Clin Nutr Res. 2017 Apr;6(2):112-121
https://doi.org/10.7762/cnr.2017.6.2.112
pISSN 2287-3732·eISSN 2287-3740

cnr
CLINICAL NUTRITION RESEARCH

Original Article

Nutritional Status of Korean Children and Adolescents with Attention Deficit Hyperactivity Disorder (ADHD)

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Received: Apr 14, 2017
Revised: Apr 21, 2017
Accepted: Apr 25, 2017

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Funding
This research was supported by the Daegu University Research Scholarship Grants (2017).

Conflict of Interest
The authors declare that they have no competing interests.

ABSTRACT

Attention deficit hyperactivity disorder (ADHD) has been associated with an elevated risk for obesity but this seems to be paradoxical to the fact that many youths with ADHD have symptoms of hyperactivity. People diagnosed with ADHD tend to have a high risk of developing undesirable diet habits and consequently have health related problems. However, less attention has been paid to obesity in ADHD while many efforts have been devoted to the prevention of childhood obesity in mentally normal people. Hence the purpose of this study was to explore the nutritional status and life habits of children and adolescents with ADHD (n = 76) based on degree of obesity by utilizing the Korean National Health and Nutrition Examination Survey (KNHANES) data from 2005–2013. As results the levels of blood pressure, total triglycerides and the fat intake relative to total energy intake in overweight ADHD group were higher than those in normal weight group. Interestingly, overweight ADHD subjects consumed significantly less amount of iron compared to normal weight ADHD subjects and the level of serum ferritin was lower in the overweight ADHD group (59.0 ng/mL) than in the normal weight ADHD group (47.9 ng/mL). After adjusting total energy intake, total vegetable consumption was 14.3% lower in overweight group compared to the consumption in normal weight group. These results indicate a plausible relationship of iron status and obesity in ADHD subjects but this relationship may not be specific to ADHD. A future study with case-control design is necessary to investigate the association of obesity, nutrient intake, and cognitive/mental status of ADHD.

Keywords: ADHD; Obesity; Fat; Iron

INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is a condition which increases physical and mental health risks for youth due to a tendency of functional impairment by difficulties in disinhibition, memory loss, and sustained attention [1-3]. Executive dysfunctions obstruct proper health management or sedentary behaviors and lead health problems in ADHD. For examples, ADHD was associated with development of allergic reaction for a certain food with food additives and the addictive consumption of wheat flour based snacks were associated with celiac disease [4,5]. Also, hyperactivity and impulsive reaction in ADHD and stimulants use were associated with high blood pressure and an increased risk of cardiovascular diseases

[6-8]. Especially, ADHD has been associated with an elevated risk for obesity due to improper nutrition intake and medication for alleviating mental stimulation and physical activity [2,9,10]. Increased prevalence of obesity in ADHD is somehow paradoxical to the fact that many ADHD youths have symptoms of hyperactivity which include performing the same physical action repeatedly and impulsive movements [8,10]. When such unusual actions, however, incorporate to their daily diet behavior, ADHD subjects would develop undesirable diet habits and consequently advance to ADHD specific path for developing obesity or nutrition problems [11-13].

Recent few decades, the prevalence of obesity in children and adolescents has increased and many efforts are given to the prevention/cure of the childhood or adolescent obesity in scientific and public health area [10,14-17]. For leveling off the obesity epidemic, various type of diet-campaigns (e.g. cutting-off fast-food consumption, restrict high sugar contained food or drink) and sociological approaches (e.g. disengage vending machine of soda or soft drink, nutrition counseling program) have been attempted [17,18]. But less attention has been paid to obesity or related dietary habit of ADHD children or adolescents relative to the fact that those ADHD youths get much more and closer attention from their family or guardian than normal children and adolescents do. Since the treatment or research priority in ADHD has been more weighed on their neuropsychological symptoms or social behaviors/adaptation, the unique dietary behavior or nutritional status or possible nutritional problem, and health risk of ADHD youths may have been in the shadows [10,19,20]. Also, only few studies have investigated nutritional status of ADHD and possible routes to develop obesity in ADHD [10,13]. Moreover, other than the consumption of foods with high-sugar content which has been reported a typical problematic dietary habit in ADHD [19,21] the difference in factors affecting obesity specific to ADHD youths has not been identified. In this study as a start-up research, the health, nutritional status, and life habits of ADHD were investigated according to the degree of overweight in Korean children and adolescents with ADHD.

MATERIALS AND METHODS

Subjects

Data of ADHD youths aged 7–18 years were extracted from the Korean National Health and Nutrition Examination Survey (KNHANES) from 2005–2013 which adopted a stratified multistage probability sampling design. The data of mental health of youth in KNHANES was collected by a structured diagnostic interview administered to parents engaged in Korea Youth Risk Behavior Web-based Survey (2005–2013). In this study, we defined "ADHD subject" for only participant who was diagnosed with ADHD by physician. Of 28,071 potential children and adolescents aged 7–18 years, 106 subjects were diagnosed ADHD. Finally, the data of 76 ADHD subjects were analyzed after excluding participants who had incomplete lab or dietary data. Investigational procedures of KNHANES were confirmed and approved by the Korea Center for Disease Control and Prevention (IRB No. 2007-02CON-04-P, 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21, 2011-02CON-06-C, 2012-01EXP-01-2C, 2013-07CON-03-4C) [22].

Anthropometric measurement

Body weight of subjects was assessed by an electronic scale (GL-6000-20; G-tech, Uijeongbu, Korea) and the height was measured by an electronic balanced beam scale (Seca 225; Seca, Hamburg, Germany). After body mass index (BMI = body weight [kg]/ height [m^2]) was

https://doi.org/10.7762/cnr.2017.6.2.112

calculated, the percentiles of BMI within the same sex and age were identified based on the 2007 Korea growth reference (Korea Centers for Disease Control and Prevention [KCDC]) which provides reference scales of BMI for each year term of children and adolescents. Subjects with BMI for age ≥ 85th percentile was classified as an overweight (risk of obese) group (n = 21) and the others were classified as a normal weight group (n = 55). For all subjects in both groups waist circumference (WC) was measured using stadiometer (Seca, Hanover, MD, USA) at the mid-point between the lowest rib and pelvic iliac crest. The systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken 3 times at 5-minute intervals and the average of those 3 measurements was incorporated into analyses.

Biochemical analysis

Blood samples were acquired from an antecubital vein of the study subjects after a 12-hour fasting. Red blood cells (RBCs) counts and white blood cells (WBCs) counts were quantified using an automated blood cell counter (ADIVA 120; Bayer, Tarrytown, NY, USA). The level of total blood triglyceride, total cholesterol, high-density lipoprotein (HDL)-cholesterol, serum ferritin, serum free iron, fasting plasma glucose, blood urea nitrogen (BUN), and creatinine were quantified by an automated chemistry analyzer (Hitachi 7000; Hitachi Ltd., Tokyo, Japan).

Life style questionnaire

Health interviews including life styles of subjects were conducted. Responses to household income were comprised of 4 categories (1st quartile: below 70,710 thousands won, 2nd quartile: 70,710 to 147,310 thousands won, 3rd quartile: 147,310 to 240,560 thousands won, 4th quartile: more than 240,560 thousands won based on 2012 data). The presence of depression was asked and the degree of mental stress recognition was valued in 4 different scales (1: very often, 2: often, 3: sometimes, 4: rarely). For measurement of physical activity of subjects, the frequency of conducting exercise with mild or moderate strength and hours of the exercise per occasion were recorded. Dietary style and environment such as frequency of dining-out, food security (availability of food on demand), experience of attending nutrition education, and the status of breakfast consumption were investigated through the questionnaire developed by KCDC [22].

Dietary analysis

Nutrient intakes were assessed with a 24-hour dietary recall questionnaire administered by a trained survey researcher. Total energy consumption, intake of carbohydrate, protein, fat, vitamins, and minerals were calculated using the food composition tables developed by the National Rural Resources Development Institute (7th revision) [23]. Also, amount of daily food consumption was analyzed according to different food groups. Due to incomplete record in subjects with ADHD, food frequency data was not utilized in this study.

Statistical analysis

All statistical analyses were conducted using SAS software version 9.3 (SAS Institute Inc., Cary, NC, USA). Values were expressed as mean and standard error for continuous variables or percentages for categorical variables. Elements of stratified multistage sampling (strata, clusters, and weights) were included in the statistical analysis. For the comparison between overweight ADHD group and normal weight ADHD group, the t-test was performed for continuous variables and the Rao-Scott χ^2 test was used for categorical variables. Also, for comparison of both continuous and categorical variables between 2 ADHD groups, the weighting of data was performed by the guideline of statistics from the KCDC. Statistical significance of data was declared at a p value of less than 0.05.

https://doi.org/10.7762/cnr.2017.6.2.112

RESULTS

Anthropometric measurement of ADHD children and adolescents

Anthropometric data of ADHD youths are presented in **Table 1**. The values of body weight and WC of overweight ADHD group were significantly higher than those of normal weight ADHD group. SBP ($p < 0.001$) and DBP ($p = 0.001$) were higher in overweight ADHD subjects than those in normal weight ADHD group. Age distribution of the subjects and the value of height were not different between 2 groups.

Biochemical data

The level of fasting glucose was not significantly different between normal weight group and overweight group in ADHD youths (**Table 2**). The amount of total triglycerides was significantly higher in overweight ADHD group than in normal weight ADHD group. The mean value of total cholesterol was higher in overweight subjects compared to that in normal weight subjects but the difference between groups was not statistically significant. The levels of hematocrit, hemoglobin, RBC counts in overweight youth were slightly (less than 8%) but significantly higher than those in normal weight group. However, the mean value of ferritin was 18.8% lower in overweight ADHD group compared to normal weight ADHD group but the difference was not significant. Level of blood creatinine was 18.6% higher in overweight ADHD youths ($p = 0.026$) than that in normal weight ADHD youths.

Characteristics of health habit and life environment

The categorical level of household income between 2 groups was not significantly different. Distribution of subjects' responses to frequency of dining-out, compliance of eating breakfast, experience of nutrition education was not significantly different between 2 groups (**Table 3**). However, more numbers of overweight ADHD subjects were under sufficient food

Table 1. Anthropometric measurements in ADHD children and adolescents

Variables	Normal*	Overweight†	p value
Age, yr	12.2 ± 0.4	13.1 ± 0.9	0.319
Weight, kg	43.0 ± 1.5	64.4 ± 4.5	< 0.001
WC, cm	63.0 ± 1.0	80.9 ± 2.1	< 0.001
Height, cm	152.7 ± 2.1	157.1 ± 3.4	0.280
SBP, mmHg	103.2 ± 1.8	116.7 ± 3.0	< 0.001
DBP, mmHg	64.0 ± 1.3	75.2 ± 3.4	0.001

WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure.
*n = 55. †n = 21.

Table 2. Biochemical analysis in ADHD children and adolescents

Indicators	Normal*	Overweight†	p value
BUN, mg/dL	12.6 ± 0.7	12.6 ± 1.0	0.993
Cholesterol, mg/dL	154.0 ± 5.3	163.1 ± 4.1	0.172
Creatinine, mg/dL	0.70 ± 0.03	0.83 ± 0.05	0.026
Fasting glucose, mg/dL	87.8 ± 1.2	92.0 ± 2.5	0.124
Fe, mg	115.7 ± 7.2	129.8 ± 31.8	0.665
Ferritin, ng/mL	59.0 ± 13.1	47.9 ± 10.5	0.509
HDL, mg/dL	52.3 ± 2.6	47.6 ± 2.2	0.171
RBC, $\times 10^6$/uL	4.8 ± 0.1	5.2 ± 0.1	0.002
TG, mg/dL	79.4 ± 14.9	131.2 ± 21.8	0.049
WBC, $\times 10^3$/uL	6.4 ± 0.3	7.0 ± 0.4	0.231

BUN, blood urea nitrogen; Fe, serum free iron; HDL, high-density lipoprotein; RBC, red blood cell; TG, triglyceride; WBC, white blood cell.
*n = 55. †n = 21.

https://doi.org/10.7762/cnr.2017.6.2.112

Table 3. Characteristics of health habit and life environment in ADHD children and adolescents

Characteristics	Normal*	Overweight†	p value
Household income (the level of quartile)	2.9 ± 0.1	2.8 ± 0.3	0.742
Frequency of dining out			0.809
At least 1 time per day	69.4 ± 7.9	65.9 ± 12.6	
Less than 1 time per day	30.6 ± 7.9	34.1 ± 12.6	
Food security, %			0.019
Sufficient supply of food	38.0 ± 7.7	69.8 ± 11.0	
Not sufficient enough to fill up	62.0 ± 7.7	30.2 ± 11.0	
Eating breakfast, %			0.145
Yes	94.7 ± 5.1	75.6 ± 16.0	
No	5.3 ± 5.1	24.4 ± 16.0	
Experience of nutrition education, %			0.915
Yes	25.4 ± 5.6	23.9 ± 12.1	
No	74.6 ± 5.6	76.1 ± 12.1	
Frequency of physical activity with mild strength, %‡			0.436
Less than 2 days per week	34.6 ± 7.7	24.4 ± 10.1	
At least 2 days per week	65.4 ± 7.7	75.6 ± 10.1	
Frequency of physical activity with moderate strength, %§			0.002
Less than 2 days per week	67.8 ± 7.7	28.7 ± 10.8	
At least 2 days per week	32.2 ± 7.7	71.3 ± 10.8	
Sum of duration in physical activity¶	35.00 ± 1.42	32.70 ± 1.32	0.105
Recognition for mental stress, %			0.682
Yes	68.7 ± 12.5	78.2 ± 19.0	
No	31.3 ± 12.5	21.8 ± 19.0	

*n = 52. †n = 17. ‡,§Weekly incidence of physical activity with moderate and mild strength including walking. ¶Hours of duration per incidence of physical activity.

supply on demand compared to normal weight ADHD subjects (p = 0.019). Overweight ADHD subjects had more responses on doing moderate strength exercise at least 2 days per week than normal weight subjects did. Frequency of physical activity with mild strength and the duration of total physical activity were not significantly different between 2 groups. Both group showed similar pattern of responses to the recognition for mental stress. About 70% or more percent of ADHD subjects recognized mental stresses.

Analysis of nutrient intake in ADHD children and adolescents

Nutrient intakes of both overweight and normal weight ADHD subjects are shown in **Table 4**. Intake of total energy and energy-producing nutrients including protein, fat, and carbohydrate was not significantly different between overweight and normal weight groups. When those nutrients intakes were normalized to total energy intake, fat consumption of overweight ADHD group was 12.5% higher than that of normal weight ADHD group (p = 0.019). Intake of iron in overweight group was 23.9% less than normal weight group (p = 0.023). Other than iron intake, the status of other nutrients intake including vitamins and minerals was not significantly different between normal weight and overweight ADHD subjects.

DISCUSSION

In this study, BMI of ADHD youths was correlated with their age (p < 0.001, data not shown) and the assigning subject into one of 2 groups (overweight vs. normal weight) was performed based on the growth reference which already had adjusted sex and age of subjects. Hence, those factors (age, sex, BMI, and body weights) were not adjusted for the analysis throughout the study. This study showed that there was no significant difference in total energy intake between overweight and normal weight ADHD subjects but the portion of fat intake relative to total calorie intake was significantly higher in overweight ADHD subjects. Such findings

https://doi.org/10.7762/cnr.2017.6.2.112

Table 4. Nutrient intake in ADHD children and adolescents

Nutrients	Normal*	Overweight†	p value
Energy, kcal	2,103.6 ± 130.6‡	2,163.2 ± 182.2	0.501
Water, g	952.7 ± 84.0	966.5 ± 108.5	0.424
Protein, g	78.3 ± 7.6	70.2 ± 5.2	0.714
Fat, g	54.9 ± 5.6	57.2 ± 4.7	0.262
Carbohydrate, g	327.8 ± 17.5	338.1 ± 33.2	0.618
Fiber, g	5.20 ± 0.47	6.30 ± 1.60	0.490
Ash, g	16.5 ± 1.0	16.4 ± 1.6	0.852
Calcium, mg	568.2 ± 58.3	512.5 ± 76.7	0.575
Sodium, mg	3,830.6 ± 312.2	3,622.3 ± 356.3	0.495
Phosphorus, mg	1,180.9 ± 81.6	1,160.9 ± 101.5	0.665
Fe, mg	13.4 ± 1.1	10.2 ± 0.9	0.023
Potassium, mg	2,760.1 ± 214.2	2,520.6 ± 250.5	0.719
Thiamin, mg	1.6 ± 0.1	1.7 ± 0.2	0.466
Vitamin C, mg	106.3 ± 18.5	99.4 ± 24.5	0.677
Vitamin A, μgRE	662.1 ± 82.7	619.4 ± 129.3	0.538
Carotene, μg	2,711.4 ± 454.7	2,438.7 ± 616.9	0.360
Retinol, μg	78.7 ± 23.8	156.5 ± 20.9	0.725
Riboflavin, mg	1.5 ± 0.1	1.6 ± 0.2	0.448
Niacin, mg	14.9 ± 1.5	16.2 ± 1.9	0.756
Protein, %	3.6 ± 0.2	3.3 ± 0.1	0.255
Fat, %	2.4 ± 0.1	2.7 ± 0.1	0.019
Carbohydrate, %	16.1 ± 0.4	15.3 ± 0.4	0.618

ADHD, attention deficit hyperactivity disorder; Fe, serum free iron.
*n = 55. †n = 21. ‡Values are adjusted to the total energy intake.

further support the observation that significantly higher level of total blood triglycerides was shown in overweight ADHD groups without a change of other types of blood lipids (i.e., cholesterols or HDL) or fasting glucose. Additionally, the intake of iron in overweight ADHD group was significantly less than those in normal weight group.

Increased consumption of total energy and energy-producing nutrients are main characteristics of obese subjects [13,19]. The overweight subjects in this study, however, did not show any differences in total energy intake compared to normal weight group, indicating that the consumption amount of foods or nutrients was similar in these ADHD youths regardless of their body weight. Such results were somewhat different with findings in previous studies comparing the nutrition intake between obese/overweight and normal weight people [14,16,19,24]. Many studies reported that overweight children and adolescents tend to consume more energy than normal weight subjects [19,24]. Furthermore, when we compared the energy intake of ADHD subjects to 2015 Dietary Reference Intake for Koreans (KDRI), energy intake of ADHD tend to be in normal range (data not shown). On the other hand, the ratio of fat consumption to the total calorie intake was higher in overweight subjects compared to that in normal weight subjects and such a result still supports the relationship between obesity and the type of nutrients consumed regardless of their total energy intake. Increased fat consumption was reflected by an increased level total blood pressure (both SBP and DBP) and total blood triglycerides in overweight ADHD subjects although we cannot differentiate the causal effect relationship between fat consumption and total blood triglycerides levels in this study.

One of the interesting findings in this study was the difference in iron intake between overweight and normal weight ADHD subjects. Compared to 2015 KDRI [25], the iron intake of normal weight subjects was in normal range of the reference intake. However, intake amount of iron in overweight ADHD subjects was only two third level of the reference intake in this study. Although the statistical significance was not detected due to small sample size

https://doi.org/10.7762/cnr.2017.6.2.112

and large variation, the level of serum ferritin in overweight ADHD subjects were less than in normal weight subjects. Previous studies suggested that iron deficiency plays a certain role in development of ADHD symptoms, obesity and obesity with ADHD [7,12,26]. In a study with children and adolescents enrolled in endocrine center in Israel, the increased prevalence of iron deficiency was reported in obese or overweight subjects (50.9%) compared to normal weight subjects (4.4%) [26]. Iron status affects the symptoms of ADHD since the iron is the cofactor of enzymes for neurotransmitter synthesis and dopamine transporters [27,28]. Iron deficiency was also associated with dysfunction and abnormal structure of ganglia which reflected by restless legs syndrome during the rest [8]. Recently, a systemic review about the relationship among iron deficiency, obesity and ADHD proposed the relationship between elevated prevalence of obesity and iron deficiency in ADHD [12]. According to their hypothesis, since the obesity induces chronic inflammatory status and the alteration of iron-regulatory proteins (e.g. hepcidin), the obesity consequently leads to iron deficiency [12,29]. Hence such conditions may aggravate neurophysiological function in ADHD subjects. However, those previous studies mostly assessed a serum ferritin level as a main laboratory measure of iron status. So iron supply has not been considered in their findings and the mechanism how iron status affects obesity or ADHD has been still unknown. Nevertheless, our results provide the possibility that decreased iron consumption is related to ADHD or the exacerbation of ADHD related comorbidity including obesity. Though the 24 h-recall data could have biases in reflecting the dietary status of study subjects so far the 24 h-recall analysis is only reliable method for identifying the micro-mineral intake of subjects in most observational and epidemiological studies [30]. Identifying the several indicators of systemic iron level and time lapse measurement of iron intake are warranted for future observational or clinical study.

In addition to nutrient consumption, the types of food eaten by the subjects contribute the development of obesity. Except for the vegetable intake, food types were not significantly different between normal weight and overweight ADHD subjects (**Table 5**). Tendency of decreased vegetable consumption ($p = 0.055$) in overweight ADHD subjects is consistent with increased levels of SBP and DBP and total blood triglycerides. Since vegetables are rich in dietary fibers and potassium which counteract high fat or sodium many evidences support the benefit of vegetable intake in lowering blood pressure and blood lipids [14,31]. In the analysis of the dietary habit, overweight ADHD subjects had more food supply on demand compared to normal weight subjects had. Status of dietary habit and environment such as frequency of dining-out, frequency of eating breakfast, experience of nutrition education were not significantly different between overweight and normal weight groups. Additionally, no clue was found in consumption of meat (**Table 5**) or milk products (data not shown) to support the difference in iron intake between overweight and normal weight ADHD. Previous studies indicated that ADHD children and adolescents addicted to high-sugar consumption through

Table 5. Amount of food consumption according to major food groups in ADHD children and adolescents

Food groups	Normal*	Overweight†	p value
Cereal, g	344.5 ± 192.9‡	273.7 ± 202.2	0.199
Potato, g	25.5 ± 42.1	29.6 ± 101.4	0.408
Sugar, g	8.3 ± 10.2	8.5 ± 15.6	0.290
Vegetable, g	202.9 ± 232.9	173.8 ± 207.9	0.055
Fruit, g	198.3 ± 290.9	132.2 ± 279.5	0.875
Plant fat, g	6.9 ± 5.8	6.5 ± 9.2	0.575
Animal fat, g	0.2 ± 0.5	0.1 ± 0.4	0.456
Seaweed, g	12.2 ± 45.6	4.0 ± 20.0	0.550
Meat, g	131.9 ± 94.2	95.0 ± 147.7	0.487

*n = 55. †n = 21. ‡Values are adjusted to the total energy intake.

https://doi.org/10.7762/cnr.2017.6.2.112

the intake of soft drink, ice-cream, and high-sugar contained cookies [4,18,21]. However, we could not find the difference in total sugar consumption between overweight and normal weight ADHD subjects. Recently, studies suggest that the hydration status not only help the performance of cognition in 9–12 year-old children but also help the alleviation of weight gain in overweight children [32,33]. In this study, we could not find the difference in water consumption between overweight and normal weight subjects. Also, the amount of water consumption of all ADHD subjects in this study was 40%–50% of KDRI, indicating being water-deficient. But this value of water consumption in ADHD subjects is not far different from the water consumption amounts reported in healthy Korean adolescents [15,20]. Taken together no ADHD specific food consumption pattern for obesity was found in this study.

Other than dietary factors, there were no remarkable differences in physical activity and the recognition of mental stress between overweight ADHD subjects and normal weight subjects. As expected over 70% of both overweight and normal weight ADHD subjects recognized mental stress, a typical symptom of ADHD [34], in this study. Overweight ADHD subjects did more physical activity with moderate strength than normal weight ADHD subjects did. However, the occurrence of physical activity with mild strength and the time duration of total physical activities were not different between 2 groups. Usually children or adolescents with ADHD tend to show different physical movement pattern than normal healthy children and adolescents in the same age [3]. So the higher frequency of moderate-strength physical activity shown in overweight ADHD subjects may be from the typical "hyperactivity" of ADHD subjects in certain occasion rather than from the physical movement for weight loss.

This study provided health characteristics and nutrition status of ADHD subjects by grouping them as overweight and normal weight. Overweight ADHD subjects showed higher levels of blood pressure and total triglycerides with higher fat consumption compared to normal weight ADHD subjects. Overweight ADHD subjects consumed less amount of iron than normal weight subjects did. Low iron consumption and body iron status may be associated with obesity and cognitive/metal status of ADHD. However, these characteristics were somewhat overlapped in neurologically and mentally healthy overweight/obese children and adolescents. In this study, only small numbers of study subjects were analyzed in spite of pooling 8 years-long accumulated National Health and Nutrition Examination Survey (NHANES) data. Also, inclusion criteria of the study were restricted to the subjects who were diagnosed with "ADHD" from physician. So we may see different aspects of physiological and nutrition status in children and adolescents who have mild ADHD symptoms without physician's diagnosis and there would be a limitation to apply the finding of this study to children and adolescents with mild ADHD symptoms or acute tendency of hyperactivity. Another limitation of this study is that the characteristics of ADHD subjects could not be compared with those of normal subjects. Therefore, a case-control study design is necessary for future study to support that the findings in this study is specific to ADHD.

CONCLUSION

This study was performed to investigate the health and nutritional status in Korean ADHD children and adolescents according to the degree of obesity (overweight vs. normal weight). Like other healthy children and adolescents, overweight ADHD subjects had increased levels of abdominal fat, blood pressure, and total triglycerides with higher fat consumption. Also, the low iron consumption in overweight ADHD subjects compared to that in normal weight

https://doi.org/10.7762/cnr.2017.6.2.112

ADHD subjects implicates a possible relationship between iron status and obesity in ADHD subjects. However, further study with controlled subjects for ADHD subjects is necessary to support such findings and to investigate the ADHD specific association of obesity, nutrient intake, and cognitive/mental status.

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