Journal of Biotechnology and Bioengineering
Volume 2, Issue 3, 2018, PP 1-8
ISSN 2637-5362

Body Fat and Visceral Fat Assessment by Bioelectrical Impedance as an Effective Health Checkup in a University Female Population

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ABSTRACT

Introduction and Objectives: *Excess body fat carries a higher risk of morbidity and mortality world wide. Various measures are used to detect excess body fat and the risk of obesity related co-morbidities including body mass index (BMI), waist circumference (WC), skin fold thickness (SFT) and waist to hip ratio (WHR). Visceral fat accumulation is considered as an increased risk of metabolic syndrome and leads to major health hazards including cardiovascular diseases and diabetes mellitus. It will be beneficial to recognize health risks early and adapt to a healthy lifestyle by the university population. Even though waist circumference and waist to hip ratio are used to assess abdominal obesity, visceral fat assessment may interfere with as those measures evaluate both subcutaneous and visceral fat. CT scans, MRI are precise methods for the measurement of visceral fat. Due to the exposure to radiation and cost of CT and MRI, recently developed Bio Impedance Analysis(BIA) can use as an easy and accessible method of measuring visceral fat (VF) as well as body fat percentage (BF%).In the present study, we evaluate the clinical usefulness of Bio-impedance analysis in accordance with commonly practiced body fat indicators to create the awareness about the recently developed Bio-Impedance Analysis method.*

Methods: *A total of 450, 3rdyear female undergraduate students were selected randomly to represent allthe faculties in the University of Peradeniya as the subject for this study. Body fat percentage and visceral fat were assessed by using BIA and was compared with other indicators of obesity such as skin fold thickness, body mass index, waist circumference and waist to hip ratio. Pearsons' correlation coefficient (r) was calculated to see the relationship between body fat percentage and visceral fat by BIA with other body fat indicators. One-way ANOVA test and Tukey post hoc testused to identify the significance of body fat percentage level and visceral fat by BIA with BMI and waist circumference using SPSS 20 software.*

Results: *Statistically significant strong positive correlations for body fat percentage and visceral fat ($p<0.001$) were observed with BMI (r =0.918, 0.940), waist circumference ($r=0.814$, 0.822) and skin fold thickness measurement ($r=0.693$, 0.642) respectively. There is a statistically significant difference between the mean BMI ($p<0.001$)and mean WC values ($p<0.001$) for both BF% and visceral fat measured by BIA, indicating that significantly increased Body fat percentage and visceral fat levels for larger waist circumference and obese persons.*

Conclusion: *BIA is useful to measure body fat percentage and visceral fat easily in an educated population such as in a university, as a health checkup and in epidemiological studies as well.*

Keywords: *Obesity, visceral fat, Body fat percentage, Bio impedance analysis, university population*

INTRODUCTION

Obesity has gained a considerable attention as a major health hazard. Obesity is defined as an abnormal or excessive accumulation of fat that may impair health(1). Worldwide obesity has increased more than double between 1980 and 2014. It has caused at least 2.8 million people to die each year and has contributed foran estimated 35.8 million (2.3%) global disability-adjusted life years. In low and middle-income countries ,the prevalence of obesity is twice higher among women than men (2).Female sex, urban living, higher education, higher income and being in the middle age were shown to be associated with overweight and obesity in Sri Lanka (3).

Obese people tend to die prematurely(4). Overweight and obesity predispose to vascular

diseases(5), diabetes mellitus(6), renal diseases(7), joint diseases(8), gallbladder diseases (9)and impairs respiratory function(10). They often suffer from anxiety, sleep apnea, psychosocial problems, depression and low self-esteem(11). Moreover, morbidity and mortality rates are higher among the obese people (12).

In the evaluation of obesity, various methods have been used. Body mass index is the most widely used method in epidemiological studies (13). Furthermore, skin fold thickness (SFT) measurement has been used since ancient times (14). Underwater weighing based on the Archimedes principle is a valid, reliable laboratory method(14). BIA is a recently developed measure to assess body fat (15). In addition, the places of distribution of fat, need to evaluate as an important risk factor, because fat cells have different metabolic activities depending on their locations (16). Measuring obesity simply by body mass index may not detect some of the people who are having central obesity and visceral fat and they may suffer from some of the health effects of it.

Abdominal obesity also known as central obesity, central adiposity or intra-abdominal fat is often referredto as belly fat. It includes both subcutaneous fat that sits just under the skin and the visceral fat that sits deep in the abdominal cavity around internal organs (17). Visceral adipose tissue, more metabolically active, more sensitive to lipolysis and more insulin resistant than subcutaneous adipose tissue thereby carries a greater risk of morbidity and mortality (18). Risk of diabetes increases when the waist circumference is more than 31.5 inches (80 cm) in women and more than 35.5 inches (90cm) in men (19).

Waist circumference and waist to hip ratio (WHR) and have been measured and calculated respectively to evaluate abdominal obesity (20). Measuring waist circumference is considered as an effective method of assessment of health risks (21).However, Waist circumference underestimates the amount of visceral fat because of the measures abdominal subcutaneous fat(22).In recent years, development of Bio-Impedance Analysis (BIA) method, which involves the assessment of the resistance of body tissues by passing an electric current of low intensity, with a fixed frequency, contributes in measuring the percentage of the different compartment of body fat(23).

It is clinically important to distinguish visceral from subcutaneous adipose tissues by using imaging techniques, such as magnetic resonance imaging (MRI)(24) or computed tomography (CT) scan(25). But, it's limited due to radiation exposure and increased cost (26). So, BIA is an accessible, safe and cost-efficient method that avoids exposure to radiation and has been widely used to measure body composition in clinical populations.

Studies have evaluated the validity and accuracy of BIA, with a comparison of CT and MRI which are known as gold standard. BIA has been recognized as an accurate measurement rather than the use of anthropometric measurements (26). There are limited researches that have evaluated the effectiveness of BIA used in Sri Lanka (27) in different specific population. However, some epidemiological studies have been conducted using BIA measurements (28). Final year students are the most experienced ones in university society. As every faculty does not have a 4th-year or 5th-year batches, 3rd-year undergraduate female students have been selected as the representative sample. This study will explore the correlation between BIA and anthropometric indicators and evaluate the effectiveness of using BIA as an easy health checkup in the study population.

Materials And Methods

The descriptive and exploratory study was carried out among female students in the University of Peradeniya over the period of six months from December 2017 to June 2018. The study population was the third-year undergraduate female students of all the nine faculties at the University of Peradeniya , Sri Lanka. Undergraduate female students who are with disabilities were excluded from the sample. The sample size was taken as 450. A predetermined number of names of the female third year students were taken randomly from the registers of each faculty separately under the permission of Deans and senior registrars of each faculty.

Ethical clearance was taken from the ethical review committee, Faculty of Allied Health Science, University of Peradeniya. Permission to conduct the study was obtained from the Deans of allthe nine faculties. Registers of names were obtained to select the random sample and get a convenient time and venue for data collection was decided after discussing with the participant of each faculty.

Four research assistants who are final year undergraduate nursing students in the University of Peradeniya were recruited for data collection purposes. Research assistants and primary investigator were trained under the supervision of experienced clinical nutritionist of a teaching Hospital for anthropometric measurements and to operate the BIA machine. Clinical nutritionist evaluates the trainees for precise and accurate measurements. Calibration of equipments was done along with the training. Participants were recruited by posters. Spent one to three days per faculty in order to obtain the total number which was expected from one faculty .

The information sheet that includes a description about the research, ethical consideration and medical boundaries of the research and the written consent forms were distributed and time was given to participants to read, understand, ask for queries and sign the document prior to data collection process.

It includes demographic data including age, district and to mention any morbid condition, anthropometric measurements, measurements that can take using bioelectrical impedance analysis(BIA) machine; body fat percentage and visceral fat.

Anthropometric Measurements

Each group of anthropometric measurements was taken by a single investigator. Anthropometric measurements were taken according to accepted guidelines (29). The chest circumference was measured by keeping the tape at the fullest part of the bust and wrapping it around the chest. The mid-arm circumference was measured using a non-stretchable tape after selecting the mid-point between the olecranon process and acromion of the bent left arm. The arm was kept hanging straight down, the calibrated tape was wrapped around the arm at the midpoint mark.

Measurement of height was taken by a studio meter to the nearest 0.5 cm. Participants were asked to remove their shoes, hair ornaments and stand with his back of the head, back, buttocks, calves and heels touching upright, feet together while looking straight keeping the eyes and earlobe in a horizontal line. The headpiece of the stadiometer into the sliding part of the measuring rod was lowered so that the hair was pressed flat and height was recorded to the resolution of the height.

Measurements for body circumferences were taken using calibrated measuring tape. Waist circumference was taken at the minimal part of the midsection and umbilicus level. Abdominal obesity was defined based on WC ≥80 cm measured by at the minimal waist.

Hip circumference was taken from the widest buttock circumference. Waist to hip ratio (WHR) was obtained by dividing waist circumference measured at the minimal waist by hip circumference.

Skin fold thickness at four different sites (triceps, supra-iliac, abdominal, thigh) was taken by Harpenden caliper while standing and taking all measurements on the same side of the body. Pinched deep enough to get the fat by the forefinger and thumb. Placed the body fat calipers less than 1/2 inch from the pinch, midway between the crest and the base. For each of the skin fold sites, it has taken three measurements and used the average of those three. Examined all the sites three times . With the use of Andrew Jackson, M. L. Pollock formula, body fat percentage was estimated (Stalker, 2012).

Body Fat percentage= (0.29669 x sum of skin folds) – (0.00043 x square of the sum of skin folds) + (0.02963 x age) + 1.4072.

Measurements for predicted percentage body fat (%BF) and visceral fat was derived from bioelectrical impedance by OMRON BF 511 body composition analyzer. Participant being measured were instructed not to contact with any other non-conducting surface by keeping legs apart and arms away from the body(Omron Healthcare Co Ltd: Body Composition Monitor BF500 Instruction Manual, 2017). BMI was estimated with the body weight (kg) / height2 (m2) formula. In accordance with the classification by the World Health Organization for Asian Population, they were regarded as underweight (BMI 18.5 kg/m2 below), normal weight (BMI 18.45-22.9 Kg/m2), overweight (BMI 23- 27.4 Kg/m2) and obese (BMI 30-39.9 Kg/m2).

Statistical Package for Social Sciences (SPSS) version 20.0 for Windows was used for data entry and analysis. The results of the descriptive statistical analysis were summarized as mean, standard deviations (±), frequencies (N) and percentages (%) and illustrated as tables and figures. Pearson's Correlation Coefficient was used to determine the correlation between body fat indicators designated level of statistical

significance was p <0.001. Difference between means of BMI and visceral fat levels analyzed using One-way ANOVA test and Tukey post hoc test. Statistical significance was p <0.001.

RESULTS

The mean age of the respondents was 23.30 ± 0.892 years. Study subjects were presented from every district from Sri Lanka. The mean ±SD values for Body fat percentage (BIA) and visceral fat (BIA), BMI, WC of the total study population were30.21± 8.85, 3.46±1.35, 20.83±3.86 and 69.87± 6.79respectively.In Table 1, based on body fat percentage (BF %) by BIA, the majority of students (47.7%) had normal BF%. Percentage of students for the high visceral fat level (VF level >10) , indicated that none of the study subjects had visceral obesity.

Table1. *Prevalence of body fat percentage and visceral fat level by BIA among undergraduate female students in the University of Peradeniya.*

	Mean ±SD*	**Frequency(N)**	**Percentage (%)**
BF% level (BIA)			
Low	13.99 ± 3.94	52	12.1
Normal	27.46± 3.42	204	47.7
High	35.71± 1.68	95	22.2
Very high	42.41 ± 2.35	77	18.0
VF level (BIA)			
1-3	2.42 ± 0.69	232	53.5
4-6	4.61 ± 0.73	199	45.9
7-9	8.00 ± 1.00	3	0.7
>10	0	0	0

*BF%: Body Fat Percentage, VF: Visceral Fat. Using body Composition Monitor BF500 Instruction Manual, (2017), Low BF%:<21, Normal BF%: 21-32.99, High BF%: 33-38.9, Very high BF%: >39,Normal VF: 0-9, high VF: ≥10.*SD- Standard Deviation.*

Table2. *Characteristics of body fat indicators.*

	Minimum	Maximum	Mean ± SD*
Weight (kg)	32.80	87.70	51.42 ± 10.63
Height (cm)	138.00	173.50	156.51 ± 5.65
BMI (kgm^{-2})	14.09	34.04	20.83 ± 3.38
Waist to hip ratio	0.66	0.92	0.76 ± 0.41
BF% SFT**	12.80	45.27	28.35 ± 4.95
Body fat percentage (BIA)	5.9	47.90	30.21 ± 8.86
Visceral fat (BIA)	1.00	9.00	3.46 ± 1.35
Body circumferences			
Chest Circumference (cm)	65.83	111.50	84.01 ± 7.47
WC(measured by minimal waist) (cm)	55.00	94.50	69.87 ± 6.79
WC(measured by umbilicus level)(cm)	53.67	101.33	77.29 ± 8.50
Hip Circumference (cm)	73.67	116.00	92.17 ± 16.05
Mid Arm Circumference (cm)	18.00	35.00	24.79 ± 2.96

***%BF SFT: Body fat percentage calculated by skin fold thickness*

Table3. *Correlation of body fat percentage and visceral fat measured by BIA with several indices of body fat .*

	Body fat percentage (BIA)		**Visceral fat (BIA)**	
	Correlation r	*p*	*Correlation r*	*p*
BMI (kgm^{-2})	0.918	<0.001*	0.940	<0.001*
Waist to hip ratio	0.230	<0.001*	0.253	<0.001*
%BF SFT**	0.693	<0.001*	0.642	<0.001*
Chest Circumference (cm)	0.833	<0.001*	0.831	<0.001*
Waist circumference (measured at minimal waist)	0.814	<0.001*	0.822	<0.001*
Waist Circumference (measured at umbilicus level)	0.812	<0.001*	0.819	<0.001*
Hip Circumference (cm)	0.825	<0.001*	0.816	<0.001*

Mid Arm Circumference (cm)	0.812	<0.001*	0.787	<0.001*

*Pearson correlation coefficient (r) calculated. *p<0.001 – statistically highly significant .*

***%BF SFT: Body fat percentage calculated by skin fold thickness.*

Descriptive characteristics of body fat indicators are shown in table 2. As shown in Table 3, Body fat percentage and visceral fat measured by BIA shows a statistically significant strong positive correlations (p<0.001) with BMI (*r* =0.918, 0.940), body fat percentage calculated by skin fold thickness measurements (r=0.693, 0.642),body circumferences including chest circumference (r= 0.833, 0.831), waist circumference measured at minimal waist (r=0.814, 0.822), waist circumference measured at umbilical level (r=0.812, 0.819), Hip circumference (r=0.825, 0.816) and Mid-arm circumference (r= 0.833, 0.831). However, the correlation is weak with waist to hip ratio (r=0.230, 0.253).

Table4. *Comparisons of means of BMI value and WC values between body fat percentages levels by BIA*

BF% level	N	Mean	SD	F	Significance
		BMI			
Low	52	16.4840	1.63963	630.521	<0.001
Normal	204	19.4076	1.39854		
High	95	22.4336	1.00723		
Very high	77	26.1088	1.69329		
		WC			
Low	52	62.5417	3.50799	286.930	<0.001
Normal	204	67.3330	3.76628		
High	95	71.9877	3.45203		
Very high	77	80.1104	4.54900		

BF%; Body fat percentage by BIA; <21: Low, 21-32.99: Normal, 33-38.99: High, <39: very high, BMI: Body Mass Index, WC: Waist Circumference, SD: Standard Deviation.

Table5. *Comparisons of means of BMI value and WC values between visceral fat levels by BIA*

VF level	N	Mean	SD	F	Significance
		BMI			
1-3	232	18.4226	1.61668	385.396	<0.001
4-6	199	23.6704	2.33731		
7-9	3	25.6721	1.20114		
		WC			
1-3	232	65.7188	3.77176	205.719	<0.001
4-6	199	74.8492	5.69002		
7-9	3	80.6111	2.59451		

VF: Visceral fat, BMI: Body Mass Index, WC: Waist Circumference, SD: Standard Deviation.

Table 4 shows the output of the One-way ANOVA analysis and there is a statistically significant difference (<0.001) in the mean values of BMI and WC with the different body fat percentage levels. Table 5 shows the same analysis and statistically significant difference (<0.001) in the mean values of BMI and WC with the different visceral fat levels measured by BIA.

Turkey post hoc test revealed that the means of both BMI and waist circumference shows a significant difference (<0.001) for each low, normal, high and very high body fat percentage levels and for each visceral fat level categories; 1-3, 4-6 and 7-9.

DISCUSSION

Excess body fat is documented as a risk factor for numerous chronic conditions, such as diabetes, hypertension, hyperlipidemia and cardiovascular diseases (32). Generally, BMI and WC used as a measure of general obesity and abdominal obesity respectively that are predictors of cardiovascular risks, non-insulin dependent diabetes, and hypertension (33). Early recognition of visceral fat level is important for the prevention of related disease conditions (34). Assessment of visceral fat level among young population in a university during their health checkups would be beneficial (34),

and it should be accurate, simple and cost-effective.

BIA can be used as an easy and effective health checkup replacing generally used methods as Body fat percentage(BIA) and visceral fat measured (BIA)shows a statistically significant strong positive correlations ($p<0.001$) with BMI (r=0.918, 0.940), body fat percentage calculated by skin fold thickness measurements (r=0.693, 0.642),body circumferences including chest circumference(r= 0.833, 0.831), waist circumference measured at minimal waist (r=0.814, 0.822), waist circumference measured at umbilical level (r=0.812, 0.819), Hip circumference (r=0.825, 0.816) and Mid-arm circumference (r= 0.833, 0.831). However, BMI is superior to detect both body fat percentage (BIA) and visceral fat (BIA) than waist circumference even though waist circumference is used to measure the abdominal obesity as an indicator of visceral fat. A study by weerarathneet always investigated that BMI (0.87, 0.77) was superior to detect both body fat and visceral fat than WC (0.72, 0.73) respectively among adiposity women Sri Lanka (35). This could be affected due to waist circumference measures both subcutaneous tissue and visceral fat(36).

According to the results of one-way ANOVA and Tukey post hoc test, means of both BMI and waist circumference shows a significant difference(<0.001) for each low, normal, high and very high body fat percentage levels and for each visceral fat level categories; 1-3, 4-6 and 7-9.

It indicates that increased body fat percentage and visceral fat measured by BIA correlate with increased BMI and larger waist circumferences. Therefore, BIA is an effective and simple method of evaluation of body fat and visceral fat in the University population and can be used as a health checkup at a low cost.

This study has several limitations. We did not have CT or MRI data to compare with the BIA values. Further studies are needed for the evaluation of body fat percentage and visceral fat among male students as this study was conducted among only female students.

Different populations of Sri Lanka should be evaluated by BIA as this study was conducted among only University students and most of the students in this study are relatively healthy having normal BMI and WC.

CONCLUSION

The results indicated that the body fat percentage estimated by BIA technique correlates with the anthropometrical indices (BMI, SFT, WC and WHR) while supporting the effectiveness of BIA.BIA is useful to measure body fat percentage and visceral fat easily in an educated population such as in a university, as a quick health checkup and epidemiological studies as well.

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Citation: *Ekanayaka EHMRK, Mudiyanse RM.," Consumption Pattern of Indian 'Chat' Based Snacks and Formulation of Millet Based Snack 'Poories'", Journal of Biotechnology and Bioengineering, vol. 2, no. 3, pp. 01-09 2018.*