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Comparison of Body Mass Index and Bioelectric Impedance Analysis Methods in the Evaluation of Body Composition and Obesity in Women

Kadınlarda Vücut Kompozisyonu ve Obezitenin Değerlendirilmesinde Beden Kütle İndeksi ve Biyoelektrik İmpedans Analiz Yöntemlerinin Karşılaştırılması

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Abstract

Objective: Body mass index (BMI) is often used to diagnose obesity, although it has the disadvantage of not being able to reveal body fat content. Our study aimed (1) to evaluate the obesity status using BMI and body fat percentage (BF_{BIA}%) determined by bioelectric impedance analysis (BIA) method among women aged 20-60 years who were admitted the outpatient nutrition clinic, and (2) to evaluate the relationship between BMI and BF_{BIA}%.

Method: This study enrolled 100 women aged 20-60 years. It was a descriptive study. The study data and the BF_{BIA}% values were obtained from outpatient BMI data recorded between October 2020 and November 2020. BMI was calculated using body weight (kg) and body height (m^2). The prevalence of obesity was determined using BMI and BF_{BIA}%. Statistical analyses were performed using the Pearson's correlation test and One-Way analysis of variance.

Results: Prevalence of obesity, based on BMI and BF_{BIA}%, was 53% and 46%, respectively and no significant difference was determined (p=0.322). Subjects determined to be obese based on the BMI had a mean BF_{BIA}% of 40±18%. The subjects determined to be obese, overweight and normal

Öz

Amaç: Obezite tanısında sıklıkla beden kütle indeksi (BKİ) kullanılmakla birlikte, vücut yağ düzeyini ortaya koymaması dezavantajlı noktasıdır. Bu çalışmanın amaçları diyet polikliniğine başvuran, (1) 20-60 yaş grubu kadın bireylerde, BKİ ve biyoelektrik impedans analiz yöntemi (BİA) ile doğrudan saptanan vücut yağ yüzdesini ($VY_{BİA}$%) kullanarak obezite durumunu ve (2) BKİ ve $VY_{BİA}$% arasındaki ilişkiyi değerlendirmektir.

Yöntem: Çalışma 20-60 yaş arası 100 kadın bireyle yürütülmüştür. Bu araştırma tanımlayıcı tiptedir. Araştırma verileri ve vücut yağ yüzdesi (% $BF_{BİA}$) değerleri, poliklinik BİA kayıtlarından Ekim-Kasım 2020 arasında elde edilmiştir. Vücut ağırlığı ve boy uzunluğu ölçümleri kullanılarak BKİ hesaplanmıştır. Bireylerde obezite görülme sıklığı BKİ ve vücut yağ yüzdesi ($VY_{BİA}$%) kullanılarak belirlenmiştir. İstatistik olarak Pearson korelasyon testi ve tek-yönlü varyans analizi kullanılmıştır.

Bulgular: BKİ'ye göre kadınların %53'ü, BİA ile elde edilen vücut yağ yüzdesine göre %46'sı obez bulunmuştur. BKİ ve vücut yağ yüzdesi kullanılarak saptanan obezite arasında anlamlı bir fark bulunmamıştır (p=0,322). BİA'ya göre obez bireylerin ortalama vücut yağ yüzdesi ($VY_{BİA}$%) %40±18 olarak saptanmıştır. BİA yöntemi kullanılarak BKİ'ye göre şişman, hafif şişman ve normal vücut ağırlığındaki kadınların vücut

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based on the BMI had a mean BF_{BIA}% of 40.4±5.3, 34.4±4.1, and 23.2±6.2, respectively (p<0.001).

Conclusion: The obesity rates determined by BMI and BF_{BIA}% were similar. Since both BMI and BF_{BIA}% have different disadvantages, their combined use may yield better results in obesity screening in outpatients.

Keywords: Bioelectric impedance analysis, body fat percentage, body mass index, obesity

yağ yüzdeleri ise sırasıyla %40,4±5,30, %34,4±4,1, ve %23,2±6,2 olarak belirlenmiştir (p<0,001).

Sonuç: BKİ ve $VY_{BİA}$% birbiriyle pozitif olarak ilişkilidir. Vücut yağ yüzdesinin eşlik ettiği BKİ, kadın bireylerde şişmanlığın daha iyi bir tanımlanmasını sağlayabilir.

Anahtar kelimeler: Beden kütle indeksi, biyoelektrik impedans analizi, obezite, vücut yağ yüzdesi

Introduction

The prevalence of obesity is increasing among children and adolescents as well as adults worldwide. Obesity is one of the important health problems in developed and developing countries, being responsible for an increased incidence of non-communicable diseases such as cardiovascular diseases, hypertension, type 2 diabetes, hyperlipidemia, stroke, some type of cancers and diseases such as sleep apnea, liver and gall bladder diseases, osteoarthritis and gynecological problems (1). According to the body mass index (BMI) classification recommended by World Health Organization, the Turkish Nutrition and Health Study 2010 reported that overall 35.6% (men: 39.1%; women: 29.7%) were overweight and 30,3% (men: 20.5%; women: 41.0%) were obese (2).

Defining body composition has an important role in the assessment of an individual's health status. The metabolic tissue in human body is composed of 1) lean body mass consisting of intracellular fluid, extracellular fluid, and bone tissue, and 2) fat mass. The main goal of the evaluation of an individual's obesity status is to determine the fat tissue (3).

The methods used to assess the body composition are categorized as the direct and indirect methods. The direct methods calculate the chemical composition of the body. They include isotope and chemical dilution method (body water, body potassium), body density and volume (underwater measurement, plethysmographic method, BODPOD), total body electric conductivity and bioelectric impedance analysis (BIA), imaging methods (USG), computerized topography, magnetic resonance, dual-energy X-ray absorptiometry (DEXA), and whole body neutron activation analysis. The indirect methods are skin fold thickness measurement, upper arm fat are, waist/hip ratio, waist circumference/height ratio, and BMI (4).

Although DEXA and magnetic resonance imaging are considered gold standard for determining body, their disadvantages such as the need for equipment and trained personnel, and high cost limit their use. Thus, BIA analysis is more practical and more widely used (5). BIA can be used for non-invasive tissue characterization because tissues produce a complex electrical impedance depending on their composition, structure, health status, and the applied signal frequency. This method is based on the electrical conductivity difference between lean tissue mass and fat mass. In this method, weak electrical current impedance is measured. Hand to hand, hand to foot, and foot to foot measurements with different BIA analysis tools could be done. A wide range of information is obtained, such as body fat content, lean body mass, body water content, and fat mass distribution in various body parts (6).

An adult human body is approximately composed of 16% protein, 15-20% fat, 0.5% carbohydrates, 4.5% minerals, and 60% water (7). Overweight and obesity are defined as abnormal or excessive fat accumulation in the body, which poses a risk to health. Based on an individual's BMI, overweight is defined as BMI ≥25 kg/m^2 and obesity as BMI ≥30 kg/m^2. Percentage of body fat (BF_{BIA}%) corresponds to 30 kg/m^2 (8).

The use of BIA may not be reliable in patients with a BMI outside the range of 16 to 34 kg/m^2, any abnormality of body shape, impaired hydration, impaired extracellular and intracellular fluid distribution, liver cirrhosis, renal failure, cardiac failure, and morbid obesity (9). Although BIA method is reliable, there is no international standardization of device manufacturing, which causes various devices to yield different results and prevents a direct comparison between studies and establishing generally accepted reference values (10). In BIA, body composition is determined by different formulae using resistance, reactance, age, gender, and different anthropometric parameters (11). Since BIA's accuracy mainly depends on the equation used, many researchers have developed special equations to be used in obese adult populations (12-14). However, definitive conclusions cannot be drawn regarding the predictive ability of these equations.

The objective of our study was to compare the obesity status that was determined by simple body fat percentage directly determined by BIA and the one that was determined by BMI in female outpatients admitted to the diet outpatient clinic. The number of studies conducted in Turkey on this subject is limited and very few of them are related to the patient population, so this study is important in terms of providing data on the patient population.

Materials and Methods

This descriptive and retrospective study was approved by Adnan Menderes University Faculty of Medicine Non-invasive Clinical Research Ethics Committee (committee decision no: 9, dated: 17.09.2020). Informed consent forms were obtained from the patients before the procedure. The study group was composed of 100 female patients aged 20-60 years who visited Aydın Adnan Menderes University Research and Training Hospital outpatient nutrition clinic between October 2020 and November 2020. The patient records determined by BIA and body weight and height measurements were recorded. The study excluded males, in-patients, morbid obese patients, cancer patients, and patients with kidney disease. As the prevalence of obesity is higher in females than in the males, females are included in the study.

Tanita BC418 device (Tanita BC418 Tanita Corp, Tokyo, Japan) (eight-contact electrode system Model BC-418 analyzer) was used for BIA analysis method. Body weight (kg), body fat mass (BFM_{BIA}-kg), body fat percentage ($\%BF_{BIA}$), lean mass (LBM_{BIA}-kg), and total body water percentage (%TBW) were determined by BIA.

BMI was calculated using the formula [weight (kg)/height (m^2)] (14). Women with a BMI of 18.5-24.9 kg/m^2 were defined as normal, those with a BMI of 25.0-29.9 kg/m^2 as pre-obese, and those with a BMI of 30.0-39.9 kg/m^2 as obese (2). In the literature, among individuals diagnosed with obesity by BMI, BF_{BIA}% corresponding to 30 kg/m^2 is defined as >25% for men and >35% for women (8). In our study, women with a BF_{BIA}% ≥35 were considered obese. The reliability study of Tanita BC418 device for use by health professionals was performed (15). Its confirmation study was conducted with dual energy X-ray absorptionmetry (DEXA), which is considered a gold standard (16).

Statistical Analysis

Statistical analyses were performed with SPSS 18 software package (IBM SPSS Inc. Chicago, USA). Normality of data distribution was tested with the Kolmogorov-Smirnov test. Descriptive statistics were given as mean ± standard deviation and frequency (percentage) for quantitative and qualitative variables, respectively. Whether the qualitative variables were independent of each other was tested by chi-square analysis. Analysis of One-Way ANOVA was used to compare the BMI groups, and the correlation between BMI and BIA measurements was determined using Pearson's correlation analysis. p-values less than 0.05 were considered statistically significant.

Results

The female individuals had a mean age, height and body weight of 45.6±11 years, 1.58±0.6 (m), and 78.9±16 (kg), respectively (Table 1). According to the BIA method, the mean fat percentage (BF_{BIA}%) was determined as 36.2±7.0%, fat mass as 29.7±11 kg, total body water content as 36.1±5.0 kg, and lean body mass as 49.2±7.0 kg. Women determined to be obese according to BMI values had a mean body fat percentage of 40±18% (Table 1).

Obesity rate was 46% by BIA body fat percentage (BF_{BIA}%) and 53% by BMI. No significant difference was found between the obesity rates determined by BMI and BIA body fat percentage (p=0.322) (Graphic 1).

The prevalence of normal, overweight and obesity among females were determined using BMI values, as 12 (13%), 35 (34%), and 53 (53%), respectively (Table 2).

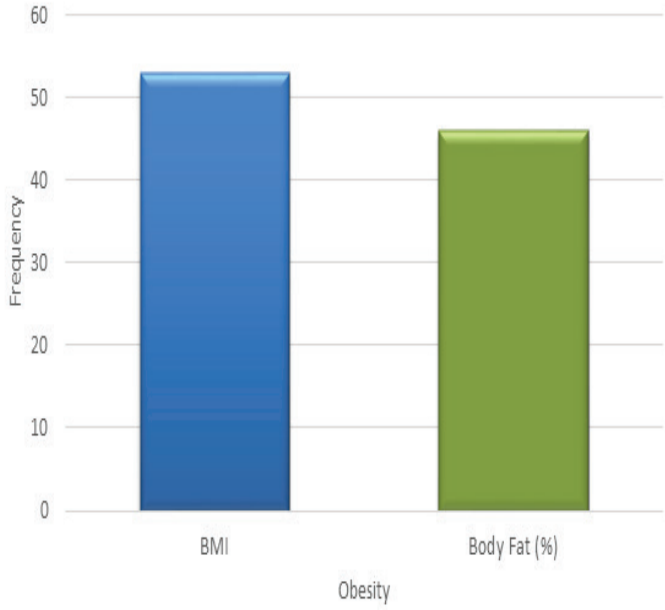
The body fat percentages ($\%BF_{BIA}$) of obese, overweight, and normal women determined by BIA were 40.4±5.3%, 34.4±4.1%, and 23.2±6.2%, respectively and BMI groups were statistically different from each other (p<0.001). Body fat percentage increased as the BMI values increased (Table 2).

Table 1. Anthropometric measurements of individuals (n=100)

Characteristics of the study sample	Mean ± SD
Age (y)	45.6±11
Height (m)	1.58±0.6
Body weight (kg)	78.9±16
BMI (kg/m^2)	31.49±6.0
BIA, body fat (BF, %)	36.2±7.0
BIA, body fat mass (FM, kg)	29.7±11
BIA, total body water (kg)	36.1±5.0
BIA, fat free mass (FFM, kg)	49.2±7.0

BMI: Body mass index, SD: Standard deviation, BIA: Bioelectric impedance analysis

There was a very strong positive linear correlation between BMI and BF% (BIA) (r=0.798) (p<0.001) (Graphic 2).



Graphic 1. Comparison of obesity rates determined by body mass index (BMI) and body fat percentage (BIA) (p=0.322)

Table 2. The distribution of obesity and body fat percentage (BIA) according to the BMI of individuals

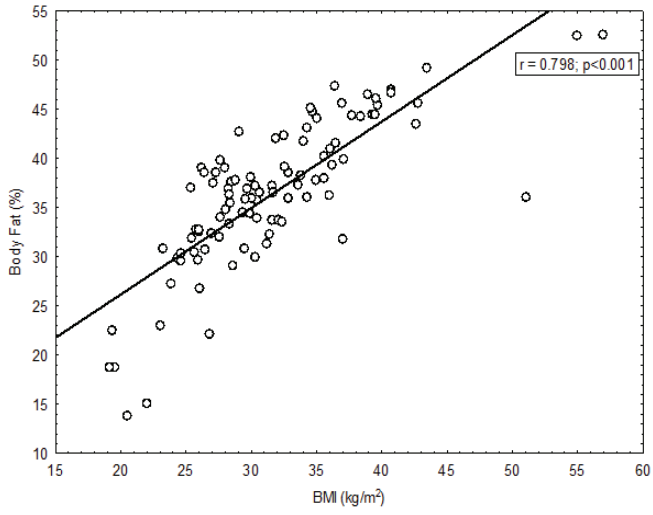
BMI (kg/m²)	n (%)	%BF_{BIA}	p	F
Normal (18.5-24.9)	12 (13%)	23.2±6.2	<0.001*	59.165*
Overweight (25.0-29.9)	35 (34%)	34.4±4.1	-	-
Obese (30.0-39.9)	53 (53%)	40.4±5.3	-	-

*Analysis of One-Way ANOVA, BMI: Body mass index, BIA: Bioelectric impedance analysis

Discussion

In a report dated 2004, ESPEN (European Society for Clinical Nutrition and Metabolism) stated that MF-BIA (Multi-frequency BIA) and segmental-BIA could be used in patients with a BMI of 16-34 kg/m² and without abnormal hydration, provided that the results were carefully interpreted (17). In this study, patients had a mean BMI of 31.49±6.0 kg/m².

This study compared the efficacy of BMI and BIA in the diagnosis of obesity. Women with a BF_{BIA}%>35 were considered obese. Our study determined that the obesity prevalence was 53% by BMI and 46% by body fat percentage (BF_{BIA}%). There was no significant difference between BMI and BF_{BIA}% in this regard (p=0.322).



Graphic 2. Determination of the relationship between body mass index (BMI) and body fat percentage (%BF_{BIA})

BMI strongly correlated with BF % estimated by bioelectrical impedance in our study (Graphic 2) (r=0.798) (p<0.001). Our results are corelated with the results of Ranasinghe et al. (18).

Women who were obese by BMI were found to have a BFBIA% of 40.4±5.3. A study carried out in Brazil revealed a BFBIA% of 41.0±3.0% among obese women with a mean age of 50 years (19).

In a study conducted among 136 obese women with a mean age of 48.1±7.7 years and a BMI of 30.4±2.9 kg/m², the mean BF_{BIA}% was found as 41.0% by using BIA (TanitaBC-418) device, which is also used in this study (20). The values of prevalences were found similar for the obese women. Chen et al. (21) reported a mean BF_{BIA}% of 29.85±7.93% in 299 healthy women with a mean age of 37.49 years and a mean BMI of 23.57±4.51 kg/m².

We determined a mean BF_{BIA}% of 23.2±6.2% in our study for normal BMI group. Willett et al. (13) evaluated the reports provided by various clinicians and reported that BF_{BIA}% was not superior to BMI as a marker of general lipoidosis in both sexes in a general population with a mean age of 21-70 years. We also reached to similar results. In a study, where Tanita Bc-418 and DEXA were used, Majeed et al. (22) compared healthy adults and reported that the strongest agreement between BIA and DEXA occurred for the estimation of total body fat percentage and the weakest in the estimation of extremity fat mass content. Uğraş and Özdenk (23) compared BMI and BIA measurements in 175 sedentary men and 105 sedentary women at the age of 18 to 25 years. They reported that BMI and BIA showed a

strong correlation for healthy body composition in both genders, being statistically significant for women (r=0.879, p<0.001). Saygın et al. (24) investigated the prevalence of obesity and body analysis values in female individuals admitted to the outpatient diet clinic. A total of 7267 women had a mean age of 37.18±13.64 years, a mean BMI of 31.33±7.35 kg/m^2, and a mean BF_{BIA}% of 36.77±7.49%. In this study it was found that 100 women with a mean age of 45.6±11 years had a mean BMI of 31.49±6.0 kg/m^2, and a mean BF_{BIA}% of 36.2±7.0%. Saygın et al. (24) used the same BIA device model as the one used in our study. We believe that the reason why we found a higher BF_{BIA}% in our study is that the females were admitted to the outpatient diet clinic for a disease event or for weight reduction diets. BIA methods is not recommended that Segal correction equation be used if a multifrequency BIA device is not used in morbid obese patients (25). We excluded morbid obese (BMI: >40 kg/m^2) patients for this reason. In our study, the BIA method determined that obese, overweight, and normal weight women had body fat percentages (BF_{BIA}%) of 40.4±5.3, 34.4±4.1, and 23.2±6.2, respectively (p<0.001). There was a significant difference in BF_{BIA}% between the groups (p<0.001). Kaner et al. (26) found body fat percentages of 41.2±4.2, 33.5±3.6, and 26.4±4.4 using BIA in obese, overweight, and normal weight women aged 20-49 years, respectively. These findings are in parallel with our study findings. Gallagher et al. (27), in a study conducted in 2000, measured body fat percentage using DEXA, the gold standard for this indication. They found body fat percentages as 21-33% in subjects with a BMI <18.5 kg/m^2 for the age groups of 20-39 and 40-50 years, respectively. Percentage of 33-34% was found in subjects with a BMI ≥25 kg/m^2 and 39-40% in subjects with a BMI≥30 kg/m^2. These results are very similar to our results.

It was reported that BIA provides a relatively accurate estimation of BF_{BIA}% in overweight and obese individuals after the end of the weight loss program, but BIA provides a less accurate estimate of body fat percentage in obese individuals during the weight change program (28).

BMI is a practical, easy and a good tool to estimate excess body weight. However, it is not as useful in determining obesity due to high fat mass or individuals with a very high muscle mass (e.g athletes) and those with a low muscle mass (e.g. in elderly, sarcopenia). BMI was never designed to make diagnosis (1,29). In this study, the mean age of individuals was 45.6±11 years and the elderly people were not included in the study and the mean FFM was 49.2±7.0 kg.

Conclusion

In conclusion, although BMI maintains its importance for obesity screening, especially in large population-based studies, but adding a body fat percentage (BF_{BIA}%) estimate using BIA may provide a good estimate ability to determine excess body fat, especially in outpatient diet clinics and hospitals in the evaluation of obesity.

Ethics

Ethics Committee Approval: This descriptive and retrospective study was approved by Adnan Menderes University Faculty of Medicine Non-invasive Clinical Research Ethics Committee (committee decision no: 9, dated: 17.09.2020).

Informed Consent: Informed consent forms were obtained from the patients before the procedure.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: F.S., Design: F.S., C.Ü., A.A.E., E.E., A.B.R., H.Ö., A.G.P., Supervision: C.Ü., A.A.E., A.B.R., H.Ö., A.G.K., Fundings: F.S., E.E., A.A.E., A.G.P., C.Ü., A.B.R., H.Ö., Materials: F.S., Data Collection or Processing: F.S., Analysis or Interpretation: H.Ö., Literature Search: F.S., A.G.P., C.Ü., E.E., A.A.E., A.B.R., Writing: F.S., E.E., C.Ü., A.G.P., A.A.E., H.Ö., A.B.R., Critical Review: A.G.P., C.Ü., A.A.E., A.B.R., E.E., A.B.R.

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References

1. Williams EP, Mesidor M, Winters K, Dubbert PM, Wyatth SB. Overweight and obesity: Prevelance, consequences, and causes of a growing public health problem. Cur Obes Rep 2015;4(3):363-370.
2. World Health Organization. Physical Status: The use and interpretation of anthropometry. Report of a WHO Expert Committee. In: World Health Organization Technical Report Series 1995;854:1-452. Available from: https://www.who.int/childgrowth/publications/physical_status/en/;2020 Accessed: 30.12.2020
3. Köksal E, Küçükerdönmez Ö. Şişmanlığı saptamada güncel yaklaşımlar. Baysal A, Baş M (editör). Yetişkinlerde ağırlık yönetimi. İstanbul: Express Baskı, 2008:35-70.
4. Pekcan G. Hastanın beslenme durumunun saptanması. Ankara: Klaasmat Matbaacılık, 2008:1-50.
5. Melikoğlu M, Öner C, Tüzün S, Temizkan Ş, Orbay E. Comparison of new and old body shape indices to estimate body fat in obese

and morbid obese turkish females. Turk J Endocrinol Metab 2020;24:1-8.

6. TC Sağlık Bakanlığı. Beslenme drumunun saptanması. 1st ed. Ankara: Klasmat Matbacılık, 2008.
7. Aksoy M. Beslenme, Diyet ve Gıda Sözlüğü. Ankara: Hatiboğlu Yayınları, 2007.
8. World Health Organization. European Health Report 2018: More than numbers - evidence for all. Available at: https://www.euro.who.int/en/publications/abstracts/european-health-report-2018.-more-than-numbers-evidence-for-all-2018;2020 Accessed: 13.12.2020
9. Ayyıldız F, Köksal E. Current approach in the evaluation of nutrition, hydration status and disease risk: bioelectrical impedance vector analysis. Journal of Health Sciences 2016;25(3):155-160.
10. Norman K, Stobäus N, Pirlich M, Bosy-Westphal A. Bioelectrical phase angle and impedance vector analysis--clinical relevance and applicability of impedance parameters. Clin Nutr 2012;31(6):854-861.
11. Gray DS, Bray GA, Gemayel N, Kaplan K. Effect of obesity on bioelectrical impedance. Am J Clin Nutr 1989;50(2):255-260.
12. Gómez-Ambrosi J, Silva C, Galofré JC, Escalada J, Santos S, Millán D, et al. Body mas index classification misses subjects within creased cardiometabolic risk factors related to elevated adiposity. Int J Obes (Lond) 2012;36(2):286-294.
13. Willett K, Jiang R, Lenart E, Spiegelman D, Willett W. Comprarsion of bioelectrical impedance and BMI in predicting obesity-related medical condition. Obesity (Silver Spring) 2006;14(3):480-490.
14. Kaya H, Özçelik O. Comparison of Effectiveness of Body Mass Index and Bioelectric Impedance Analysis Methods on Body Composition in Subjects with Different Ages and Sex. F.U. Med. J. Health. Sci 2009;23(1):1-5.
15. Kelly JS, Metcalfe J. Validity and reliability of body composition analysis using the tanita BC418-MA. Journal of Exercise Physiology Online 2012;15(6):74-83.
16. Sluyter JD, Schaaf D, Scragg RKR, Plank LD. Prediction of fatness by standing 8-electrode bioimpedance:A multi ethnic population. Obesity (Silver Spring) 2010;18(1):183-189.
17. Kyle UG, Bosaeus I, De Lorenzo AD, Deurenberg P, Elia M, Manuel Gómez J, et al. Bioelectrical impedance analysis-part II: utilization in clinical practice, Clin Nutr 2004;23(6):1430-1453.
18. Ranasinghe C, Gamage P, Katulanda P, Andraweera N, Thilakarathne S, Tharanga P. Relationiship between body mass index (BMI) and body fat percentage, estimated by bioelectrical impedance, in a group of Sri Lankan adults: a cross sectional study. BMC Public Health 2013;13:797.
19. Ravaglia G, Forti P, Maioli F, Boschi F, Cicognani A, Gasbarrini G. Measurement of body fat in healthy elderly men: a Comparison of Methods. J Gerontol A Biol Sci Med Sci 1999;54(2):70-76.
20. Pimentel GD, Bernhard AB, Frezza MRP, Rinhaldi AEM, Burini RC. Bioelectric impedance over estimates the body fat in overweight and underestimates in Brazilian obese women: a comparation with Segal Equation. Nutr Hosp 2010;25(5):741-746.
21. Chen KT, Chen YY, Wang CW, Chuang CL, Chiang LM, Lai CL, et al. Comparison of standing posture bioelectrical impedance analysis with DXA for body composition in a large, healthy chinese population. PLoS One 2016;11(7):e0160105.
22. Majeed KG, Sulyman SAA, Fathi HB. Estimation of segmental and total body fat in healthy adults: comparison of bio-electric impedance analysis and dual energy X-ray absorptiometry. Turk J Endocrinol Metab 2019;23:240-247.
23. Uğraş S, Özdenk Ç. Comparative evaluation of bioelectrical impedance analysis and anthropometric measurements of body composition in sedentary young male and female subjects. Journal of Health Sciences 2020;29(1):14-18.
24. Saygın M, Öztürk Ö, Akbulut S, Kılınç F, Saygın RR. Obesity prevalence in patients of SDU School of Medicine Hospital diet policlinic. Med J SDU 2015;22(3):53-59.
25. Segal KR, Loan MV, Fitzgerald PI, Hodgdon JA, Itallie TBV. Lean body mass estimation by bioelectrical impedance analysis: a four-site cross-validation study. Am J Clin Nutr 1988;47(1):7-14.
26. Kaner G, Pekcan G, Pamuk G, Pamuk BÖ. Skinfold thickness versus bioimpedance analysis: body fat prediction in adults. Bes Diy Derg 2015;43(2):111-118.
27. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. Healthy percentage body fat ranges:An approach for devoloping guidelines based on body mass index. Am J Clin Nutr 2000;72(3):694-701.
28. Li YC, Li CI, Lin WY, Liu CS, Hsu HS, Lee CC, et al. Percentage of body fat assessment using bioelectrical impedance analysis and aual-energy X-ray absorntiometry in weight loss program for obese or overweight Chinese adult. PloS One 2013;8(4):e58272.
29. Bogin B, Varela-Silva. The body mass index: The good, the bad, and the horrid. Bulletin der Schweizerischen Gesellschaft für Anthropologie 2012;18(2):5-11.