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Comparison of Body Composition and Body Mass Index in the Determination of Obesity in Schoolchildren

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What is already known on this topic?

- *Obesity is defined as an increase in body fat percentage. Body mass index (BMI), calculated as weight divided by height squared, may not give sufficient information about the body fat mass and fat percentage, essential for cardiovascular risk.*

What this study adds on this topic?

- *As the fat ratio is valuable in evaluating obesity, body fat percentage measurements obtained by examining body composition with bioelectrical impedance analysis (BIA) should be evaluated according to age and gender body fat percentage (BFP) curves. Not every child who is obese according to body mass index (BMI) is actually obese, and therefore, the decision should not be made based on BMI alone.*
- *This study can be considered of value as the first to have evaluated the results obtained using the BIA method according to Turkish children's BFP curves and compared these with BMI results.*

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ABSTRACT

Objective: The determination of obesity that develops with an increase in the percentage of fat in the body may not always be possible in the real sense with body mass index, which is frequently used in practice. This study aimed to compare the results obtained from body mass index and bioelectrical impedance analysis measurements in evaluating obesity in Turkish school-aged children using age-related percentile curves.

Materials and Methods: The study included 1127 children (604 boys and 523 girls) recruited from a screening of the schools in the city center of Isparta between May 20 and June 20, 2014. Body mass index was calculated, and the variables of fat mass, body fat percentage, fat-free body mass, and total body water were measured with a Tanita BC-418 MA device.

Results: According to the body mass index values, 23.8% of the study sample was overweight/obese, and according to bioelectrical impedance analysis, this rate was 14.7%. When examined by gender, males' overweight/obese ratio was 19.9% (overweight 11.3% and obese 8.6%) according to body mass index and 12.9% (overweight 7.1% and obese 5.8%) using the bioelectrical impedance analysis method. In females, the overweight/obese ratio was 19% (overweight 9.4%, obese 9.6%) according to body mass index and 16.7% (overweight 9.6% and obese 7.1%) using the bioelectrical impedance analysis method.

Conclusion: The results obtained from the weight-based body mass index method were not consistent with the body fat percentage results obtained with the bioelectrical impedance analysis method. Since the fat ratio is also crucial in evaluating obesity, care should be taken when diagnosing obesity using body mass index only.

Keywords: Body composition, children, fat, obesity

INTRODUCTION

The increasing incidence of obesity in children and adults has become a global health problem. In a previous study of 7116 children aged 6-18 years in our region, 13.6% were overweight and 9.9% were obese according to body mass index (BMI) values.[1] Obesity in childhood and adolescence is a significant risk factor for developing obesity as an adult. Therefore, it is necessary to take timely precautions in obese and overweight children detected by screening at an early age.[2]

Of the evaluation methods suggested by the World Health Organization (WHO), BMI is an inexpensive, noninvasive, portable way that does not require detailed training, so it is usually preferred in population studies. Obesity is defined as an increase in the fat ratio in the body, and BMI, calculated as weight divided by height squared, may not give sufficient information

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about the body fat mass, fat percentage, and fat distribution, which are essential in terms of cardiovascular risk.[3] A high BMI value may be due to a high fat-free mass (FFM).[4]

There is evidence in the literature that BMI does not have the sensitivity to detect the changes observed in fat mass (FM) with an increase in body weight.[5] It has also been emphasized that using the same cutoff points for BMI in populations with different physical characteristics will give false results. Therefore, it may be a correct approach to determine obesity with a method that evaluates body composition.[6]

There are significant changes in body composition during the growth and development period; it is more challenging to determine body composition in children than in adults.[7] There is a need for screening methods to identify overweight or obese children, which can be easily applied, inexpensive, used in population screenings, and determined close to actual body fat status. One of these methods to measure body composition is bioelectrical impedance analysis (BIA).[8] As the BIA method can be easily applied in both children and adults, can be repeated, provides results rapidly, and is noninterventional, it is an effective method used to evaluate body composition.[9] Studies have shown that BIA is superior to BMI in evaluating body fat percentage.[10-12] Bioelectrical impedance analysis is very useful, but there are many methodological differences. The device's model, the electrodes' placement, the frequency of the electric current, and the reference method used to develop the regression formula of the model cause differences and inconsistencies in the measurements. The technique requires a suitable ambient temperature, and the subject has not eaten or drunk anything within the last 4 hours, has been to the toilet within the last 30 minutes, and has not undertaken any physical activity within the last 12 hours. Disadvantages also include a lack of widely accepted reference data for excess body fat in children and difficulties in interpreting the results.[13]

This study was planned as there is no BIA study of children using the percentiles of body fat percentage of the Turkish population. The aim of this study was to compare the results of the 2 methods of BMI and BIA which are used in the assessment of obesity in schoolchildren.

MATERIALS AND METHODS

Ethics Committee Permission and Consent to Participate

Permission for the study was granted by the National Education Authority and approved by Süleyman Demirel University's Clinical Research Ethics Committee (Date: 2014, No: 82). Written informed consent for participation in the study was provided by all the children's parents or legal guardian.

The Research Universe and the Measurements

The schools in the city center of Isparta were screened between May 20 and June 20, 2014. The children included in the study were separated into 3 age groups, 6-10 years, 11-13 years, and 14-16 years. Height, weight, BMI, FM, BFP, FFM, and total body water (TBW) were recorded. Height was measured using a portable stadiometer. For weight, FM, BFP, FFM, and TBW values, the Tanita BC-418 MA (50 Hz) model body composition analyzer was used (Tanita Corporation of America Inc., Arlington Heights, Ill, USA). All the measurements were performed by the same person, taking the operating principles of the BIA device into consideration. Height was measured with the child standing with feet together, knees straight, heels, hips, and shoulder blades touching the device, with the eyes and ear lobes at the same level parallel to the floor. The BMI value was calculated as weight divided by height squared (kg/m^2).

Calculations and Evaluation

In interpreting the BMI results, the percentile (pctl) values recommended by Neyzi et al[14] were used; those with BMI in the 85-94 pctl were evaluated as overweight, and those with BMI ≥95 pctl as obese.[14] In evaluating the BIA results, the BFP values obtained from the study of Turkish children by Kurtoglu et al[15] were used. Children with BFP in the 85-94 pctl were evaluated as overweight and those in the ≥95 pctl as obese.[16]

Statistical Analysis

Data obtained in the study were analyzed statistically using the Statistical Package for Social Sciences version 26.0 software (IBM Corp.; Armonk, NY, USA). Frequency analysis and normality tests were applied to the data, with no difference detected between the groups. The independent Student's *t*-test and chi-square test were applied in the data analyses. Multivariate analysis of variance and two-way ANOVA were used to compare multiple variables. Pearson correlation analysis was performed. A value of $P < .05$ was accepted as statistically significant.

RESULTS

Demographic Features

One thousand one-hundred twenty-seven children, comprising 604 males and 523 females with a mean age of 11.17 ± 2.38 years (5.8-15.9 years), were evaluated. The distribution of the children according to age and gender is shown in Table 1. No significant difference was determined between the genders in respect of age ($P = .45$).

Comparison of Body Mass Index and Bioelectrical Impedance Analysis Methods

According to the BMI values, 19.5% of the study sample were overweight/obese (overweight 10.4% and obese 9.1%), and according to BIA, this rate was 14.7% (overweight 8.3% and obese 6.4%). In the evaluations made with BMI, the ratio of overweight+obesity was higher than the results obtained with the BIA method, and the difference was statistically significant ($P = .00$).

When examined by gender, males' overweight/obese ratio was 19.9% (overweight 11.3% and obese 8.6%) according to BMI and 12.9% (overweight 7.1% and obese 5.8%) using the BIA method. In females, the overweight/obese ratio was 19% (overweight 9.4% and obese 9.6%) according to BMI and 16.7% (overweight

Table 1. The Distribution of the Children According to Age and Gender

	Boys		Girls		Total	
	n	%	n	%	n	%
6-10 age	175	29	178	34	353	31.3
11-13 age	261	43.2	201	38.4	462	41
14-16 age	168	27.8	144	27.5	312	27.7
Total	604	100	523	100	1127	100

Table 2. The Distribution of Overweight and Obesity by Gender and Age Using BMI and BIA methods

		Gender			Ages		
BMI		**Girls**	**Boys**	**Total**	**6-10 years**	**11-13 years**	**14-16 years**
Overweight	**n**	49	68	117	34	56	27
	%	9.4	11.3	10.4	9.6	12.1	8.7
Obesity	**n**	50	52	102	33	42	27
	%	9.6	8.6	9.1	9.3	9.1	8.7
Overweight+ obesity	**n**	99	120	219	67	98	54
	%	19	19.9	19.5	18.9	21.2	17.4
BIA							
Overweight	**n**	50	43	93	20	49	24
	%	9.6	7.1	8.3	5.7	10.6	7.7
Obesity	**n**	37	35	72	21	32	19
	%	7.1	5.8	6.4	5.9	6.9	6.1
Overweight+ obesity	**n**	87	78	165	41	81	43
	%	16.7	12.9	14.7	11.6	17.5	13.8

BMI, body mass index; BIA, bioelectrical impedance analysis.

9.6% and obese 7.1%) using the BIA method. In the comparison of the 2 methods, overweight, obesity, and overweight+obesity according to BMI were statistically significantly higher than the results obtained with BIA in males (P = .00). The rate of overweight females was similar, and the rates of obesity and overweight+obesity in females according to BMI were statistically significantly higher than the rates obtained with BIA (P = .00) (Table 2). Gender and age distribution of overweight and obese according to BMI and BIA is provided in Table 2

Correlation Assessment

Correlations between BMI and height and weight were determined as r = 0.53 (P = .000) and r = 0.88 (P = .000), and correlations of BFP with height and weight were weaker at r = 0.18 (P = .000) and r = 0.54 (P = .000), respectively. Correlations between BMI and age were weak in males (r = 0.39) and moderate in females (r = 0.52). The correlation between BFP and age was negative in males (r = −0.15) and positive at a weak level in females (r = 0.39). The correlation between BMI and BFP is given in Table 3.

Evaluation by Age Groups

When the mean weight and BMI values were evaluated according to the age groups, no statistically significant difference was determined between the genders. Mean height was statistically significantly higher in males than females only in the 14-16 years age group (P = .000). The mean BFP value was higher in females than males, at a statistically significant level of difference in all age groups except the 6-10 years group (P = .000) (Table 4).

Table 3. The Correlation Between BMI and BFP by Gender

Correlation	**BFP**			
	Girls		**Boys**	
	r	***P***	***r***	***P***
BMI				
Underweight	0.53	<.001	0.49	<.001
Normal	0.78	<.001	0.36	<.001
Overweight	0.80	<.001	0.07	>.05
Obese	0.88	<.001	0.49	<.001

BMI, body mass index; BFP, body fat percentage.

BIA Assessment in Body Mass Index Groups

When the subjects were grouped according to BMI, the mean BFP value was slightly higher in the underweight males group, but the difference was not statistically significant (P = .459). In average, overweight and obese female groups, the mean BFP value was statistically significantly high (P = .000). The mean BFP increased with an increase in body weight in both genders, but it increased more evidently in females, and the difference was statistically significant (Table 5).

DISCUSSION

To the best of our knowledge, this is the first study to indirectly evaluate obesity in Turkish children according to BFP curves using the BIA method and compare the results with BMI values.

In a study of adults by Bektaş et al.[17] the obesity prevalence obtained with the BIA method (males 7% and females 10%) was higher than the values calculated with BMI (males 6% and females 1.5%), especially in females. Amani[18] examined 637 adult Iranian females and determined obesity prevalence as 18.3% with BMI and 39.4% in the evaluation with the BIA method. A sample of children aged 11-15 years was evaluated by Bodur and Uğuz,[19] and the obesity prevalence obtained with BIA was seen to be higher than the rate obtained with BMI. It was emphasized that it was more convenient to use BIA as it had high sensitivity in diagnosing obesity in this study.

Unlike those studies, the obesity prevalence rates obtained in the current study were 6.4% (males 5.8% and females 7.1%) with the BIA method and 9.1% (males 8.6% and females 9.6%) with BMI. The reason for this difference from other studies was attributed to the use of the BFP percentile curves developed according to age and gender for the Turkish population when evaluating with the BIA method, whereas other studies have considered the upper limit of fixed BFP values irrespective of age (BFP for males 18%-25% overweight, >25% obese; BFP for females 25%-30% overweight, >30% obese). Previous studies considering the same rate for all age groups will not reflect reality, as BFP is not the same for all ages and both genders. It is more appropriate to use percentile values according to age and gender.

In the study by Bodur and Uğuz,[19] the correlation of BFP measured with BIA with height and weight was lower than the correlation of BMI with size and weight. The results of the current study were similar, and thus it can be said in one sense that BFP measured with BIA is more independent of height and weight and is more valuable in showing the fat percentage. A weak positive correlation was determined between BMI and the children's age in the same study. In contrast to a weak negative correlation between age and BFP in males, a more positive correlation was determined in females. Similarly, in the current study, the correlation determined between age and BMI was weak in males and at a moderate level in females, whereas the correlation between age and BFP was negative in males

Table 4. The Mean Value of Anthropometric and Body Composition Measurements by Age and Gender

	Weight			Height		
	Boys	**Girls**	***P***	**Boys**	**Girls**	***P***
6-10 age	29.6 ± 8.2	28.8 ± 8.4	0.370	131.8 ± 7.3	131.2 ± 8.6	.505
11-13 age	41.7 ± 10.8	42.3 ± 12.2	0.629	146.4 ± 8.6	147.8 ± 10.4	.117
14-16 age	54.7 ± 13.5	52.5 ± 10.4	0.122	163 ± 9.5	159.2 ± 5.7	**.000**
Total	41.8 ± 14.5	40.5 ± 14.1	0.124	146.8 ± 14.5	145.3 ± 14.1	.083
	BMI			**BFP**		
	Boys	**Girls**	***P***	**Boys**	**Girls**	***P***
6-10 age	16.7 ± 3.1	16.3 ± 3.1	0.221	15.8 ± 6.4	16.8 ± 8.5	.239
11-13 age	19.2 ± 3.6	19 ± 3.6	0.465	16.7 ± 7.2	21.9 ± 8.2	**.000**
14-16 age	20.4 ± 3.8	20.6 ± 3.7	0.535	12.8 ± 6.9	23.2 ± 7.3	**.000**
Total	18.8 ± 3.7	18.5 ± 3.8	0.207	15.4 ± 7.1	20.5 ± 8.5	**.000**

BMI, body mass index; BFP, body fat percentage.

and positive at a weak level in females. In the study by Bektaş et al[17], a robust significant correlation was observed between BMI and FM and BFP in both sexes, and the correlation values were determined to be higher in females than in males. In contrast, the current study's correlation between BMI and BFP was moderate in underweight females and high in the other females groups. In males the correlation was low and insignificant in overweight males group.

In a study of schoolchildren by Gültekin et al.[20] no statistically significant difference was determined between age groups regarding mean BMI of the sexes. The mean BFP was statistically significantly higher in females than males. In the current study, there was no difference between the genders regarding weight and BMI. Only males in the 14-16 years age group were determined to be statistically significantly taller than females. Gültekin et al[20] reported that the females' height, weight, and BMI values were higher than those of the males only in the 11-13 years age group. In the current study, the females were ahead of the males regarding mean height and weight only in the 11-13 years age group. This finding can be explained by girls entering puberty earlier than boys and showing an earlier increase in height and weight. With increasing age, there is an increase in BFP in females and a decrease in males. Although there is an increase in BMI with increasing age in both sexes, this increase does not reflect the change in BFP.

Various studies have shown higher FM and BFP values in obese girls than in boys, whereas significantly higher muscle mass has been reported in boys than girls.[21-23] In the current study, in the obese children, there was no difference between the genders in respect of age, height, weight, FFM, and TBW, but the BFP and FM mean values were statistically significantly higher in females.

Table 5. The Mean BFP Value According to BMI Classification and Gender

BFP			
	Boys	**Girls**	***P***
BMI			
Underweight	9.05 ± 4.2	8.4 ± 3.8	.459
Normal	12.9 ± 4.6	18.9 ± 5.8	**.000**
Overweight	21.1 ± 4.6	29.3 ± 3.7	**.000**
Obese	27.5 ± 6.2	36.8 ± 3.4	**.000**

BMI, body mass index; BFP, body fat percentage.

Farbo and Rhea[24] demonstrated a significant difference in how BMI and BIA discriminate between the different body composition categories. Bioelectrical impedance analysis consistently shows more accuracy in assessing obesity rates in children since it directly measures body fat. Similarly, the BIA method shows the body fat ratio more accurately in our study. Mateo-Silleras et al[25] demonstrated that bioelectrical impedance vector analysis reflects differences in the bioelectric patterns of children classified as overweight or obese (BMI) and who have different levels of %FM and FM index. Bioelectrical impedance vector analysis permits a fast and easy monitoring of the evolution of the nutritional state and changes associated with body composition, and it identifies those children whose body compartments may be precisely estimated using traditional BIA methods

Limitations

The limitations of this study were that it is not the gold standard method that clearly reveals obesity, and thus the results obtained with this method cannot be compared. Moreover, the BFP measurements were not compared with other methods such as skinfold or Dual-energy X-ray absorptiometry (DEXA).

CONCLUSION

This study showed that the rates of overweight and/or obesity obtained by BMI on a weight basis were higher than the rates obtained by considering BFP in the BIA method. Although BMI increases with age in both sexes, BFP increases with age in females and decreases in males. This increase in BMI did not appear to reflect gender-related changes in BFP. As the fat ratio is valuable in evaluating obesity, care should be taken when diagnosing obesity with BMI alone, especially in adolescence, which is a definitive period. Every child who is according to BMI may not actually be obese. Some children may face unnecessary financial and moral difficulties if the decision is made according to BMI alone. Therefore, each child should be evaluated individually.

Ethics Committee Approval: This study was approved by Ethics committee of Süleyman Demirel University, (Approval No: 82/2014).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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