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The prevalence of obesity in adolescent age group and its relationship with dietary habbits, family history, anthropometric measurements and muscle analysis

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ABSTRACT

Objective: The prevalence of obesity is rapidly increasing in adolescents and children. The aim of this study is to investigate the obesity prevalence in the adolescent age group and to identify the relationship between obesity and various anthropometric measurements, as well as muscle strength and nutritional habits.

Methods: A total of 502 male and 99 female students (15-18 years old) in a high school in Beykoz district of Istanbul participated in this study. Anthropometric measurements, handgrip strength and nutritional status were evaluated. Body fat mass (n=601) were determined by bioelectrical impedance analysis (BIA).

Results: 12.4% of males were underweight, 66.2% were normal, 16.7% were overweight, 4.5% were obese and 0.2% were morbidly obese. 18.4% of girls were underweight, 69.4% were normal, 7.1% were overweight, 4.1% obese and 1% morbidly obese. A positive correlation was found between body mass index (BMI) and waist circumference, middle upper arm circumference, and calf circumference. Body fat mass (BFM) measured by BIA was 14.6±6.6% in boys and 24.8±7.6% in girls. It was 29.2% in obese boys and 45.2% in obese girls. There was no correlation between BFM and daily consumed meat, vegetable-fruit, fast food and bread amount. Fast food consumption rate in obese people was 72.9%. Muscle strength was higher in those who consumed meat every day and was inversely correlated with BFM.

Conclusion: Prevalance of overweight and obesity were significant in adolescents. Waist circumference was best predicted obesity. Fast food consumption was common in obese individuals and BFM was inversely correlated with muscle strength.

Keywords: Adolescence, body mass index, muscle strength, obesity

Introduction

The World Health Organization defines obesity as abnormal or excessive fat accumulation that poses a risk to health, and individuals with a body mass index of 30 kg/m^2 and above are considered obese (1). The incidence of obesity is increasing in our country and globally. According to the 2016 data of the Turkish Statistical Institute (TSI), 19.6% of the population aged 15 years and above are obese and 34.3% are overweight (2). Epidemiological studies have shown that demographic factors such as age and sex; socio-cultural factors such as education level and marital status; biological factors and dietary habits; and lifestyle factors such as smoking, alcohol consumption, and lack of physical activity are risk factors for obesity (3).

According to the Turkish Epidemiology Survey of Diabetes, Hypertension, Obesity, and Endocrine Disease (TURDEP-II) in 2010, the prevalence of obesity was 32%. Since the TURDEP-I study was conducted in 1998, the frequencies of diabetes and obesity have increased in Turkey by 90% and 44%, respectively (4). The onset of obesity in 30% of the cases is in childhood period (5). One third of the obese children and 80% of the obese adolescents remain obese when they reach adulthood. Although body mass index (BMI) is used to diagnose obesity in adults, there are different approaches in children and adolescents

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(6). In children and adolescent age group, it is often recommended to use the percentage (percentile) for the individual, and Z score (SD score) for the society (7). Growth reference values were published by the World Health Organization in 2007 for ages between 5–19 years. According to these reference values, it is recommended to use the BMI in the evaluation of overweight and obesity (8, 9).

Fat accumulation in the abdominal region and internal organs is associated with insulin resistance. Insulin resistance is the most important factor influencing the relationship between obesity and Type 2 Diabetes, hypertension, dyslipidemia, and coronary artery diseases (7, 10). For this reason, waist circumference measurements alone can be used in the evaluation of obesity and can predict the risk of those chronic metabolic diseases. Various other anthropometric measurements can be evaluated using bioelectrical impedance analysis (BIA), including body fat amount, fat-free mass, skeletal muscle mass and appendicular skeletal muscle mass. BIA is frequently used to evaluate body composition, as it is easy to apply and can provide a detailed analysis (11, 12).

The aim of this study was to determine the prevalence of obesity among individuals in the adolescent age group and to explore the relationship between obesity and various anthropometric measurements, fat mass, muscle strength, dietary habits and family history.

Methodology

This study was conducted among 15–18-year-old students from a vocational high school in the Beykoz district of Istanbul. Active and volunteer students without any health problems were included in the study. Anthropometric measurements, BIA analysis, muscle strength, nutritional status assessment and dietary habits of 502 male and 99 female students were examined. The measurements were conducted by two nurses and a dietician working in the Istanbul Faculty of Medicine, Clinical Nutrition Team together with 4 doctors working in internship program in Istanbul Faculty of Medicine, Department of Internal Medicine.

Measurement of body composition including bioelectrical impedance analysis (BIA)

Body composition of the adolescents were evaluated by the measurements of weight, height, mid-upper arm and calf circumferences, waist circumference, triceps skinfold thickness and BIA. The mid-upper arm circumference measurement (MUAC, cm) was made at the midpoint of the distance between the shoulder and the elbow. Calf circumference (CC, cm) was made from the thickest parts of both calves. Triceps skinfold thickness (TSF, mm) was measured with a special caliper. For this, the thickness was obtained at the mid-point of the acromion and olecranon, with the arms freely stretched along the body. A fold of the skin was then pinched with the caliper.

BIA is based on the principle of body tissue resistance to low electrical current that can differenciate and measure fat and muscle tissue and body water. In our study, the Tanita (BC 532, Japan) BIA device was used. Due to the analysis patterns for the age 18 years and below, our BIA device could only measured body fat of the participants.

BMI

BMI (kg/m^2) was calculated using the individuals' weight (kg) and height (m). Based on the BMI results, the participants were evaluated as underweight (<18.5 kg/m^2), normal weight (18.5–24.99 kg/m^2), overweight (25–29.99 kg/m^2), obese (30–39.99 kg/m^2), and morbid obese (≥40 kg/m^2) (1).

Z-score

Z-score is a value that allows us to determine the extent to which the numerical data of a sample are either below or above the average. The values of the sample such as the mean, variance, and standard deviation (SD) are needed. To calculate the Z-score, the difference between a value in the sample set and the average is first taken, and the result is then divided by the standard deviation. The Z-score is used to determine by how many standard deviations the sample is above or below the mean (10, 11). In our study, overweight was accepted as a z-score >+1 SD or >85th percentile, and obesity as a z-score >+2 SD or >97th percentile in children aged 5-19 years and adolescents.

Mid-arm Muscle Area (MAMA)

MAMA (cm^2) was calculated with the following formula; (MUAC - ʌTSF)^2/4ʌ-10 for boys and (MUAC - ʌTSF)^2/4ʌ-6.5 for girls (13).

Hand muscle strength

Jamar (USA) hand dynamometer was used to measure the hand muscle strength. Three measurements were obtained from the dominant hand, and the highest value was recorded for each patient.

Statistical analysis

The data obtained from the study were analyzed using IBM Statistical Packag for the Social Sciences (IBM SPSS Corp.; Armonk, NY, USA) version 21.0. Descriptive statistics including the mean, standard deviation, minimum, maximum, median, 25th and 75th percentile, and ratio and frequency values were used. Categorical variables were compared using the chi-square test. The means and medians of the variables were compared using the Mann-Whitney U test,

Student's T-test, and Wilcoxon test. A p value below 0.05 was considered significant. The study was approved by the Istanbul Medical Faculty Ethics Committee (1563/2013).

Results

A total of 601 adolescents (mean age: 15.8±0.9 years) were included in the study (502 boys: 83% and 99 girls: 17%). Anthropometric measurements, hand muscle grip strength and body fat ratio results of the participants were shown in Table 1. Table 2 showed the distribution of boys and girls according to BMI and Z-score measurements. According to this assessment, 62 (12.4%) boys were underweight, 332 (66.2%) were of normal weight, 84 (16.7%) were overweight, 23 (4.5%) were obese, and 1 (0.2%) was morbid obese. Eighteen (18.4%) girls were underweight, 69 (69.4%) were of normal weight, 7 were overweight (7.1%), 4 were obese (4.1%), and 1 (1%) was morbid obese.

According to food consumption habits, 165 individuals (27.4%; 29.4% of boys, 17.2% of girls) consumed meat and 573 individuals (95.3%; 95.4% of boys, 94.9% of girls) consumed vegetables and fruits every day. 507 participants (84.3%) had 3 or more meals in a day. The number of individuals who consumed 'fast food' every day was 473 (78.7%; 77.4% of boys and 84.8% of girls). The average daily bread consumption was 11.0±7.8 slice for boys and 6.4±3.8 slices for girls (Table 3).

The family history of overweight individuals showed that, mothers of 132 individuals (21.9%), fathers of 168 individuals (27.9%), and siblings of 52 individuals (8.7%) were overweight or obese. In addition, 182 individuals (30.3%) had diabetic family members. A significant relationship was found between BMI and the presence of overweight mothers (p=0.002) and overweight siblings (p<0.001). There was no significant relationship between BMI and the presence of diabetic individuals in the family (p=0.17).

BMI showed a significant positive correlation with MUAC, CC, and waist circumference (p<0.001). The highest positive correlation was found with waist circumference (p<0.001, r=0.909) (Table 4). The body fat ratio (BFR) measured with BIA was 14.6±6.6% in boys and 24.8±7.6% in

Table 1. Anthropometric measurements, hand muscle strength, and body-fat ratio values in volunteer individuals

	Male students (n=502) Mean±SD	Female students (n=99) Mean±SD	Total (n=601) Mean±SD
Height (cm)	172.4±6.9	160.8±7.0	170.5±8.2
Weight (kg) (min-max)	66.7±13.3 (38.1-116.6)	56.6±12.1 (35.8-119.3)	65.0±13.7 (35.8-119.3)
BMI (kg/m^2) (min-max)	22.4±3.9 (14.5-40.6)	21.9±4.3 (15.3-41.3)	22.3±4.0 (14.5-41.3)
Right MUAC (cm)	27.85±3.59	25.81±3.48	27.52±3.65
Left MUAC (cm)	27.44±3.50	25.57±3.42	27.13±3.55
Right TSF (mm) (min-max)	12.03±6.35 (4-39)	16.41±6.30 (6-37)	12.75±6.54 (4-39)
Left TSF (mm) (min-max)	13.09±7.18 (4-39)	17.45±6.58 (2-37)	13.82±7.27 (2-39)
Right CC (cm)	36.61±3.42	34.85±3.64	36.32±3.51
Left CC (cm)	36.45±3.46	34.81±3.63	36.17±3.54
Waist circumference (cm) (min-max)	81.30±10.65 (60.0-123.0)	77.73±10.55 (59.0-114.0)	80.71±10.71 (59.0-123.0)
Right MAMA (cm^2)	36.74±10.74	27.95±8.48	35.29±10.89
Left MAMA (cm^2)	33.95±10.42	26.18±8.77	32.64±10.57
Right hand strength (kg)	45.7±8.3	31.5-6.0	43.4±9.5
Left hand strength (kg)	44.2-7.5	30.0±6.1	41.9±9.0
Body fat ratio (%)	15.7±7.2	26.0±8.4	17.4±8.3

CC: calf circumference; MAMA: mid-arm muscle area; TSF: triceps skinfold thickness; MUAC: mid upper arm circumference; BMI: body mass index; BFR: body fat ratio

Table 2. Distribution of males and females according to BMI and Z-score measurements.			
BMI (kg/m²)	**Z Score (SD SCORE)**	**Male (n=502)**	**Female (n=99)**
<18.5 low	< -1 SD	62 (12.4%)	18 (18.4%)
18.5-24.9 normal	Between -1 SD and +2 SD	332 (66.1%)	69 (69.4%)
25-29.9 overweight	Between +1 SD and +2 SD	84 (16.7%)	7 (7.1%)
30-39.9 obese	>= +2 SD	23 (4.5%)	4 (4.1%)
≥40 morbid obese		1 (0.2%)	1 (1.0%)
Total		502 (100%)	99 (100%)
BMI: body mass index			

Table 3. Daily food consumption characteristics of males and females			
	Male (n=502)	**Female (n=99)**	**p**
Those consuming meat everyday	147 (29%)	17 (17%)	0.013
Those consuming vegetables/fruit everyday	478 (95%)	94 (94%)	0,7
Those consuming 'fast food' everyday	388 (77%)	84 (84%)	0,1
Those having meals for three times and more	426 (85%)	80 (80%)	0,3
Daily consumed slices of bread (mean±SD)	11±8	6±4	<0.001

Table 4. BMI and other anthropometric measurements and BFR correlation analysis		
BMI (kg/m²)	**p**	**r**
MUAC	<0.001	0.868
Calf circumference	<0.001	0.863
Waist circumference	<0.001	0.909
TSF	<0.001	0.739
BFR	<0.001	0.775
BMI: body mass index; BFR: body fat ratio; TSF: triceps skinfold thickness; MUAC: mid upper arm circumference		

girls (p<0.001). BMI was positively correlated with BFR (p<0.001, r=0.775, Table 4, Figure 1). BFR showed positive correlation with MUAC (p<0.001, r=0.612), TSF (p<0.001, r=0.758), waist circumference (p<0.001, r=0.700), and calf circumference (p<0.001, r=0.582). BFR did not show any significant association with daily meat, vegetable/fruit, fast food and bread consumptions.

According to distribution of the measurements of all participants, cut-off for normal muscle strength (mean±1.96 SD) were ≥29.5 kg on the right hand and ≥29.5 kg on the left hand for boys, ≥19.7 kg on the right hand and ≥18.0 kg on the left hand for girls. Since the distribution was irregular, cut-off for normal mid-arm muscle area (MAMA) was assumed at ≥2.5 percentile. Accordingly, the normal MAMA was ≥19.84 cm^2 for right arm and ≥16.75 cm^2 for left arm in boys, and ≥16.95 cm^2 for right arm and ≥13.67 cm^2 for left arm in girls. Muscle strength was positively correlated with MUAC, MAMA and CC, and negatively

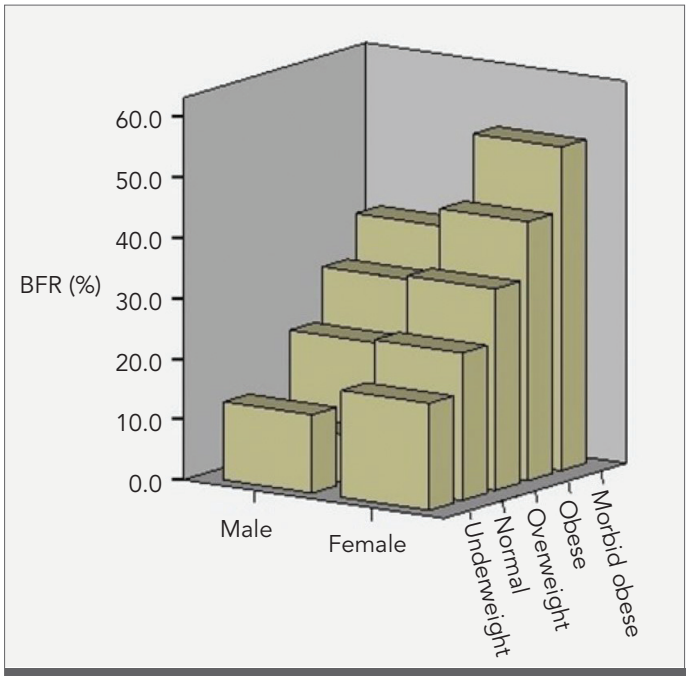

Figure 1. Body fat ratio and body mass index relationship in males and females
BMI: body mass index; BFR: body fat ratio

correlated with TSF and BFR (p<0.001). MAMA showed strongest relationship with muscle strength and muscle strength was significantly correlated with meat consumption (p<0.001, t: 1.962).

Mean muscle strength values of the participants according to different BMI groups were 37.0±7.6 kg for underweight,

Table 5. Underweight, overweight, and obesity prevalence in adolescents (%)

			Underweight	Thin	Normal	Overweight	Obese	Morbid obese
			<-2SD	Between -2SD and -1SD	Between -1SD and +1SD	Between +1SD and +2SD	≥ +2SD	
			<5%	5%-14.9	15%- 84.9	85%- 94.9	≥95%	
Study year	Number of people	Age (year)	-	BMI <18.5	BMI 18.5-24.9	BMI 25-29.9	BMI 30-39.9	BMI ≥40
Uğuz et al. (36)	496	11-16				17.8%	3.8%	
Gözü (37)	715	6-15				14.7%	4.33%	
Our study (2015)	601	15-18		15.4%	67.75%	11.9%	4.3%	0.6%
Krassas et al. (28)	3703	6-17				10.6%	1.6%	
Şimşek et al. (38)	6924	6-17				10.3%	6.1%	
Akman et al. (40)	625	11-15				10.2%	8.3%	
Ozmen et al. (29)	2101	15-17				9%	1.1%	
Arslan et al. (30)	2291	5-20	7.3%			8.8%	4.1%	
Turan et al. (31)	781	14-18				7.8%	5.9%	
Ece et al. (32)	3040	9-17	21.7%			2.1%	1%	
Süzek et al. (33)	4260	6-15					8.4%	

Table 6. Body weight, height, and body mass index (BMI) mean (X) and standard deviation (S) values in adolescents aged 15-18 years

			Body weight (kg)			Height (cm)			BMI (kg/m²)		
			Number	X	S	Number	X	S	Number	X	S
TNHS (2010)	Male	15-18	290	65	12.8	290	171.3	8.2	289	21.9	3.7
	Female	15-18	335	56.3	13.1	336	159.8	7.5	335	22.1	4.7
Our study	Male	15-18	502	66.7	13.3	502	172.4	6,9	502	22.4	3.9
	Female	15-18	99	56.6	12.1	99	160.8	7	99	21.9	4.3

43.4±9.2 kg for normal weight, 48.5±9.8 kg for overweigt and 45.4±8.8 kg for obese. Muscle strength was significantly higher in normal, overweight and obese adolescents when compared to underweight ones ($p<0.001$). Highest muscle strength measurements were achieved in overweight group.

Mean MAMA values of the participants according to different BMI groups were 24.57±6.35 cm^2 for underweight, 34.94±8.94 cm^2 for normal weight, 42.42±11.00 cm^2 for overweight and 49.24±13.36 cm^2 for obese. MAMA was significantly higher in normal, overweight and obese adolescents when compared to underweight ones ($p<0.001$). Highest MAMA measurements were achieved in obese group.

Discussion

Beykoz is located on a Bosphorus and is one of the most important fishing centers. The school where the research

conducted was established in Beykoz in 1967-1969 through the Turkish-Japanese government cooperation. The school was established under the name of "Istanbul Fisheries and Aquaculture Art Institute" to train staff who are active in the evaluation of existing marine resources and in the fields of maritime, shipping, aquaculture, and food technology (14, 15).

In the survey performed on socioeconomically disadvantaged students (aged 15 years old) who participated in the 2009 PISA (Program for International Student Assessment) in Turkey, vocational high schools came to the forefront with a rate of 41.5% in the distribution according to the school types (16). The students in our study had a similar socioeconomic status as the students in the vocational high schools seen in the PISA study, and these students were socioeconomically more disadvantaged than those in other school types.

Obesity is an increasing health problem in the world and in our society, as in childhood and adolescence. Those who are obese during adolescence are more likely to remain obese throughout life (17). Therefore, the prevention, early diagnosis, and treatment of obesity is very important. According to the National Health and Nutrition Examination Survey (CDC / NCHS) in the USA, the frequency of obesity in children aged 12–19 years was 19.6% for boys, 17.1% for girls, and 14.4% on average (18). Countries with a high prevalences of overweight in school-aged children are Spain (35% at age of 6–9 years) and Portugal (32% at age of 7–9 years). Countries with a low prevalences are Slovakia (15% at age of 7–9 years), France (18% at age of 7–9 years), Switzerland (18% at age 6–9 of years), and Iceland (18% at age of 9 years).

In "The Pro Children" study (2003), which was carried out in 9 European countries and included 11-year-old children, the prevalence of overweight was 17% in boys and 14% in girls (19). In the "Health Behavior in School-Aged Children Survey (HBSC)" (2001-2002) study conducted in children aged 11–15 years in 41 countries, 24% of girls and 34% of boys were overweight in the age group of 13 years, and 31% girls and 28% boys were overweight in the 15 years age group (20). In the USA, the obesity rate for children aged 12–19 years was 20.9% in girls and 20.2% in boys (21). In the study conducted in adolescents aged 12–17 years in Bahrain in 2002, the prevalences of overweight and obesity were 30% and 15% for boys and 42% and 18% for girls, respectively (22).

The World Health Organization Regional Office for Europe reports that approximately 20% of children and adolescents in Europe are overweight, and one-third of them are obese. These data show that the obesity prevalence in the adolescent age group increased in 16 of 27 countries between 2002 and 2014 in Europe (23). In addition, according to the World Health Organization data, the prevalence of obesity in adolescents increased 10-fold from 1975 to 2016 (24).

There are many studies investigating the relationship between anthropometric measurements and obesity in recent years. In a study conducted among adolescents in Iran, a correlation was found between MUAC and obesity, and it was emphasized that the obesity limit value of MUAC should be calculated separately for each country (25). In a study conducted in India, a linear relationship was found between MUAC and BMI, and it was stated that MUAC measurements could be used in the evaluation of malnutrition and obesity (26). In a study conducted in Turkey, BMI, body fat mass, skinfold thickness measurements, and waist circumference measurements were compared in obese patients and it was shown that there was a high level of correlation between body fat mass and waist circumference measurements (27). Other studies form Turkey indicated obesity prevalence between 3.1 to 13.7% in adolescent age group (Table 5) (28-33), which was 4.7% in boys and 5.7% in girls participated in our study (obese and morbidly obese together).

In our study, a significant positive correlation was found between BMI and other anthropometric measurements (MUAC, CC, waist circumference, and TSF). Among these, the best indicator for obesity in adolescent age group was waist circumference. BFR measured with BIA was also associated with BMI (Table 4).

A study that examined the relationship between family history and BMI (1244 children aged 5–11 years) showed that, the most common obesity related dietary disorder was excessive consumption of sweetened beverages, the most common behavioral disorder was having a television in the bedroom, and the most common family history was the presence of obesity in the family (34). In another study conducted in Italy, the presence of obesity and cardiovascular disease in the family suggested as a risk factor for the onset of obesity at an early age (35). Uğuz et al. (36) reported that obesity in adolescence is associated with the presence of an obese father, mother, and/or sibling, the education level of the mother, the profession of the father and the economic level of the family. Gözü et al. (37) indicated a negative correlation between obesity and maternal education level and number of siblings. In a study with 6924 children (3281 boys and 3643 girls), Şimşek et al. (38) reported that obesity is a significant problem in children which might be associated with genetic predis-

position, nutritional habits, and inadequate physical activities. In our study, a significant relationship was found between obesity prevalence and the presence of overweight individuals in the family.

In the 2010 Turkey Nutrition and Health Survey (TNHS), the rate of underweight children in the 6-18 years age group was 14.9% among 2248 children, while it was 15.4% in our study (39). The rate of those with normal weight was 58.7% in the TNHS and 67.7% in our study. The rates of overweight and obesity in TNHS and in our study was 14.3% and 8.2%, and 11.9% and 4.9%, respectively (Table 6). All of these studies reveal that overweight and obesity have become an important problem in childhood and adolescence. In the TNHS study, the rate of those consuming meat every day among individuals aged 20 years was 10.5%; in our study, it was 27.4% in the 15–18 age groups (4% of males and 17.2% of females). While the daily consumption rates of vegetables, potatoes, citrus fruits, and fruits in TNHS were reported to be 47.6%, 10.1%, 16.2%, and 51.5%, respectively. 95.3% of individuals in our study stated that they consumed vegetables and fruits every day. The results of the two studies suggest that the consumption of vegetables and fruits by adolescents is sufficient. In the study conducted by Akman et al. (40), among 625 students (50.5% girls) in the 11–15 years age group in Istanbul, the ratio of those having breakfast everyday was 51%, the rate of those who consumed fast food once a day was 31%, and the rate of those who skipped meals was 60.8%. As a result of the study, they concluded that the children did not eat enough and balanced diet. In our study, it was shown that the frequency of daily "fast food" consumption among adolescents was 78.7%. Such high rates have been attributed to the significant increase in "fast food" consumption among adolescents and children in recent years, the promotion of these products in social media and the food industry, and the fact that most students consume their meals from the canteen of the school.

In our study, no significant relationship was found between BMI and daily bread and "fast food" consumption. The anthropometric measurements of adolescents in TNHS-2010 study and our study were compared in Table 6. It is observed that the body weight, height, and BMI mean values were similar in both studies.

Although varies according to age and sex, there was a positive correlation between body fat ratio (BFR) and obesity (41). Such a relationship between BFR and obesity has been shown to increase with advancing age and it has been stated in a study conducted with 899 adolescents aged 11–14 years that BFR is a more apropriate measurement in the diagnosis of obesity compared to BMI (42). A positive correlation was found between BFR and BMI in our study.

Obesity is related with increased adipose tissue and loss of muscle strength. Studies have shown that hand muscle strength measurements increase in obese individuals, while other studies reported that they neither change nor decrease (43). According to a study conducted in Belgium, a positive correlation was found between hand muscle strength and waist circumference, triceps skinfold thickness, and BMI (44). In a study conducted with 491 adolescents aged 10–17 years in South America, it was shown that hand muscle strength in both sexes decreased with obesity in adolescents who were diagnosed with severe obesity according to the BMI and waist circumference measurements (45). In our study, hand muscle strength was shown to be directly proportional to MUAC, TSF, and MAMA, but inversely proportional to CC and BFR. Moreover, muscle strength of our participants was higher in normal, overweight and obese individuals when compared to underweight ones. Muscle strength was found highest in the overweight group. When mean mid arm muscle area (cm^2) levels of the different BMI groups were taken into consideration, muscle mass was found increased with BMI.

Our data showed that, prevalence of obesity is high in adolescent age group of our society which can be related with increased fast food consumption. Obesity prevalence is higher in those with obese family members. Muscle strength and muscle mass were higher in normal, overweight and obese adolescents when compared to underweight ones. Muscle strength was found increased with daily meat consumption and inversely corraleted with BFR.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of İstanbul University (13.11.2013/2013/1554).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

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