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Assessment of Body Fat Percentage by Different Methods: A Comparative Study

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ABSTRACT

The aim of this study was to compare measurements of body fat percentage (%BF) by bioelectrical impedance analysis (BIA) with two other methods, skinfold thickness measurements (STM) and Body Mass Index (BMI), in healthy subjects. A total of thirty healthy male with age ranges 26 to 49 years were selected as a subject from Gwalior for this study. % BF was assessed by using BIA and was compared with that measured by skinfold thickness equation and body mass index. Predicted percentage body fat (%BF) was derived from bioelectrical impedance by Maltron BF 908 body composition analyzer, skinfold equation given by Durnin and Womersley and body mass index specific prediction formula given by Deurenberg, Weststrate and Seidell. One way ANOVA result showed significant difference of %BF among different weighing methods. In the total group, %BF (BIA) (9.40 ± 4.1%) was significantly different from %BF (SFT) (19.95 ±5.9%) and %BF (BMI) (19.67 ±4.3 %).Although %BF (BIA) was significantly correlated with %BF (SFT)(r=0.667,p<.003)and with %BF (BMI)(r=0.816,p<.01). BIAin compare to skinfold thickness equation,underestimated body fat percentage by 10.55 kg and with BMI, underestimated body fat percentage by 10.27 Kg(p<.000 both). Bodyfat measurements using BIA were significantly correlated with those using STM and BMI across a wide range of body fat levels in healthy adults. The results between BIA and other two methods were significantly different. BIA underestimated%BFto %BF assessed by SFT and BMI methods. However, the error associated with level of body fat is not negligible and requires further investigation.

Key word: Body Fat Percentage (%BF), Skinfold Thickness Measurements (STM), Bioelectrical Impedance Analysis (BIA), Body Mass Index (BMI).

INTRODUCTION

The growing popularity of physical activity for enhancing health and fitness has sharpened the health care professional’s perspective on techniques for evaluating body composition. Health care professionals require accurate measurements of body composition in order to consult with patients about desirable body weights and appropriate proportional body compositions for optimal health [1].

Preventing and managing overweight and obesity are complex problems, with no easy answers. Numerous methods for estimating these figures are available, and each has its own limitation, be it technical or biological. Quantification of body fat is needed not only for studies of the nature and treatment of obesity, but also for a variety of investigations that range from the assessment of nutritional status to the determination of the nature of the response of patients to a variety of diseases and metabolic disorders. Body fat mass is the difference between total body mass and FFM or LBM [2].

Body fat assessment is an important tool for fitness professionals and can provide an indicator of health and health risk. The determination of the percentage of body fat (% Fat) has gained increasing emphasis as a factor in physical fitness. Obesity and overweight have been associated with the susceptibility to cardiovascular disease, and the use of % Fat determinations may be useful in estimating more optimal weights for most individuals[3].

Bioelectrical Impedance Analysis (BIA) offers a great potential for noninvasive assessment of body composition becauseit is safe, portable, easy to use and much cheaper than the previous,Instrumental techniques. From the measurement of reactance and resistance, the total body water (TBW) and FFMcould be calculated [4] andconverted into BF content using a variety of equations [5]. The Cheapest and most common methods to assess BF% are anthropometric techniques, especiallyskinfolds thickness measure, which provide an estimate ofthe subcutaneous fat depot, recalculated for the total BF orBD [6].For the assessment of BF in epidemiological studies, a weight-height index is also the most simple and inexpensive method, and the errors in measurement due to intra-or inter-observed variation are small. The body mass index (BMI) seems to be the most appropriate, because its correlation is high with BF% and low with body height [7].

Question remain unanswered whether bioelectric impedance analysis tends toover- or underestimate percentage of body fat when compared with skinfolds thickness measurements and body mass index methods of fat assessment because most of the studies were performed in patients with different diseases. Therefore, the present study was conducted in order to evaluate the measurements of body fat obtained by skinfolds thichness measurements and body mass index using bioelectric impedance analysis as a reference method in healthy peoples.

MATERIALS AND METHODS

2.1. Subjects

A total of thirty (N=30) males with age ranges from 26 to 49 years, were randomly selected as a subject for the study from Gwalior City. Written consent was taken from each subject willing to participate before the start of study. Subjects were free to withdraw their names from study at any time without asking for any reason. Body fat Percentage was assessed by using skinfold thickness equation, bioelectrical impedance and body mass index. Predicted percentage body fat (%BF) was derived from skinfold equation given by Durnin and Womersley, bioelectrical impedance by Maltron BF 908body composition analyzer and body mass index specific prediction formula given by Deurenberg, Weststrate and Seidell.

1.2. Procedures

Measurements were made on a single day between 06:30-10:00 AM. Subjects did not allow eatingupto eight hours before testing, refrained from exercise for at least the previous twelve hours. Skinfold measurementwas performed at four sites (biceps, triceps, subscapular and suprailiac) on the opposite side of the vascular access using the skinfold caliper. Three sets of measurements were averaged for each site. Body density was calculated using the formula of Durnin and Womersley and the percentage of body fat was then calculated by Siri's equation.

Maltron BF-908 Analyser with a four electrode arrangement that introduces a painless signal into the body was also used to estimate the %BF. This equipment uses the scientific tetrapolar method of four electrodes which are applied to the right side of the body on the hand, wrist, foot and ankle. First of all subject was allow to resting in supine position with hands and legs slightly apart, after that entering was done regarding all the parameters asked by the instrument afterward Maltron BF-908 was activated. The processing powers of the BF-908 analyses the data and displays the statistics within seconds.

Body Mass Index, was another method used in this study for estimating a person's body fat percentage based upon simple weight and height measurements. While the body mass index calculation is an indirect measurement, it has been found to be a fairly reliable indicator of body fat measures in most people. Body mass index prediction formula given by Deurenberg, Weststrate and Seidell was used to determine body fat percentage using age, body mass index and sex (R^2 0.79, SEE = 4.1% BF %).

2.3 Statistical Analysis

The results were expressed as Mean and Standard Deviation. The measurements obtained by the Bioelectrical Impedance Analysis (BIA) were compared with obtained from Skinfold Thickness Measurements (STM) and Body Mass Index (BMI) using one way analysis of variance (ANOVA). Further, LSD test was used to determine the cause of significance obtained through one-way ANOVA. To evaluate the strength of relationship between fat percentage assessment methods namelyBIA, STMand BMI, was obtained by the Pearson product moment correlation. Agreement between these three methods was shown by plotting the difference in body fat percentage against mean body fat percentage as obtained by three methods (Bland and Altman, 1986)[8] with the help of MedCalc software and SPSS version 19. Statistical significance was set at $p < .05$.

RESULTS

The results of body fat percentage assessment methods by three different methods namely Bioelectrical Impedance Analysis, Skinfold Thickness Measurements (STM) and Body Mass Index (BMI) are presented in the following tables.

Table 1 Subjects Characteristics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Age	30	23.00	26.00	49.00	35.17	7.3
Height	30	22.20	165.50	187.70	174.49	5.9
Weight	30	35.00	53.00	88.00	70.45	8.3

Table 2 Descriptive Statistics for Different Methods of Body Fat Percentage Assessment

Methods of Fat Percentage Assessement	N	Mean	Std. Deviation
Skinfold Thickness Measurements	30	19.95	5.9
BioelectrialImpedence	30	9.40	4.1
Body Mass Index	30	19.67	4.3

The characteristics of the study subjects with the help of descriptive statistics are presented in Table 1. There were total thirty participants included in this study. The mean and standard deviation for age, height and weight of the subjects were 35.17 ± 7.3, 174.49 ± 5.9 and 70.45 ± 8.3 respectively.

Table 2 reveals the descriptive statistics for the three different body fat percentage assessment methods used in the study. The mean and standard deviation values for percentage of body fat by skinfold thickness measurements, bioelectrical impedance and body mass index for the study group as a whole were 19.95 ± 5.9, 9.40 ± 4.1 and 19.67 ± 4.3 respectively as shown in figure 1.

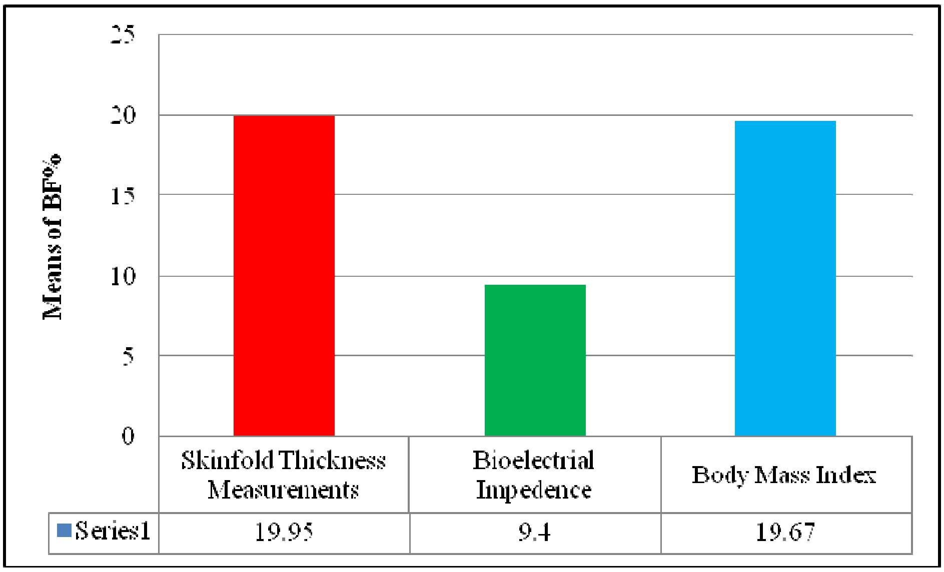

Figure 1: Graphical Representation of Body Fat Percentage Means Assessed by Three Different Methods

Table 3 Significance of Difference between Means of Different Body Fat Percentage Assessment Methods

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2168.307	2	1084.154	45.763	.000
Within Groups	2061.069	87	23.690		
Total	4229.376	89			

**Significant at 0.05 level.; F_{05} (2, 87) = 3.09*

Table 3 reveals that there was a significant difference between different methods of body fat assessment namelyBioelectrical Impedance Analysis (BIA), Skinfold Thickness Measurements (STM) and Body Mass Index (BMI)as calculated value of F (45.763) was greater than that of tabulated value (3.09) at .05 level of significance with 2, 87 degree of freedom.

Table 4 Pair wise Comparison between Body Fat Percentage Means Assessed by Different Methods

Bioelectrical Impedance	Skinfold Thickness	Body Mass Index	MD	p-value
9.40	19.95		-10.55^{*}	.000
9.40		19.67	-10.27^{*}	.000
	19.95	19.67	0.29	1.000

**Significant at 0.05 level; p<0.01.*

As the differences between the means ofbody fat percentage determined by different methods i.e., Skinfold Thickness Measurements, Bioelectrical Impedance andBody Mass Index found significant as shown in Table 3. Therefore, the post-hoc test was employed to compare each method with each other, using the null hypothesis that the means are equal as shown in Table 4. Looking at the results (p-values) we can see the comparison between bioelectrical impedance analysis and skinfold thickness measurements was significant, as the p-value was lower than 0.05, so we reject the null hypothesis of no difference in means between these two methods. When looking at the comparison of bioelectrical impedance analysis with body mass index method, the p-value was again less than 0.05, and even 0.001 so the value was highly significant. So, again we reject the null hypothesis of the means for these two methods being equal. The comparison of skinfold thickness measurements and body mass index method shows no significant difference as the p-value was more than 0.05.

Table 5 Correlationof Body Fat Percentage Obtained by Three Different Methods

	BioelectrialImpedence	Skinfold Thickness	Body Mass Index
BioelectrialImpedence	1	$.667^{**}$	$.816^{**}$
Skinfold Thickness		1	$.751^{**}$
Body Mass Index			1

**Significant at 0.05 level.; $r_{.05}$ (28) = 0.361*

Table 5 reveals that Body Fat Measurements using Bioelectrical Impedancewas significantly correlated with two other methods i.e., Skinfold Thickness measurements and Body Mass Index as calculated value of ‘r’ was greater than that of tabulated value at .05 level of significance with 28 degree of freedom.Figures 1- 3 present comparison of Bioelectrical Impedance, Skinfold Thickness measurements and Body Mass Index. They show the individual differences in all methods.

DISCUSSION AND CONCLUSION

Body-composition information is extensively used in clinics, sports medicine, and other health-related fields [2,9,10,11,12]. Methods such as DXA, air-displacement plethysmography, and underwater weighing can provide accurate results; however, these methods are costly and often inaccessible to the public. In most situations, Bioelectrical Impedance Analysis and other field methods are the only techniques available for body-composition measurements. The results of the present study bridge the gap between previous contradictory studies and provide reliable information on the correct interpretation of body fat percentage analysis.

The statistical finding of the present study revealed that there was a large variation in body fat percentage among three different fat assessment methods. The mean body fat percentage obtained by bioelectrical impedance in all subjects was significantly lower than that measured by skinfold thickness measurements and body mass index methods: 9.40 ± 4.1compared with 19.95 ± 5.9 and 19.67 ± 4.3 as shown in Table 2. From this finding, we may conclude that bioelectrical impedance analysis method underestimated the body fat.

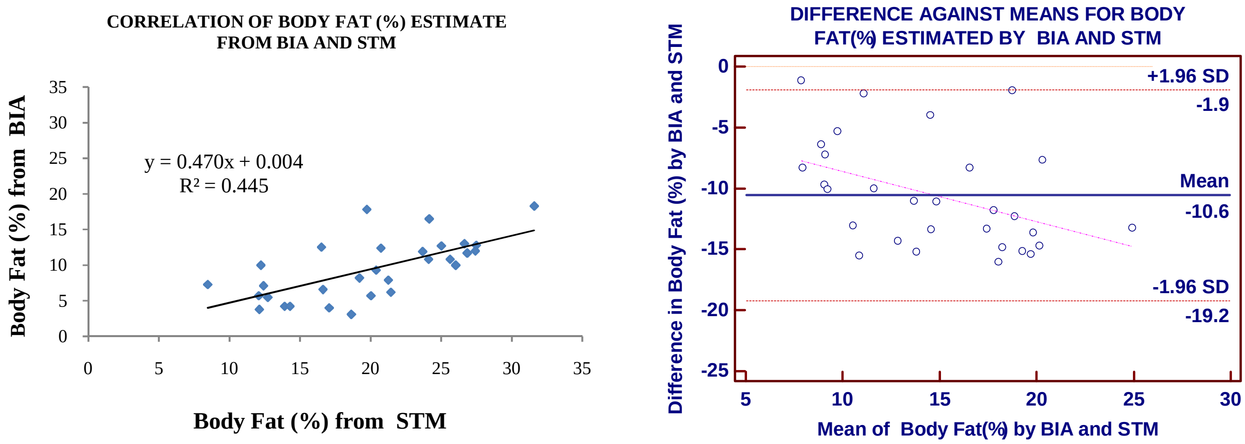

Figure 2: The correlation of Body Fat Percentage estimated from Bioelectrical Impedence Analysis (BIA) and from Skinfold Thickness Measurement (STM) methods of Fat Assessment, and the difference in the two estimates plotted against their mean.

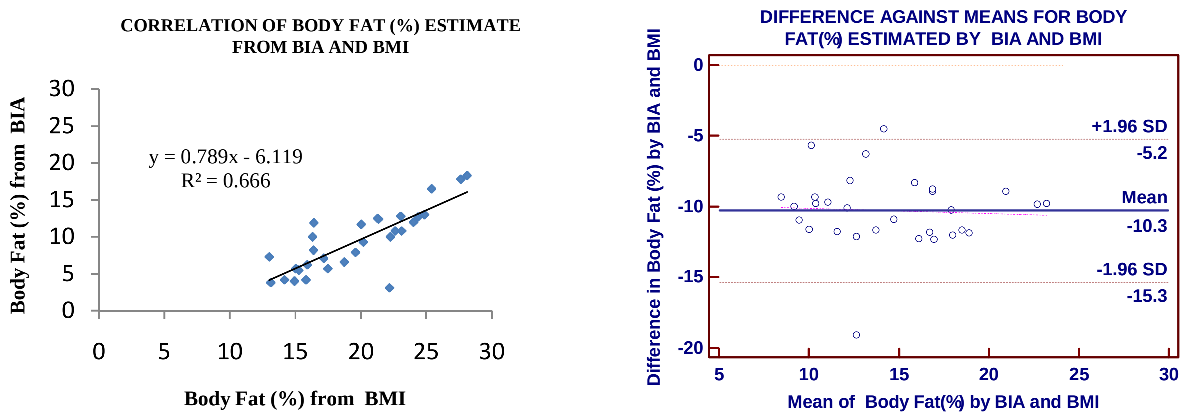

Figure 3: The correlation of Body Fat Percentage estimated from Bioelectrical Impedence Analysis (BIA) and from Body Mass Index (BMI)methods of Fat Assessment, and the difference in the two estimates plotted against their mean.

From Table 3 it was concluded that there was a significant difference among bioelectrical impedanceanalysis, skinfold thickness measurements and body mass index methods for assessing the body fat percentage. Compared with bioelectrical impedance analysis, skinfold thickness equation overestimated body fat by 10.55 kg and body mass indexoverestimated body fat by 10.27 Kg(p<.000 both).Pair wise comparison also showed that BIA significantly differ from other two methods namely SFT and BMI. Stall et al. [13] found in peritoneal dialysis patients that the results for body fat varied significantly by different techniques in men and women. They observed a tendency for BIA to underestimate fat content in men and overestimate fat in women. Moreover, with the increase in BMI there was a larger error of BIA, as demonstrated by the significant and direct correlation coefficient found between the difference in BIA and the parameter of BMI.

As shown in Table 4, bioelectrical impedance was significantly correlated toothers two methods namely skinfold thickness measurements and body mass index, which is also consistent with other reports. The results of this study are in the line of study conducted byDinizAraújoet. al., SiqueiraVassimon H. et. al.;Kamimura MAet. al. and Natália Cristina Lima Rodrigues et.al. [14,15,16,17]They found strong correlation between body fat percentage assessed by bioelectrical impedance and that assessed by different anthropometric indicators. This is, perhaps, not surprising given the fact that the impedance method is based on an estimate of total body water which is then used to calculate body fat content. This finding was in the line of study conducted by R J Maughan [18].

In nutshell, parallel measurement of body fat percentage by bioelectrical impedance analysis, skinfold thickness measurements and body mass index method showed that bioelectrical impedance analysis must be carefully interpreted when used on lean and obese persons. Bioelectrical impedance analysis tends to underestimate body fat in all subjectsin comparison to Skinfold thickness and Body Mass Index methods. Bioelectrical impedance method cannot be replace by the skinfold thickness method and body mass index methods. This thing must be taken into consideration when interpreting bioelectrical impedance data.

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REFERENCES

[1]Kennon T Francis. *Physical Therapy*.**1990**,**70**(10):657-662.
[2] S. H. Cohn et. al. *The American Journal of Clinical Nutrition*.**1981**,**34**: 2839 –2847.
[3] T. R. Thomas, and P. L. Cook, *Brit. J. Sports Med.* **1978**, 12(1): 33-36.
[4] National Institute of Health, Bioelectrical impedance analysis in body composition measurement: National Institutes of Health Technology Assessment Conference Statement. *Am. J. Clin. Nutr.* **1996**, **64**: 524S-532S.
[5.] Hautkooper L.B., Lohman T.G., Going S.B., Howell W.H. *Am. J. Clin. Nutr.*, **1996**, **64**: 436S-448S.
[6] Durnin JV, Womersley J. *Br J Nutr.* **1974**,**32**(1):77–97.
[7] Durnin J.V.G.A., Rahoman M.M. *Br. J. Nutr*.**1967**, 21: 681-689.
[8] Bland MJ and Altman DJ. *Lancet* **1986**,**1**:307–10.
[9] Deurenberg P., Weststrate J.A., Leidell J.C. *Br. J. Nutr*.**1991**, **65**: 105-114.
[10] Corcoran C, Anderson EJ, Burrows B, et al. *Am J ClinNutr*.**2000**,**72**:1053– 8.
[11] Cox-Reijven PL, van Kreel B, Soeters PB. *Am J ClinNutr*.**2003**,**78**:1111–9.
[12] Wells JC. *ProcNutrSoc*, **2003**,**62**:521– 8.
[13] Stall SH, Ginsberg NS, De Vita MV et al. *Am J ClinNutr*.**1996**,**64**: 125–130.
[14] M. L. DinizAraújo, P. Coelho Cabral, I. Kruze Grande de Arruda, A. P. Siqueira Tavares Falcão and A. Silva Diniz. *Nutr Hosp.* **2012**,**27**(6):1999-2005.
[15] SiqueiraVassimon H, Jordao AA, Albuquerque de Paula FJ, Artioli Machado A, Pontes Monteiro J. *Nutr Hosp.* **2011**, **26**(3):458-64.
[16] Kamimura MA, Avesani CM, Cendoroglo M, Canziani ME, Draibe SA, Cuppari L. *Nephrol Dial Transplant.* **2003**,**18**(1):101-5.
[17] Natália Cristina Lima Rodrigues, Priscila Campos Sala, Lilian Mika Horie, Maria Carolina Gonçalves Dias,Raquel Susana Matos de Miranda Torrinhas, JoãoEgídio Romão , Ivan Cecconello, Dan Linetzky Waitzberg. *Journal of Renal Nutrition*,**2012**, **22**(4): 409-415.
[18] R J Maughan. *Br J Sports Med.* **1993**,**27**:63-66.
[19] Sawaya AL, Martins P, Hoffman D, Roberts SB. *Nutr Rev.* **2003**,**61**:168 –75.
[20] Guang Sun et. al. *Am J ClinNutr*.**2005**,**81**:74 –8.
[21] Maria AyakoKamimura. *Nephrology Dialysis Transplantation*.**2003**,**18**: 101–105.
[22] Henry C Lukaski. Assessment of fat-free mass using bioelectrical impedance measurements of the human body.*Am J ClinNutr*.**1985**, **41**:810-817.
[23] JacekBujko, JacekKasprzak,.*Pol. J. Food Nutr. Sci*.**2006**, **15/56**(SI 2): 139-144.
[24] Durnin J.V.G.A., Womersley J. *Br. J. Nutr*.**1974**, **32**: 77-97.
[25] JacekBujko, JacekKasprzak, Paul Houlshof and Victor Schreurs. *Polish Journal of Food and Nutrition Sciences*, **2006**, **15/56**: 139-144.
[26] RatihI.Isjwara, Widjaja.Lukito and Jan Werner Schultink. *Asia Pac J ClinNutr.* **2007**; **16** (4):641-648.
[27] DilekBerker, SühaKoparal, SerhatIsik, LalePasaoglu, Yusuf Aydin, KutluErol, TuncayDelibasi and SerdarGüler. *DiagnIntervRadiol*. DOI 10.4261/1305-3825.
[28] Eisenkölbl J, Kartasurya M, Widhalm K. *European Journal of Clinical Nutrition*. **2001**,**55**(6):423-9.