Application of Bioimpedance Analysis for Estimating Body Composition of Adult Males

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Abstract
The present study was conducted to assess the nutritional status and body composition of Adult males age 40-50 years working at an institution in the city of Ajmer. A total of 28 subjects, who were healthy and willing to participate in the study, formed the sample for study. Firstly anthropometric measurements were taken and later body composition analysis was done through application of Bioimpedance Analysis using Tanita Body Composition Analyzer (Tanita- BC 420 MA). The mean age of subjects participating in the study was 44 years. The calculation of Body Mass Index from the weight and height measurements reflected that almost half of the subjects 53.57% fell in the normal category and 35.71% were classified as pre obese as according to the classification given by WHO. The mean for BMI measurements was 24.31±3.05. Considering the body composition parameters 11 subjects (39.28%) possessed fat mass per cent in the normal range of 11-22 %. The subjects who were classified as Overfat were 50%. Very few, 10.71 per cent, fell into the Obese category, using the fat mass per cent standards. The mean fat mass per cent values were 22.70±4.24 (15.06±4.98Kg). The range was 13.55-30 (2.2-26.2 Kg). Moving forward in the study, majority of the subjects (67.85%) had Visceral Fat Rating within the normal range of 1-12. The mean of muscle mass measurements was found to be 74.7±5.13 (50.72±6.68). The range was found to be between 67.21 to 92.10 (40.3-68.8 Kg). The bone mass measurements results showed that majority of the subjects (78.57%) had bone mass measurements between 2-3 Kg. For the measurement of the most integral component of the body that is water the results revealed that 92.85per cent possessed water levels which fell into the normal range of 50-65 per cent of body weight. Majority of the subjects (67.85%) possessed BMR which was less than the reference values. In the study a large number of subjects (78.57%) possessed Ideal Body Weight which was less than actual weight. The fat free mass measurements reflected that majority of the subjects, (67.85%) had fat free mass per cent values between70-80 % of their body weight. The mean for fat free mass values was 53.5±7.03Kg. The metabolic age was less than the actual age in majority of the subjects. Majority of the subjects had a positive value for degree of obesity.

Keywords: Bioimpedance analysis, BMI, Body composition, Ideal body weight, BMR

I. Introduction

Human body is made up of water, fat, protein, Mineral Ash, Carbohydrates. Water and Fat are the two chemical constituents that vary at the expense of each other. Other constituents, namely Protein and Minerals also vary with the state of nutrition of the individual.

Composition of human body changes as age increases. Changes in body composition occur with age and different parameters show specific correlations (1) After the age of 35, Basal Metabolic Rate decreases, Fat tissue increases, and per cent muscle tissue decreases. The average body fat percentage in males increases from 15 percent when young to 25 per cent at 60 years. This change in body fat is attributable to less intense physical activity and to an alteration in Testosterone and
Growth hormone production that affects anabolism and lean tissue growth (2). Measuring body composition in humans is usually in response to the need to describe either deficiencies or excess of a component that is thought or known to be related to health risk. In conditions such as Obesity and Osteoporosis, the levels of body fat and bone mineral density (BMD), respectively allow for clinical diagnoses with implications for formulating appropriate interventions. Body composition measurement methods are continuously being perfected with the most commonly used methods being bioelectrical impedance analysis, dilution techniques, dual energy X-ray Absorptiometry, and MRI or magnetic resonance spectroscopy.

The advantages of Bioelectrical Impedance Analysis (BIA) include its portability and ease of use, relatively low cost, minimal participant participation required, and safety (not recommended for participants with a pacemaker), thus making it attractive for large-scale studies. Validity of BIA is also influenced by sex, age, disease state, race or ethnicity, (3). The importance of measuring body composition has increased due to the need to evaluate changes in the Nutritional Status, which can affect body reserves differently. Subjects can gain body fat, fat free mass, cellular mass components as a result of overeating and sedentary lifestyle. These changes can be detected by using valid body composition techniques (4). Other than this extreme behaviour related to diet brings about a change in body composition and can be easily studied through body composition analysis. Eating disorders and as such diet followed bring about a deviation in normal body composition parameters and can be detected through body composition analysis. In patients of eating disorders lower whole body mass, protein mass, mineral mass, fat free mass can be seen (5).

TANITA BC 420 MA provides estimated values for each measured value of body fat percentage, fat mass, fat free mass, muscle mass and bone mass by the Dual Energy X Ray Absorptiometry method, estimated value for the total body water measured value by the dilution method and estimated value for the visceral fat rating by Magnetic Resonance Imaging method using the Bioelectrical Impedance Analysis (BIA method).

For measurement, a mode must be selected based on body type.  
1) Standard (for 5-99 years of age)  
2) Athletic (for Athletic persons who exercise considerably more than non-athlete)

Making a distinction by body type in the measurement mode produces more reliable body composition measurements for athletic persons, whose body compositions differ from those of average persons. BIA is a means of measuring body composition – fat mass, predicted muscle mass, etc. – by measuring bioelectrical impedance in the body. Fat within the body allows almost no electricity to pass through, while electricity passes rather easily through water, much of which is found in muscles. The degree of difficulty with which electricity passes through a substance is known as the electrical resistance, and the percentage of fat and other body constituents can be inferred from measurements of this resistance. The Tanita Body Composition Analyzer measures body composition using a constant current source with a high frequency current (50 kHz, 90μA). The 8 electrodes are positioned so that electric current is supplied from the electrodes on the tips of the toes of both feet, and voltage is measured on the heel of both feet. The current flows into the upper limbs or lower limbs, depending on the body part(s) to be measured (6).

II. Research Methods

Selection of Area:- The study was conducted on Males working at Maharshi Dayanand Saraswati University (M.D.S.) Ajmer.

Sample Selection:

The sample framed for the present study comprised of men in the age group of 40-50 years, who were working at M.D.S. University Ajmer. The number of sample units was twenty eight, who were apparently healthy and were willing to participate in the study.
Anthropometric Measurements:
To make an assessment of the nutritional status of the subjects first weight and height were taken and then the Body Mass Index of the subjects was calculated with the help of these measurements. Body Mass Index helped to classify the subjects as Normal, Overweight or obese.

Body Composition Measurements:
Human body has a specific composition which differs in each individual. The components (water, Fat, Muscle, Bone mass) remain constant in their type, but vary in their proportion from individual to individual. To make an idea of this composition is very interesting, helpful to give guidelines for management of health. In this study Body Composition was assessed using TANITA BC- 420 MA, the body composition Analyser that uses the BIA technique to assess the body composition. A complete assessment of body make up can be made through this machine easily in very less time and safely.

Statistical Analysis:
The results were calculated in form of Mean and Standard Deviation for various body composition parameters to give an overall picture of the study, and to arrive at generalised results. The range for different parameters was also calculated.

III. Results and Discussion
The results of the study conducted to assess the anthropometric measurements and body composition parameters of the subjects have been discussed under the following sections:

A) Anthropometric Measurements:-
Body Mass Index: - The mean weight of the subjects was 68.59 ±9.19Kg, and the mean height was 168.03±6.57cm. The values for weight fell between the range of 53.4-91 Kg, while for height they were 154-187 centimetres. The mean Body Mass Index values were 24.31±3.05, falling between the ranges of 17.11-30.43.(Table 1) Almost half of the subjects 15, (53.57 %) fell in the normal category according to classification given by World Health Organisation(8). Other than this 10 subjects, (35.71%) were in the pre obese category. Only 2 subjects were underweight, (7.14%) and one is obese (Figure 1).

B) Body composition parameters:-
1) Fat Mass Per cent: - When the fat mass of the body is measured as a proportion of body weight it is called as fat mass percent. Fat mass percent between 11-22% is considered as normal, 22-28% as overweight and greater than 28% is considered Obese. The mean fat mass per cent values were found to be 22.70±4.24 (15.06±4.98 Kg). Range of fat mass per cent in the subjects was found to be 13.55-30 (2.2-26.2 Kg).(Table 2). Using the reference standards 11 subjects, (39.28%) had fat mass per cent in the normal range of 11-22% and were thus classified as normal. Other than this 14 subjects, (50%) had fat mass per cent values ranging from 22-28% and could be classified as overweight. Only 3 subjects, (10.71%) had fat mass per cent greater than 28% and could be classified as obese (Figure 2).

2) Visceral Fat Rating: - The term Viscera implies the internal organs of the body. Visceral fat is the fat in the internal abdominal cavity surrounding vital organs in the trunk (abdominal) area. Greater values (when compared with standards) indicate increased susceptibility towards diseases like Hypertension, Heart Diseases and Insulin Resistance leading to type II Diabetes. Values from 1-12 are considered healthy whereas from 13-59 are classified as unhealthy and require diet and lifestyle changes. The mean values for Visceral Fat rating were 10.9±3.32, which fell in the appropriate or healthy class. The ranges of values for visceral fat measurement were 1-15.(Table 2). A total number of 19 subjects (67.85%) had visceral fat rating falling in the normal range of 1-12,
while 9 subjects (32.14%) had visceral fat rating from 13-15 which fell into the unhealthy category and suggested the need for diet and lifestyle changes. (Figure 3)

3) **Muscle mass:** It indicates the weight of the muscles in the body. Males have higher proportion of muscle tissue as compared to females. Exercise and protein rich diet help to build muscles in the body. In the present study, muscle mass per cent of the subjects ranged from 67.21 to 92.10 (40.3-68.8 Kg). The mean values of muscle mass per cent were found to be 74.7±5.13 (50.72±6.68 Kg). (Table 2).

The results thus revealed that majority of the subjects (18, 64.28%) had muscle mass measurement values between 67-75% of body weight, 7 subjects (25%) had muscle mass per cent values between 75-80% of body weight and 3 subjects (10.71%) possessed muscle mass per cent values as 80% of their body weight.

4) **Bone Mass:** Bones are primarily made up of calcium and phosphate. Measurements of bone mass indicate the amount of bone mineral in the body. The mean values of bone mass were 2.77±0.34 Kg and for bone mass per cent were 4.06±0.28. The range of bone mass per cent was 2.92-6.39 whereas for bone mass measured in kilograms was 2.2-3.7 Kg. Bone mass measurements revealed that almost all the subjects (78.57%) had bone mass between 2-3 Kg and 21.42% had bone mass measurement values between 3-4 Kg. (Table 2).

5) **Total body water percentage:** Water is an integral part of human body. However all metabolic reactions also occur in presence of water. Thus for both making up and functioning of the body, water is required. The normal body water content for males ranges from 50-65% of body weight. The mean values of body water percent measurement were 54.75±5.8 of total body weight (36.28±9.37 Kg). The total body water ranged from 25.89-59.9 Kg and the water per cent had values fell in the range of 48.5-80.9. (Table 2). Almost all the subjects 26 (92.85%) had a body water per cent value within the normal range of 50-65%.

6) **Basal Metabolic Rate:** A Basal Metabolic Rate of 1515 Kcal is considered normal for adult males (7). In the present study the mean values of Basal Metabolic Rate of the subjects chosen for study was 1480.53 Kcal with the range falling between 1155-2034 Kcal. (Table 2). A BMR higher than the reference was observed in only in 9, (32.14%) of the subjects, whereas majority of the subjects 19, (67.85%) had a BMR which was less than the standard.

7) **Ideal Body weight:** Ideal body weight is one for which the BMI is 22 (Tanita standards, 2005). The mean value of ideal body weight of the subjects was found to be 61.71±3.71 Kg, and the range was 52.2-69.7 Kg. Actual weight of the adult males was in the range of 53.4-91 Kg and the mean value was 68.59±9.19 Kg. (Table 2). In the study, 22 subjects, (78.57%) weighed more than Ideal Body Weight that is the actual body weight was higher than Ideal Body Weight. Only 6 subjects, (21.42%) weighed less than the ideal body weight.

8) **Fat free mass** – It implies the measurement of body tissue, other than the adipose tissue. In the current study the mean fat free mass values were 53.5±7.03 Kg. The values fell into the range of 42.5-72.5 Kg. The mean value for fat free mass per cent was found to be 78.21±5.41. The fat free mass per cent values covered a range from 64.83-125.21 per cent. (Table 2). The analysis revealed that 11 subjects (39.28%), had fat free mass per cent between 40-50 Kg, and an equal percentage (39.28%) had fat mass percentage between 50-60 Kg, and subjects 5 in number, (17.85%) had fat free mass between 60-70 Kg. In consideration to the fat mass percentage majority that is 19 subjects, (67.85%) had fat free mass percent values between 70-80% of body weight.

9) **Metabolic Age:** It indicates the average age associated with the type of metabolism a particular person has. If metabolic age is higher than actual age it indicates that a person needs to improve his metabolism. This may be done through exercise. The mean values for metabolic age was
40.03±10.86. The range for the values was 17-61. (Table 2). Metabolic age greater than actual age was observed in 8 subjects, (28.57 %), while Metabolic Age less than the actual age was seen in 18, (64.28%) of the subjects. Metabolic age equal to actual age was seen in 2, (7.14%) of the subjects.

10) Degree of Obesity - degree of obesity reflects whether extra calories are deposited in the body as fat leading to obesity. It may be positive or negative. In the present study the mean value for degree of obesity was 12.66±15.82. The range was -18.01-64.15. (Table 2). Subjects 22 in number, (78.57) had a positive degree of obesity, which meant that the actual body weight was more than the Ideal or desired body weight, while 6, (21.42%) had a negative degree of obesity. This implied that the desired weight was more than the actual body weight.

IV. Summary and Conclusion

Thus from the study it can be said that on the basis of Bioimpedance analysis of body composition parameters majority of the subjects were healthy when classified according to BMI values. Some had normal fat percentage while others had fat percentage in the overfat range. The body water content and visceral fat rating was normal for majority of the subjects. The metabolic age results also showed that the subjects were healthy. Majority of the subjects had a positive degree of obesity. The Basal Metabolic Rate was less in greater number of subjects as compared to standards. Thus it can be concluded that bioimpedance analysis information is essential for providing a detailed insight into a personal health status and for indicating health risks such as severe dehydration or oedema.

Bibliography


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<tr>
<td>Height (cm)</td>
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<td>Weight (Kg)</td>
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<td>Body Mass Index (Kg/ (m)^2)</td>
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Table 2- Body Composition parameters of the subjects under study

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<th>Standard Deviation</th>
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<td>12.66</td>
<td>±15.82</td>
<td>-18.01-64.15</td>
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Figure 1-Assessment of Nutritional Status using BMI

Figure 2- Classification of subjects on the basis of Fat Mass per cent
Figure 3 - Classification of subjects according to Visceral Fat Rating

- Healthy: 32.14%
- Unhealthy: 63.5%