mentioned study, the population consisted of both sexes and the evaluation was carried out using a food frequency questionnaire (42).

Moreover, in a recent study, it was shown that the energy intake in the control group was significantly higher than the ADHD group (43). The main reason behind these contradictory results is unclear. However, by comparing the incosistent results of various studies and differences in the evaluated anthropometric indices in the current research, it can be concluded that irregular and possibly differing dietary patterns, varying levels of physical activity, use or non-use of medications, and duration of medication use can be among the influencing factors for the dietary intake and anthropometric indices of ADHD children, despite the similarity in their food intake.

Although it seems that ADHD children should consume more energy during physical activity, in our study, there was no difference between the groups in terms of energy intake. Therefore, it seems essential that future studies examine the physical activity of children with ADHD. The stregnths of this study included selecting uni-sex groups and use of a questionnaire for screening the two groups. The constraints of 3-day food record form including under-reporting, over-reporting, non-reporting, and inaccurate recording are the limitations of this study; however, in most previous studies, the same method has been applied for assessing the nutritional intake. Non-recording of physical activities and the small sample size are other limitations of this study.

Therefore, further research with a larger sample size and an emphasis on ADHD children's physical activity is suggested. In the current study, there was no meaningful difference between the dietary intake of children with ADHD and healty children. However, ADHD children were heavier and taller than healthy ones (higher BMI in the case group). The dietary intake of some micronutrients in both groups was lower than RDA values, although further research is required to clarify this issue.

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