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Original article

Association of the Relationship Between Nutritional Status and Certain Biochemical Parameters in Obese Children

Dilek Ozcelik-Ersu[1], *Gul Kızıltan*[2]

[1]Department of Nutrition and Dietetics, Istanbul Arel University School of Health Sciences, Istanbul, Turkey; [2]Department of Nutrition and Dietetics, Baskent University School of Health Sciences, Ankara, Turkey

Abstract. The prevalence of childhood obesity is increasing globally. Adiposity is more concentrated in subcutaneous tissue in women and visceral fat tissue in men. Abdominal obesity is more commonly associated with metabolic diseases in men. The results showed that the mean BMIz scores of boys was higher than girls, but total body fat was lower than girls. Total body fat free mass, water and muscle mass were higher in boys than girls. It was determined that children aged 10-17 years consumed fatty and sugary snacks and sugary drinks at school. Food consumption containing the carbohydrate, fat, saturated fat and cholesterol were higher in boys than girls. As a result, it was thought that it would be more beneficial and reliable to use anthropometric methods showing body composition together with BMI zscore while evaluating body weight in adolescents. While nutritional counseling, it may be beneficial to consider that the energy and nutrient requirements of male adolescent individuals and their daily food consumption are higher than girls. When the results of the study are evaluated, we mention that it would be appropriate to evaluate girls more carefully in terms of iron deficiency anemia and diseases such as insulin resistance and diabetes.

Key words: Nutritional status, gender, childhood obesity, adolescent nutrition

Introduction

The prevalence of obesity in infants, children and adolescents is increasing globally. Many pre-obese children who are not yet obese have the risk of becoming obese (1). Childhood obesity causes insulin resistance, type 2 DM, hypertension, hyperlipidemia, liver and kidney diseases, reproductive disorders. Furthermore, it increases the risks of obesity and cardiovascular disease in adulthood and negatively affects social, educational and economic efficiency (2). Despite the increasing prevalence of obesity in children, the importance and consequences of childhood obesity can be overlooked, especially in countries where malnutrition is common (1).

Environmental effects and genetic variations cause inter-communal differences in the frequency of obesity. It has been suggested that this is caused by the interaction of irreversible genetic and modifiable environmental factors (3).

Children gain eating habits by observing their families. Therefore, one or both of the parents being overweight or obese may be an important risk factor for the development of childhood obesity (4). The income and education level of the family, the working status of the parents, the types of food that the family consumes and the methods of cooking can also affect the body weight of children (5).

In obesity, hyperplasia and hypertrophy of adiposides cause an increase in adipose tissue. obesity, hyperplasia and hypertrophy of adiposides cause an increase in adipose tissue and the release of free fatty acids and proinflammatory cytokines increases adipose dysfunction. Also obesity is associated with increased cell

hypoxia and impaired insulin sensitivity (3). Although adipose tissue's main role is to store energy in the form of fat, it is also now accepted as an endocrine organ which is secreting signaling molecules and hormones that regulate metabolic homeostasis (6). Increased adipose tissue may cause an increased risk of cardiovascular disease (associated hyperglycemia, dyslipidemia), hypertension and non-alcoholic fatty liver disease in obese children. These health problems that start in childhood are likely to be more severe in adulthood (3). Childhood obesity reduces academic achievement in children and prevents children from physical, social and psychological well-being. childhood obesity is an important and preventable risk factor for adult obesity and noncommunicable diseases (1).

Fat distribution in all mammals and humans differences by gender. Adipose tissue is more concentrated in subcutaneous tissue in women and visceral fat tissue in men. Abdominal obesity is more commonly associated with metabolic diseases in men (7). The aim of this study is to examine the relationship between nutritional status and biochemical parameters in obese children.

Materials and Methods

Subject Population and Recruitment

We conducted a descriptive and cross-sectional study. The cohort consisted of from the doctoral thesis entitled "Determination of the relationship between obesity and nutrition ın children and adolescents and kidney and liver functions" (8). Data were collected between February and August 2014. We included 93 children which were obese (39 male and 54 female) in this study. Their median age was 12 (min:10-max:17). Each patient's weight and height were obtained, and their z-score was calculated by using World Health Organisation (WHO) AnthroPlus software (9). And also their body composition was obtained with bioelectrical impedance analysis.

Data Collection and Measures

Food frequency questionnaire was used to determine the frequency of food consumptions of the children. Also daily energy and nutrient intakes were determined by a 24 hours food records and evaluated by "Nutrition Information Systems Package Program (BEBIS)" (10).

In the classification of obesity in children and adolescents, percentile and / or z-score values were used. In 2007, the World Health Organization published growth reference values for children and adolescents aged 5-19 (11). Thus, nowadays BMI values in children and adolescents have been used to classify obesity. According to these tables proposed by WHO for the classification of obesity in children and adolescents; Children and adolescents in the 5-19 age group;

Overweight > +1 Sd or > 85th percentile, (19 years old BMI: equal to 25 kg / m2 value)

Obesity is defined as > +2 Sd or > 97th percentile (BMI of 19 years old: equal to 30 kg / m2).

The levels of Thyroid Stimulating Hormone (TSH), Free Thyroxine (FT_4), total cholesterol, Low Density Lipoprotein cholesterol (LDL-C), High Density Lipoprotein cholesterol (HDL-C), triglycerides, Aspartate transaminase (AST), alanine transaminase (ALT), Hemoglobin, Hematocrite, Blood Urea Nitrogen (BUN), Creatinine, uric acid, sodium, potassium, phosphorus, calcium, iron, Iron Binding Capacity, 25-hydroxyvitamin D (25 OH vit D), fasting blood glucose, fasting insülin, The homeostatic model assessment of Insulin resistant (HOMA IR), C-reactive protein (CRP), sedimentation 1_{st} hour, sedimentation 2_{nd} hour were evaluated. The exclusion criterias of this study were as follows: age less than 10 and more than 17, current history of inflammatory, infectious and malignant diseases, follow-up diet clinic patients, having chronical disease and eating disorders diagnosed except obesity.

Statistical Analysis

Spss 17 statistical package program was used for the data analysis. Descriptive statistical methods were used to explain children's characteristics in data evaluation. Parametric methods were used for variables with normal distribution, and non-parametric statistical methods were used for data with normal distribution. The normality was tested with Kolmogorov Smirnov test. Data were expressed as the mean value ± standard deviation (Sd) for the homogeneity and the median (min-max)

for the nonhomogeneity. The differences between the female and male children were tested using the parametric tests for homogeneous data and nonparametric tests for nonhomogeneous data. Correlation between the different parameters was tested by Pearson test. P values below 0.05 were considered statistically significant.

Ethical Considerations

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Ethics Committee of Istanbul Health Sciences University Zeynep Kamil Maternity and Children Hospital (decision dated 24/01/2014 and numbered 17). Written informed consent was obtained from all subjects/patients.

Results

Results for General Properties

Fifty-four (58.1%) female and 39 (41.9%) male subjects were included in the study. Approximately one-third (30.1%) of the children had obesity in both parents and approximately half (46.3%) of them had at least one of their parents.

While total body fat mass and total body fat percentage were found to be higher in girls than boys, total lean body mass, total muscle mass, total body water and total body water percentage were higher in girls than boys (Table 1).

Table 2 shows the energy and macro nutrients intake by gender and Table 3 shows the mean ± standard deviation and median (min-max) values of biochemical parameters by gender.

Results of the Relationship Between Biochemical Parameters and Energy and Macro Nutrients

There was a negative weak correlation between dietary animal source protein consumption and total protein percentage and iron binding capacity ($r = -0.282$, $p = 0.006$ and $r = -0.265$, $p = 0.010$, respectively). Also, a positive weak correlation was found between total protein percentage and serum iron levels ($r = 0.229$, $p = 0.027$).

The correlation was investigated between lipid profile (total cholesterol, LDL cholesterol, HDL cholesterol and triglyceride) and dietary fat intake (saturated, n-3, n-6, n-3 / n-6) and fiber (total, soluble,

Table 1. Anthropometric properties of children by gender

Variables	Female (n:54)	Male (n:39)	
	Mean±Sd	Mean±Sd	p[e]
Age (year)	12,4±2,1	12,2±1,4	0,470
Height (cm)	155,9±8	157,3±10	0,457
Weight (kg)	75,5±16,4	72,3±13,7	0,329
z-score (BMI for age)	2,7±0,5	2,8±0,5	0,627
z-score (Height for age)	0,5±1	0,5±0,9	0,926
Total body fat percentage (%)	40,8±4,6	33,9±5,7	0,000*
Total body fat mass (kg)	31,4±10,2	24,6±7,1	0,000*
Total body fat free mass (kg)	44,1±6,8	47,7±9,2	0,032*
Total body muscle mass (kg)	41,8±6,5	45,2±8,8	0,034*
Total body water (kg)	32,3±5	34,9±6,7	0,033*
Total body water percentage (%)	43,3±3,4	48,4±4,2	0,000*

[e]Independent Samples T Test (Student T Test)
* p<0,05

Table 2. Energy and macro nutrient consumption of children by gender

Variables	Female (n:54)	Male (n:39)	p
	Mean±Sd / Median (min-max)	Mean±Sd / Median (min-max)	
Energy (kcal)	1802,9 (737,9-4024,5)	2554,2 (1336,9-8744,6)	0,000**
Protein (%)	16,5 (12-25)	17 (11-28)	0,925
Protein (g)	74,1 (33-151,8)	101,6 (45-373,6)	0,001**
Plant based protein (g)	27,6 (9,4-101,5)	33,8 (10,8-272,8)	0,009**
Fat (%)	32 (19-28)	31 (21-31)	0,978
Fat (g)	65,7 (31,7-144,9)	90,9 (43,1-292,7)	0,000**
CHO (g)	229,2 (67,2-519,5)	285,1 (130,9-1230)	0,007**
CHO (%)	52 (30-67)	52 (20-66)	0,991
Fiber (g)	21,1 (7,8-72,4)	27,7 (11,8-187,1)	0,030**
Water soluble fiber (g)	5,9 (2,3-21,1)	7,9 (2,6-55,6)	0,043**
Water unsoluble fiber (g)	12,6 (4,8-48,6)	14,8 (5,3-131,6)	0,204**
SFA (g)	24 (9,4-53,6)	30,9 (14-86)	0,004**
SFA (%)*	36±6,9	33,1±5,9	0,035*
MUFA (%)	32,8 (5,6-32,3)	33,7 (21,4-43,2)	0,350
MUFA (g)	21,3 (10,7-52,4)	29,9 (13,9-104,2)	0,000**
PUFA (%)*	19,8±4,9	20,4±5,2	0,628*
PUFA (g)	12,9 (5,6-32,3)	16,7 (6,2-71,39	0,001**
Cholesterol (mg)	282,1 (85,1-805,1)	351,1 (63,5-1261,6)	0,005**
n-3 (g)	1,7 (0,5-4,4)	2,3 (1-14,3)	0,001**
n-6 (g)	9,9 (2,3-24,7)	11,9 (3-57)	0,027**
n-3/n-6*	0,1±0,0	0,2±0,0	0,046*

* Independent Samples T Test (Student T Test)
** Mann-Whitney U Test

insoluble). There were no significant relationship was observed (p> 0.05).

Fasting blood sugar, fasting insulin levels and HOMA IR values were not found to be significantly correlated with carbohydrate (total amount, percentage, fiber) and monosaccharide consumption (p> 0.05). However, the mean rank of monosaccharide consumption (mean rank: 50.39) was higher in children with HOMA IR value of ≥ 2.5 than those with a HOMA IR value of < 2.5 (mean rank: 35.38) (p = 0.025).

Discussion

In 2016, more than 340 million children and adolescents aged 5-19 were overweight or obese, according to the World Health Organization (12). In Turkey, while the percentage of overweight and obesity in 2013 is 23.3% in boys and 21.6% in girls (13). It has increased in 2016 to 24.9% in boys and 24.2% in girls (14). In the study, we included only obese children and aimed to evaluate whether there is a difference between male and female individuals in terms of nutritional status and some biochemical values.

There is a strong relationship between the prevalence of obesity in childhood and genetic factors. The risk of childhood obesity increases 2-3 times when one parent is obese and 15 times when both are obese (15). In addition, feeding habits and obesity in children are also related to parental feeding style (16). In this study, at least one of the parents of 76.4% of the children was obese. Although BMIz score is sensitive to

Table 3. Biochemical parameters of children by gender

Variables	Female (n:54)	Male (n:39)	p
	Mean±Sd / Median (min-max)	Mean±Sd / Median (min-max)	
TSH (mU/L)	1,9 (0,1-6,2)	2,9 (0,7-1,5)	0,004**
FT4 (ng/L)	1,1 (0,7-1,5)	1,0 (0,8-17,8)	0,752**
Total cholesterol (mg/dL)*	174,8±32,4	176,3±31,0	0,825*
HDL cholesterol (mg/dL)	46,5 (26,6-78,6)	45 (34-78)	0,197**
LDL cholesterol (mg/dL)*	102,0±24,6	109,6±33,0	0,212*
Triglyceride(mg/dL)	100,3 (55,0-937,5)	107,0 (46,0-334,0)	0,405**
AST (U/L)	20,2 (11,0-55,0)	23,0 (10,0-99,0)	0,023**
ALT (U/L)	18,3 (8,1-99,0)	21,0 (13,0-97,0)	0,044**
Hemoglobin (g/L)*	12,9±1,1	13,6±1,0	0,002*
Hemotocrite (%)	38,7 (26,1-43,8)	40,5 (35,4-50)	0,006**
BUN (mg/dL)	9,1 (5,4-13,5)	11,1 (6,7-32,0)	0,001**
Creatinin (mg/dL)*	0,5±0,1	0,6±0,1	0,264*
Uric acid (mg/dL)*	5,5±1,0	5,0±1,4	0,088*
Sodium (mmol/L)	139 (135,2-145,3)	139 (134,9-146)	0,749**
Potassium (mmol/L)*	4,8±0,4	4,7±0,3	0,198*
Phosphorus (mmol/L)	4,5 (3,6-6,4)	4,9 (3,8-8,9)	0,121**
Calcium (mmol/L)	10,3 (9,0-11,5)	10,3 (9,1-10,8)	0,981**
Iron (serum) (mcg/dL)	56,2 (15-192,1)	66,2 (21-137)	0,012**
Iron binding capacity (mcg/dL)*	367,5±58,7	335,2±62,3	0,013*
25 OH vit D (ng/dL)*	10,9±4,8	14,4±6,5	0,004*
Fasting blood sugar (mg/dL)	89,1 (76-161,4)	91,0 (79-111,0)	0,073**
fasting blood insulin (mU/L)	20,9 (4,2-79,7)	12,7 (3,3-44,1)	0,001**
HOMA IR	4,8 (0,8-16,7)	2,8 (0,8-11,8)	0,001**
CRP (mg/dL)	0,3 (0,0-5,9)	0,3 (0,0-3,3)	0,151**
Sedimantation 1. st hour (mm/h)	17,5 (4,0-96,0)	13,0 (1,0-46,0)	0,016**
Sedimantation 2. nd hour (mm/h)*	41,4±19,8	31,6±15,3	0,012*

* Independent Samples T Test (Student T Test)
** Mann-Whitney U Test

changes in adiposity, it is a poor indicator of changes in total body fat (% fat). Therefore, it should not be missed when evaluating the body composition of a growing child (17). Vanderwall et al (2017) reported that BMIz score is a strong indicator of total fat mass but a weak indicator of relative body fat in youth (9-18 years) (18). In this study, the mean BMIz scores of boys was higher than girls, but total body fat (% fat & kg) was lower than girls. Total body fat free mass (kg), total body water (kg), and total muscle mass (kg) were higher in boys than girls. We thought that the use of BMIz score only would be insufficient in the evaluation of obesity in adolescent children. Other methods that show body composition should also be evaluated, especially in adolescents.

Increased caloric consumption in the obesogenic environment, sugar-sweetened drinks and snacks, high-fat fast-food, large portion sizes and high-glycemic index of food consumption as a result of increased risk of obesity (19). Since school-age children spend

most of their time at school, they consume most of their daily calories at this time, so the school environment has an impact on the development of obesity (20), (21). It has been reported that low-nutritional, high-calorie-fat foods, sugar and sugar-sweetened beverages are associated with obesity (22). However, it is determined that children and adolescents get 30-40% of their energy from this kind of food and drinks (23). In this study, it was determined that children aged 10-17 years consumed fatty and sugary snacks and sugary drinks at school. We found that 57.4% of girls and 71.8% of boys consumed fruit juice, 59.3% of girls and 74.4% of boys consumed other sugar sweetened beverages once a week. Also 26.1% of girls and 30.8% of boys consumed these drinks every day. In another study conducted in Turkish children (6-10 years), it was found that high BMIz scores were associated with sugar-sweetened beverages consumption, and that all children consumed these kind of drinks, most of them (88.7%) consumed more than 1 time a day and 11.3% of them more than 1 time a day.(24).

The incidence of some diseases (cardiovascular diseases, insulin resistance, musculoskeletal disorders, some cancers) increase in obese children. Therefore, it is very important that infants and young children consume healthy foods. Foods with high levels of fat, sugar and salt contribute to childhood obesity (25). In this study, food consumption containing the carbohydrate (g), fat (g), saturated fat (g) and cholesterol (mg) were higher in boys than girls. Wei-Ting Lin et al. (2016) reported that the consumption of fructose-rich sugary drinks is associated with insulin resistance, which may be partly mediated by central adiposity and serum uric acid (26). There is concern that higher sugar intake is associated with an increased risk of pediatric insulin resistance. 1999-2004 National Health and Nutrition Examination Survey in the United States reported that additional sugar intake in overweight / obese adolescents was positively associated with fasting serum insulin and HOMA-IR(27). According to the results of a multicenter study in Europe, consumption of sugar-sweetened beverages was reported to be associated with higher HOMA-IR among adolescents aged 13-18 (28). In this study, girls' serum uric acid and HOMA-IR levels were higher than boys. In addition, children with HOMA-IR ≥ 2.5 had higher monosaccharide consumption in their diet. Glucose, galactose, fructose are the monosaccharides and found naturally in foods such as fruit, honey, milk and dairy products. Free sugars are all mono-disaccharides added to foods/beverages, and natural sugars found in foods such as honey/syrups/unsweetened fruit juices and fruit juice concentrates. The sugars present in foods such as fresh fruits, unsweetened milk and infant formula are not free sugar. Intake of free sugars should be reduced with a desirable goal of <5% energy intake in children and adolescents aged 2-18 years (29). In this study, 35.2% of girls and 35.9% of boys consumed sugar and sugar sweteened snacks every day.

Serum ferritin concentration is directly related to iron levels in the organism (30) and is the most convenient laboratory test to estimate iron stores (31). Fernando Pizarro et al. (2015) reported that heme iron intake of animal origin increases serum ferritin levels. Similarly, in this study, protein percentage and also animal protein content of the diet and serum ferritin level were positively correlated (32).

As a result, it was thought that it would be more beneficial and reliable to use anthropometric methods showing body composition together with BMI zscore while evaluating body weight in adolescents. While nutritional counseling, it may be beneficial to consider that the energy and nutrient requirements of male adolescent individuals and their daily food consumption are higher than girls. When the results of the study are evaluated, we mention that it would be appropriate to evaluate girls more carefully in terms of iron deficiency anemia and diseases such as insulin resistance and diabetes.

Author Contributions: Dilek Ozcelik-Ersu: Constructing an idea or hypothesis for research and/or manuscript, Providing personnel, tools and place that are vital for the project, Taking responsibility in the construction of the whole or body of the manuscript, Taking responsibility in logical interpretation and presentation of the results, Making statistical analyze. Gul Kızıltan: Constructing an idea or hypothesis for research and/or manuscript, Organising and supervising the course of the project or the article and taking the responsibility.

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Correspondence
Dilek OZCELIK-ERSU
ORCID ID: 0000-0002-0247-5347
İstanbul Arel University School of Health Sciences,
Department of Nutrition and Dietetics,
Cevizlibag– Zeytinburnu 34010 Istanbul-Turkey
Email: dytdilekozcelik@gmail.com