DOI: 10.7860/JCDR/2019/39781.12535

Original Article

Health Management and Policy Section

A Comparative Evaluation of the Body Fat Percentage using Bioelectrical Impedance Analyser, Skin-fold Thickness Measurement and BMI

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ABSTRACT

Introduction: As there is a global increase in the number of people with obesity world-wide, there is an increasing need for estimation of body composition especially, the calculation of Body Fat (BF) percentage for treatment and prevention of obesity. Hence, the present study deals with the estimation of BF percentage using three methods.

Aim: To compare the percentage of BF obtained by bioelectrical impedance method with percentage BF obtained by two other methods, {Skin-fold Thickness Measurements (STM) and Body Mass Index (BMI)}, in healthy subjects.

Materials and Methods: A cross-sectional, observational study was conducted on 50 healthy male subjects of the age group 25-55 years in a tertiary care hospital in Rajamahendravaram, Andhra Pradesh, India. BF percent measured using Karada scan HBF-701, compared with percentage BF as calculated by Siri equation (from the sum of skin fold thickness measured at four places-Triceps, Biceps, Suprailiac and Subscapular areas) and percentage BF calculated from BMI. Statistical analysis was done using SPSS software version 20 and MS-Excel-2007 by Pearson Correlation Coefficient test and ANOVA.

Results: Mean value of percent BF assessed by bioelectrical impedance was 18.27±3.32, mean BF percentage from Siri equation was 23.33±2.75 and mean BF from BMI was 19.55±3.22 the results showed significant difference in percent BF by different methods. Bioelectrical Impedance Analysis (BIA) underestimated BF when compared to other two methods. There was a statistically significant positive co-relation between Karada scan and BMI (r is 0.336, p is 0.017).

Conclusion: According to the results of the study, we can conclude that bioelectrical impedance analyser underestimated BF percentage when compared to other two methods (skinfold thickness measurements and BMI) though there was a positive correlation between BF measurements by BIA and other two methods.

Keywords: Anthropometric measurements, Body composition, Karada scan

INTRODUCTION

Overweight and obesity are important public health problems and the percentage of the people with overweight is alarmingly increasing. According to researchers, the centrally distributed adipose tissue is linked to high blood pressure, dyslipidaemia, impaired fasting glucose, and insulin resistance. As adipose tissue has got a major role in regulating the lipid metabolism and glucose tolerance of the body, the factors mentioned above further cause increased risk of morbidity from cardiovascular disease [1,2].

As it has become a global problem, the requirement for assessment of BF percentage is on an increase for both prevention and treatment purpose. There is growing interest towards BF analysers by health care professionals as they need correct measurement of body composition in order to advise the patient regarding maintenance of optimal weight. Measurement of BF is not possible in a direct way and is difficult. Many types of indirect methods of BF measurement have been proposed to measure percentage BF. Indirect methods are developed from the results of the direct methods of BF measurement [3]. The examples for indirect methods are: anthropometric methods (weight, stature, abdominal circumference and skin fold measurements) and Bioelectrical Impedance Analysis (BIA).

BIA is a method used for evaluating body composition and BF. The first commercial device was available in the1980s and became popular as it is easy to use, portable and less expensive, compared to the other methods. Other advantages are there is no need for operator training or cross validation of the machine. BIA measures the electrical impedance or resistance when the electric current flows through the body tissues. This resistance to the flow of current determines the amount of Total Body Water (TBW). Fat-free body mass can be estimated from total body water, and then BF is determined by calculating the difference with body weight. After making many technological improvements to the instrument, BIA is now considered a more reliable method for determining the free fat mass and TBW in subjects when there are no fluid and electrolyte abnormalities [4]. While looking into the factors affecting BIA, dehydration causes an increase in the body's electrical resistance and thereby results in an underestimation of fat-free mass or overestimation of BF mass [5]. When readings are taken immediately after a meal, lower BF measurements are recorded, leading to a variation between the highest reading and lowest reading of BF percent and the variation may be upto 9.9% [6]. If BIA is measured after moderate exercise, overestimation of fat free mass and an underestimation of BF percentage is seen due to reduced resistance to the flow of current [7]. Therefore, it is recommended that BIA estimation should not be done upto 12 hours after exercise [8]. BIA is recommended for taking readings in groups and it is not considered to be accurate enough for single measurement of body composition [9].

Hence, the present study was proposed to evaluate the measurement of percentage BF in healthy subjects, using the three methods- Karada scan BIA, STM and BMI.

MATERIALS AND METHODS

A cross-sectional, observational study was carried out enrolling healthy volunteers from GSL general hospital, Rajamahendravaram Andhra Pradesh, India. The study period was three months from 1-10-2017 to 20-12-2017. Permission from the institutional ethics committee was obtained (GSLMC/RC:403-EC/403-6/17) and informed written consent taken from all the participants. Subjects were allowed to drop from the study at any time if they were not interested.

The BF percent of 50 (n=50) healthy, male volunteers was recorded using Karada Scan HBF-701, by skin-fold thickness measurements and from BMI. The variables used were age in years, height, body weight and BMI. The age range of the subjects was 25-55 years. BMI was calculated from height and weight. (BMI=weight in Kg/Height in square centimetres).

Inclusion Criteria

Subjects with BMI in between 25-30, healthy subjects without co-morbidities like hypertension and diabetes, subjects not taking any medication for the treatment of over weight or obesity during the study period were included in the study.

Exclusion Criteria

Subjects in extremes of age, patients with other co-morbidities, patients on dialysis, subjects with chronic disabilities and professional sportsmen or body builders.

Each day BF percentage of two volunteers was measured by all the three methods. Measurements were made on a single day between 10 AM to 12 noon. Subjects were not allowed to eat up to 2-4 hours before testing, refrained from exercise for at least the previous 12 hours.

First measurements were taken with Karada scan HBF-701. The subject was asked to stand on the device bare footed holding the handles straightly. Initially age, sex and height of the person were recorded. Then, the BF percentage was noted following the instructions in the manual.

STM are used to characterize subcutaneous fat thickness at various regions of the body. Triceps, biceps, subscapular and supra-iliac skin-fold thicknesses were obtained in mm by pre-standardized callipers. The average of the three readings of skin-fold thickness was taken at each place. BF percentage obtained using Siri equation.

Body fat percent={(4.95+Body density)-4.5} × 100 [10]

Firstly, the sum of skin-fold thicknesses at 4 places - biceps, triceps, suprailiac and subscapular areas was calculated.

The formula for calculation of body density is as follows:

Body density=1.1610-0.0632×log sum of skin-fold thicknesses [11] Body density calculated according to different age groups.

Body fat percentage is calculated from BMI according to the formula created by Deurenberg P et al., [12]. They created the formulae for estimation of BF percentage from BMI. Age and sex should be considered when making calculations from the densitometrically determined BF percentage (BF%) and BMI. The BF percent in the adults calculated with the following formula.

Adult BF %=(1.20×BMI)+(0.23×Age)-(10.8×sex)-5.4 Where value of sex is 1 for males and 0 for females.

STATISTICAL ANALYSIS

All the statistical analysis were performed using SPSS software version 20 and MS Excel-2007. Descriptive statistics were presented in the form of mean±standard deviation and percentages. ANOVA was performed to compare the percentage BF obtained by the three methods. Post-hoc test was done to compare the results of each group with each other. For all statistical analysis, p-value <0.05 was considered as statistically significant. Pearson correlation co-efficient test was done.

RESULTS

Mean value of body percentage fat assessed by bioelectrical impedance was 18.27±3.32, mean BF percentage from Siri equation is 23.33±2.75 and percentage BF from BMI is 19.55±3.22. There was a mean significant difference between the three groups. Mean BF percentage obtained by Karada scan is less when compared to other two methods STM and BMI. Karada scan underestimated percent BF when compared to the percent BF obtained by the other two methods [Table/Fig-1]. There was a positive correlation between the three methods but the difference was statistically significant between Karada scan and BMI [Table/Fig-2].

Body fat percentage distribution								p-value
	N	Mean	Standard Deviation	95% Confidence Interval for Mean		Mini-mum	Maxi-mum	
				Lower Bound	Upper Bound			
Karada scan	50	18.278	3.3281	17.332	19.224	13.9	28.2	0.001*
STM	50	23.332	2.7563	22.549	24.115	16.9	27.8	
BMI	50	19.554	3.2254	18.637	20.471	14.8	27.8	
Total	150	20.388	3.768	19.78	20.996	13.9	28.2	

[Table/Fig-1]: Body fat percentage distribution.
One-way ANOVA used, *Statistically significant

Variables	Correlated Variables	R	p-value
Karada scan	Skinfold Thikness	0.198	0.169
	BMI	0.336	0.017*
BMI	Skinfold Thikness	0.068	0.641

[Table/Fig-2]: Correlation between variables.
*Statistically significant

[Table/Fig-3] shows Post-hoc test was done to compare the results of each group with each other. The comparison between Karada scan and skinfold measurements was significant (p=0.000), null hypothesis was rejected. Again the p-value was significant (p=0.000) when BMI and skinfold measurements were compared and the null hypothesis was rejected. The comparison between Karada scan and BMI showed no significant difference as the p-value is more than 0.05.

Post-Hoc Test						
(I) Group	(J) Between groups	Mean Difference (I-J)	Standard Error	Significance	95% Confidence Interval	
					Lower Bound	Upper Bound
Karada scan	STM	-5.0540*	0.6226	0.000	-6.284	-3.824
	BMI	-1.2760*	0.6226	0.042	-2.506	-0.046
STM	Karada scan	5.0540*	0.6226	0.000	3.824	6.284
	BMI	3.7780*	0.6226	0.000	2.548	5.008

[Table/Fig-3]: Comparison between the three tests using post-hoc analysis.

DISCUSSION

In the present study, the three different methods for calculating BF percent were compared. To get an accurate measure of the BF, methods like Dual X-ray absorptiometry and underwater weighing can provide accurate results: but the disadvantage is these methods are expensive and inaccessible to the public. Mostly, BIA and other anthropometric methods are the most commonly employed procedures for body composition measurements and in the present study correlation between the three methods was found.

In a similar study conducted by Webber J et al., a comparison of skin-fold thickness, BMI, bioelectrical impedance and dual energy X-ray absorptiometry was done in obese subjects before and after weight loss. Compared to the present study where the methods correlated well, they concluded finally that inspite of strong correlation between some methods, degree of agreement is lacking [13].

In another study conducted by Kitano T et al., in Japanese female college students, evaluation of body composition using three methods, dual energy X-ray absorptiometry, skinfold thickness and bioelectrical impedance was done. According to these researchers, there was no significant difference among the three methods by one way ANOVA. There were variations in the values among the three methods when the data were analysed by one way RM-ANOVA [14]. As in the present study, the results obtained from BIA correlated with those of the skinfold measurement and the BF mass and percentage obtained was lowest.

There is an increasing demand for body composition analysis and this information is useful in health clinics, sports persons and other fields in health care to monitor weight status, weight loss therapy, or outcome of therapy. In a study conducted by Johnstone AM et al., they have measured body composition changes during weight loss in obese men using multifrequency BIA and multicompartment models [15]. They compared the accuracy of bioelectrical spectroscopy to body composition reference methods. This was done in obese subjects following three different weight loss programmes (fasting, low calorie diet and very low calorie diet). They conclude that rapid weight loss affects the accuracy of BIS in detecting changes in body composition. This is not comparable to the present study as we have not followed weight loss programme. In another study conducted by Sun G et al., they have compared multifrequency bioelectrical impedance analysis with dual energy X-ray absoptiometry for estimation of percentage BF in a large healthy population [16]. They have concluded that BIA is a good alternative for estimation of percentage BF when subjects are within a normal BF range only and results are similar as in the present study.

The prevention as well as management of obesity are very much complicating and problematic issues. Estimation of percent BF is essential for the treatment of obesity and the interest is growing towards the use of bioelectrical impedance analysers for the estimation of BF mass. From a study conducted by Kyle UG et al., the data suggests that BIA works well in healthy subjects and in patients with stable water and electrolyte balance. The authors suggest that clinical use of BIA cannot be recommended for patients with extremes of BMI ranges or abnormal hydration until BIA is further validated to be used in such subjects [17]. As there will be racial and ethnic differences in climatic and nutritional factors, hence the difference was found between the studies. the present study was conducted in healthy subjects in the south Indian population to assess the validity of the method in comparison with other two methods STM and BMI where BIA showed lesser values than the other two.

Diniz Araujo ML et al., in their study found that BF percent measured by BIA strongly correlated with percent BF measured by different anthropometric methods in a similar way to the present study [18]. In another study conducted by Lukaski HC et al., they have assessed fat-free mass using bioelectrical impedance measurements of the human body [19]. They conclude that the bioelectrical impedance technique is a valid method and is reliable for the estimation of the human body composition unlike the present study. This study appears similar to the study conducted by Maughan RJ [20]. In their study, they compared values of BF content obtained by hydrostatic weighing, skin fold thickness measurement and electrical impedance in 50 healthy volunteers. The results indicate that the correlation between skinfold thickness method and hydrostatic weighing is more than that obtained between hydrostatic weighing and impedance method where as hydrostatic weighing was not done in the present study. In another study conducted by Frisard MI et al., they compared the three different methods of assessment of body composition during a period of weight loss [21]. Air displacement plethysmography and BIA were compared with dual-energy X-ray absorptiometry in subjects during weight loss. They concluded that all the three methods are sensitive to detect changes with weight loss and are also accurate. As in the present study the results from BIA were found to be sensitive. In a similar study conducted by Chahar PS where the three methods were compared, BIA underestimated BF when compared to skinfold thickness measurements and BMI [22] similar to the present study.

LIMITATION

The limitations of the present study are, the study conducted is a cross-sectional study and the sample size is small. Only males are included as men and women have different BF distribution and the classification criteria are different. Other limitation may be the possibility of technical error with skin-fold thickness measurements. Further studies on a large population and in both the genders are recommended to support the results of the present study. Further validation of BIA is necessary to understand the mechanisms for the changes if BIA is to be used in patients with disease states and other conditions which affect the normal balance.

CONCLUSION

The present study comprising simultaneous estimation of percent BF by BIA, STM, and BMI in south Indian population showed that BIA cannot be used as an alternative method to skin-fold thickness and other anthropometric indicators as there was underestimation of BF with karada scan. There was a mean significant difference between the three groups though good correlation exists between them.

ACKNOWLEDGEMENTS

The authors express their sincere thanks to the colleagues and technicians of department of pharmacology, GSL Medical College, Rajamahendravaram for their support in conducting the study.

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FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Sep 29, 2018**
Date of Peer Review: **Oct 09, 2018**
Date of Acceptance: **Dec 19, 2018**
Date of Publishing: **Jan 01, 2019**