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Comparatively Evaluation of the Methods Used in the Assessment of Health and Impairment of Body Composition

Sukru Ahmet Ayyildiz[1], Suleyman Yagiz[1], Sermin Algul[2], Oguz Ozcelik [2]

[1] *Kastamonu University, Faculty of Medicine, Department of Physiology, Kastamonu, Türkiye*
[2] *Van Yuzuncu Yil University, Faculty of Medicine, Department of Physiology, Van, Türkiye*

Abstract

Introduction: Assessment of body composition is an important way that reveal valuable information about the health status of individuals. To evaluate the effectiveness of the methods, the body compositions of young male and female students were comparatively evaluated using the bioelectrical impedance method (BIA), body mass index (BMI), and waist-hip ratio (WHR).

Materials and Methods: A total of 226 (n= 112 males and n= 114 females) young students participated in this study. Body composition analyses were performed using BIA, BMI, and WHR.

Results: Considering the whole data, a statistically significant correlation between BMI and BIA was observed. However, there is a difference in risk groups with low and normal values that may result in the differences between the cut-off points determined by ethnicity and gender.

Conclusion: In general, although anthropometric measurements have provided meaningful results for population evaluation, technological evaluations should be taken into account in measurements in decision-making situations related to the health status of individuals.

Keywords: Body composition; fitness; fat mass; bioelectrical impedance analyses; body mass index; waist to hip ratio.

Introduction

In clinical medicine, sports science, and public health research, valid and effective body composition analysis can provide valuable information about an individual's health and fitness status (1). Assessment of human body weight and composition, especially the content of fat-free mass (FFM), fat mass (FM), total body water (TBW), and their distribution, is an important topic that is widely used for health-related situations (2, 3). One can also asses the theoretical impact of effective and valid assessment of body compositions component on health outcomes. Thus, in time, a wide range of methods based on different parameters have been introduced to evaluate body composition, including body height-to-weight relationships (BMI), waist-to-hip ratio (WHR), bioelectrical analysis method (BIA), dual-energy x-ray absorptiometry (DXA), doubly labeled water (DLW), computed tomography (CT) skinfold measurements (4-6). Despite providing effective and valid measurements of body composition, some of these methods are not suitable for routine clinical practice because of high cost and taking a long time (7). BIA and anthropometric measurements are generally preferred methods used to evaluate body composition in routine clinical practice and public health studies (2, 8-10). Bioelectrical impedance is a tool that estimates body composition by measuring the resistance of body components. Waist-to-hip measurements provide information about abdominal adiposity that reflects an increased risk for heart disease, diabetes, and hypertension. Thus, body composition analysis using BIA and waist-to-hip ratio (WHR) provides valuable information regarding the nutritional status and risk assessment in cardiometabolic conditions of the person (5, 8, 11). The evaluation of body composition distribution in young medical students, who are aware of the importance of fluctuation in body composition parameters especially fat percent on health status, is an essential issue. Thus, in the study, it was aimed comparatively evaluate body composition using BIA, BMI, and WHR and then asses the

*Corresponding Author: Sermin Algul, Van Yuzuncu Yil University, Faculty of Medicine, Department of Physiology, Van, Türkiye
E- maill: serminalgul@hotmail.com **Orcid:** Sukru Ahmet Ayyildiz 0000-0003-1131-493X, Suleyman Yagiz0000-0001-6622-0514
Sermin Algül 0000-0003-2489-3619, Oguz Ozcelik 0000-0002-2391-9883

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Table 1: The subjects mean (±SD) and minimum-maximum ranges for physical characteristics, body composition analyses parameters and body waist hip measurements values for male and females.

Subjects Characteristics	Male (n=112) Mean±SD	Male Range (min-max)	Female (n=114) Mean±SD	Female Range (min-max)
Age (yr.)	19.9±1.1	18-24	19.5±1.1	18-23
Height (cm)	177.4±5.9	160-193	164.4±5.8	152-178
Weight (kg)	76.0±12.5	50.9-114.3	60.3±13.8	40-134.4
Body Mass Index (kg/m²)	24.10±3.68	17.6-34.7	22.24±4.71	16 - 49.4
BMR (Kcal)	1868±185	1497-2464	1447±138	1217-2157
BMR (Ki)	7818±776	6264-10308	6027 ±644	2976-9025
Impedance (ohms)	499±56	385-651	590 ±74	295-745
Fat Mass (%)	15.92±6.06	4-33.7	25.05±8.05	6.7-47.8
Fat Mass (kg)	12.77±6.97	2.0-37.8	16.08±9.53	2.7-63.3
Fat Free Mass (kg)	63.27±6.62	48.9 -76.5	44.19±4.65	37.3-71.1
Total body Water (kg)	46.32±4.84	35.8- 56.0	32.42±3.44	27.3-52.1
Waist circumference (cm)	86.87±9.85	66 -115	70.13 ±9.93	56 -114
Hip circumference (cm)	99.42±7.69	81-123	96.71±9.40	80 -138
Waist / Hip ratio	0.87± 0.05	0.73-1.04	0.72 ±0.05	0.6-0.9
Fat mass / Fat free mass ratio	0.196±0.09	0.04-0.50	0.35±0.15	0.07-0.91

nutritional status of the male and female medical students from Kastamonu University.

Materials and Methods

A total of 226 subjects (112 males and 114 females) voluntarily participated in the first three years of medical school students. The age of subjects ranged between 18 years to 25 years old. The subjects' physical characteristics are given in Table 1. The subjects were questioned regarding renal, metabolic, respiratory, and cardiometabolic system disorders. In females, the menstrual cycle period was considered before measurements. In this study, three commonly used methods, body mass index (BMI), waist-to-hip ratio (WHR), and bioelectrical impedance analysis (BIA), were applied to all subjects. Based on World Health Organisation criteria (12), Body mass index (BMI) between 18.50 kg/m2 to 24.99 kg/m2 is accepted in the normal range. In addition, BMI <18.50 kg/m2 is considered as underweight, between 25.00 kg/m2 to 29.99 k kg/m2 is considered as overweight, and >30.00 kg/m2 is considered as obese. There are four categories in determining the level of fat mass percent and females using body composition analyzer which is based on bioelectrical impedance analysis: Low FM <8%, Normal 8% to 20%, Increased 20% to 25%, and High >25% in male and Low FM <21%, Normal 21% to 33%, Increased 33 to 39% and High >39% in female (13). The cut-off points for the waist-hip ratio (WHR) for males and females were categorized as excellent <0.85 and <0.75, as good 0.85–0.89 and 0.75–0.79, as average 0.90–0.95 and 0.80-0.86, as at risk >0.95 and >0.86, respectively (14). All subjects were advised to avoid any exercise and told not to eat meals or drink any fluid at least 12 hours before the measurements. Fat distribution was evaluated by measuring the waist and hip circumferences then waist to waist-to-hip ratio was calculated. The waist circumference was measured between the rib cage and the iliac crest while subjects were in a standing position. The hip circumference was measured at the widest circumference between the waist and the thighs. All measurements were performed by an expert medical doctor. BIA measurements were performed by using the foot-to-foot bioelectrical analyses system (TBF 300 A, Japan) that measures lower body resistance between the right and left foot while the subjects with light clothes stand on the electrode plates of the analyzer. The subjects' water intake status was controlled carefully to avoid water retention effects on body composition analysis (15). The body composition analyzer automatically measures weight and then impedance that is directly linked to the subject's gender, height, weight, and fitness status.

Ethical approval: The ethical permissions were taken from the local ethical committee Kastamonu University (Decision No:2022-KAEK-89). A signed informed consent was obtained from each subject before participating in this study.

Statistical analyses: Data are expressed as mean ±SD. Pearson correlation analysis was used to evaluate the data obtained in this study. One

Way Anova test was applied to statistically analyze the values of body composition measurement obtained from three methods in male and female subjects.

Results

The body composition values and their combinations obtained from BIA measurements for male and female participants are presented in Table 1. BMI parameters and their distribution for it is cut-off points for male and female subjects are presented in Figure 1.

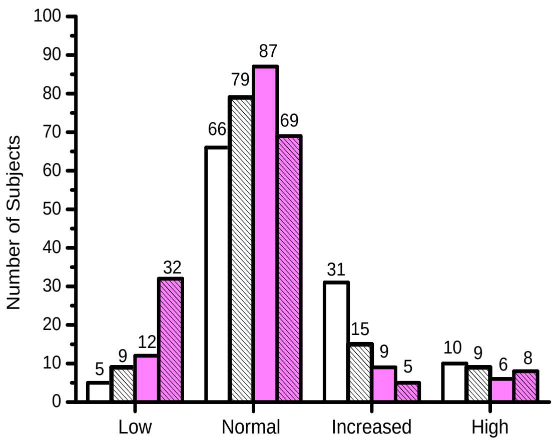

Figure 1: The number of subjects for the low, normal, increased, and high-risk groups which are obtained from body mass index evaluation (blank column) and bioelectrical analyses evaluation (striated column) for males (n=112) (white column) and females (n=114) (pink column).

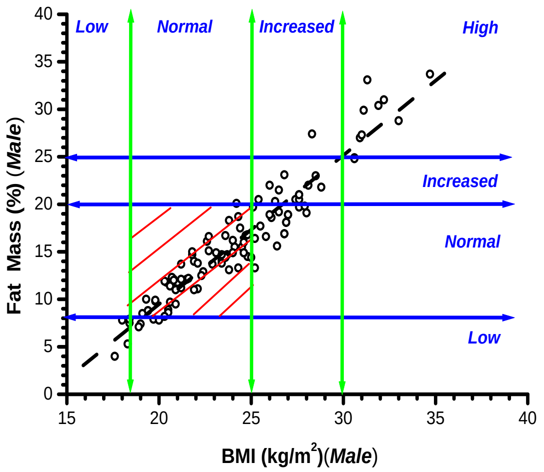

Figure 2: Correlation analyses between body mass index and fat mass percent in males (n=112). Horizontal blue lines represent the cut-off points for fat percent values. Vertical green lines represent the cut-off points for body mass index values. Dashed black lines reflect the correlation between BMI and fat mass percent. The red striated region reflects the normal values for both BMI and fat mass percent values

The distributions of health risk groups obtained from body mass index measurements and fat mass percent evaluated by bioelectrical impedance are shown in Figure 1. The low-risk group that was evaluated by BMI and bioelectrical impedance for males and females were found to be 4% vs 8%

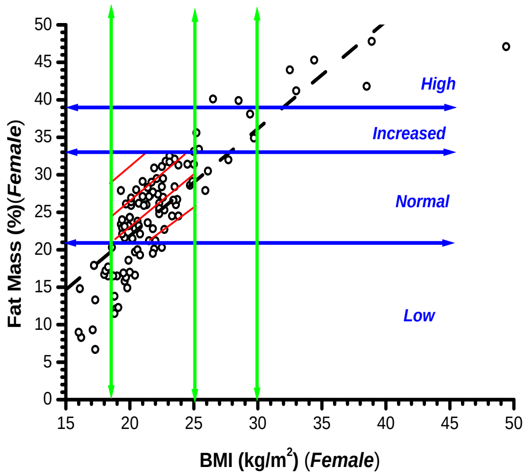

Figure 3: Correlation analyses between body mass index and fat mass percent in females (n=114). Horizontal blue lines represent the cut-off points for fat percent values. Vertical green lines represent the cut-off points for body mass index values. Dashed black lines reflect the correlation between BMI and fat mass percent. The red striated region reflects the normal values for both BMI and fat mass percent values

and 11% vs 28%, respectively. The normal group determined by BMI and bioelectrical impedance for males and females were found to be 59% vs 71% and 76% vs 61%, respectively. The increased risk group determined by BMI and bioelectrical impedance for males and females were found to be 28% vs 13% and 8% vs 4%, respectively. The high-risk group (i.e. obese group) determined by BMI and bioelectrical impedance for males and females were found to be 9% vs 8% and 5% vs 7%, respectively. There were wide ranges of distribution in BMI values and fat mass percent despite the normal mean values for BMI and fat mass percent in males and females (Table 1). There was a significant correlation between the change in BMI and body total fat mass in males (R = 0.94823, p<0001) and females (R = 0.94529, p<0001). In addition, as can be seen in Figure 1 and Figure 2, there was a significant positive correlation between increased BMI and percent of fat mass in males (R = 0.95286, p <0.0001) and females, (R = 0. 83715, p <0.0001). There was a correlation in the number of subjects in each risk group determined by cut-off points for BMI and fat mass percent parameters in males and females

(Figure 1, 2, 3). The waist-hip ratio was also found in a wide range but with normal mean values (Table 1) in both groups. The cut-off point of WHR for females showed markedly higher values in excellent groups compared to males (Table 2). In addition, Person correlation analysis of the data showed that WHR had significant low-level correlations with the percent of fat mass in females (R = 0.35336, p<0.0001) than males (R = 0.47027, p<0.0001). The distribution of WHR for males and females is presented in Table 2.

Table 2: The distribution of Waist to Hip Ratio (WHR) for male (n=112) and female (n=114) subjects.

	Excellent		Good		Average		At Risk	
WHR	**Male- Female**		**Male - Female**		**Male - Female**		**Male - Female**	
Ranges	<0.85 & <0.75		0.85-089 & 0.75-0.79		0.90-95 & 0.80-0.86		>0.95 & >0.86	
Number	36	82	36	18	32	10	8	4
Percent	32%	72%	32%	16%	29%	9%	7%	3%

Discussion

In the current study, we did not primarily aim to determine obesity prevalence or the optimal WHR and body fat percent cut-off points for male and female medical students. We aimed to evaluate the distribution of body compositions in the first three years of medical students and compare the obtained results from the widely used three procedures, BMI, WHR, and body fat percent estimated by bioelectrical impedance methods. We have observed a noteworthy correlation between anthropometric risk indicators (e.g. BMI and WHR) and bioelectrical impedance method (10).

In today's world, successful advantages in scientific technology have increased knowledge and understanding of body composition and its impact on health risk and clinical outcomes. Body composition, bodythe measurement and characterization of percent fat mass, total fat mass, and fat-free mass, may indicate fitness status levels and also clarify the possible mechanisms and pathophysiological situations in diseases associated with energy imbalance. BIA is a practical method used for the low-cost measurement and the accuracy of the obtained results. Body composition analysis provides valuable diagnostic and therapeutic information in clinical medicine (16, 17). BMI is not an effective method to distinguish between body composition components including fat mass, fat-free mass, body water content, and cannot estimate the body fat mass percent (18). BMI is mainly used in epidemiologic studies to evaluate any possible health risk associated with different levels of body weight (19). Despite the doubt about the strength of BMI as an index of adiposity, there is a strong positive correlation between BMI and fat percent in total body weight in young males and females (Figure 1, 2) (20). In this study, we have observed some interesting findings, fat mass and percentage of body fat mass as evaluated by the bioelectrical impedance method significantly correlated with BMI than WHR among males and females. WHR is mainly applied to evaluate visceral fat accumulation that indicates an increased cardiometabolic risk of the subjects rather than a general risk level (21). In this study, the observation of low significance in WHR and other methods in determining body composition and risk factors could be the result of the cut-off points for the national differences (22). It should be emphasized that high-risk indications based on anthropometric measurements from the waist-to-hip ratio provide better association than the risk measurements obtained BIA method (23). Body composition analysis in university student using BIA is mainly preferred way to follow their fitness and nutritional status and results (24). According to body composition analyses using the cut-off point of three different methods, BIA, WHR, and BMI, the risk distribution of medical students showed a wide range (Figure 1). Despite the significant correlation between increased fat mass and BMI, the distribution of normal and increased risk groups showed gender differences between (25) (Figures 2 and 3). The range of normal values estimated from BMI is overestimated with normal values of fat mass percent estimated by the BIA method in females while underestimation is observed in males (26) (Figure 2). The subjects in the high-risk group were similar in all three methods, BMI, BIA, and WHR parameters. These could be related to the cut-off point in the BIA formula for male subjects (27). The differences in body composition between male and female medical students have been found. There were 8% of high-risk groups in medical students who have information harmful effects of increased BMI and fat mass. The accuracy of valid body composition assessment using the BIA method has been questioned in some studies (28). However, it should be considered that the bioelectrical hydration (15) or dehydration (29). The study performed on patients before and after hemodialysis showed invalid body composition analysis (30). The selection of an effective method for assessing body composition in youth using bioelectrical impedance analysis or anthropometry may vary depending on the purpose, i.e. normal or obesity or abdominal adiposity (8).

Study Limitations: The main limitation of this study is the application of the bioelectrical impedance method to assess of body fat mass and fat-free mass, total body water content, instead of more accurate methods including energy dual x-ray absorptiometry, and air displacement plethysmography. However, the accuracy of the bioelectrical impedance method is an acceptable range, and its easy application with low cost and lack of radiation may be practicable for measuring body fat content in the young population.

Conclusion

Among young medical students, despite knowing the devastation of increased body fatness, there is nearly 8% in the high-risk group in all three groups. Although there was a correlation between BMI and BIA when the whole study group was taken into account, differences were observed between the groups with low and normal values may result in the differences between the cut-off points determined by ethnicity and gender. In general, although anthropometric measurements have provided meaningful results for population evaluation, technological evaluations should be taken into account in measurements in decision-making situations related to the health status of individuals.

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Ethics approval: The study, ethical approval was obtained from Kastamonu University Non-Interventional Clinical Research Ethics Committee with the decision numbered "2022-KAEK-89". All study procedures were carried out in accordance with the Declaration of Helsinki.

Conflict of interest: All authors declare that there is no conflict of interest.

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Author contributions:

S. A. A.: Visualization, Formal analysis.
S. Y.: Visualization, Formal analysis.
S. A.: Writing – review & editing.
O. O.: Writing – review & editing.

impedance method could result in invalid body composition analysis under the condition of

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