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Research Paper

Electrical Techniques Implied for Body Composition Analysis

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ABSTRACT:*Body composition of an Individual is the term used to describe different components or parameters present in Human Body such as Water, Protein, Minerals, Fat Mass Content, Fat Free Mass which when added together constitute body weight. To determine the different parameters of Human Body discussed above which constitute the body weight physical tests are done, which constitute of several field and reference method which are helpful in the analysis of body composition. Body Composition Analysis is done therefore, to classify cohorts of individual as overweight, obese and underweight.This paper provides an overview of laboratory and field methods commonly used in research, clinical, and health/fitness settings to obtain valid measures of body composition and recommends specific methods and prediction equations for this purpose.*

Keywords: *Total Body Water, Fat Free Mass, Impedance index. Body Mass Index (BMI)*

I. INTRODUCTION

Maintaining body health and level of body fatness is a key to healthier and longer life. Body Composition Analysis is necessary to yield data about normal growth, maturity and longer life. It is necessary area of research especially for diseased patients. It has been found that the unhealthy eating habits are responsible for the imbalance in eating habits. Normally people who eat improper food suffer from dehydration, cardiovascular metabolic diseases and certain types of cancer, while malnourished individuals suffer because they are not being provided with proper nutrition. And so there is fluid electrolyte imbalance in the body, and therefore in case of women there is renal and reproductive disorder.

Body Composition Analysis of Indian subjects has been done to study the imbalance in the health status of individual. It has been found that obesity is the serious problem that the world is facing due to improper food intake, when it comes to determining about the health, Indian subjects are facing the problem of unhealthy body composition. This may be due to the fact that they are not being provided with healthy nutrition. It is a well known fact that Human body is composed of 70-75% of water. Unhealthy nutritional intake has trapped them in the mode where people are facing lot of diseases.India is one such country where the condition of unprivileged sector of society is very bad. They suffer from the problem of malnutrition. Moreover, the living style of this sector is very unhygienic and they are ignorant of healthy eating habit. This is the reason, they suffers from a variety of diseases such as Anemia, Diarrhea, Irritability, Anxiety and attention deficits and Goiter. Besides this there is also a vast section of society who suffers from the problem of obesity which in turn is the cause of several other diseases such as cancer, kidney related problem, cardiac diseases and diabetes (Type –II). With the help of BIA Analysis the person Fat content and hydration status can be measured. Moreover, this method is cheap comparative to other reference method. That is why; the benefits of BIA Analysis can be available to mass population at low cost.

II. TECHNIQUES FOR ASSESSING BODY COMPOSITION AND PERCENTAGE BODY FAT:

Numerous techniques are used to assess the body composition of Human Body. Some of the methods are called as field methods, whereas some of the methods are called as reference methods. The reference methods are more complicated and require expertise technical skill to measure the body fat. But they are more accurate then the field. The reference methods are more accurate then the field methods, but they are still prone to errors and have basic assumptions that do not always hold true. Therefore, none can be considered singly as a "gold standard" for *in vivo* body composition assessment.

2.1Reference Methods/ Laboratory Methods:

2.1.1Hydrodensitometry or underwater weighing: The principle of measurement of Hydrodensitometry is based on Archimedes Principle. The client is submerged in water and Volume of subject submerged in water = Volume of water displaced. Since it is not practical to collect and measure the displaced water, the individual's underwater weight is used to calculate the weight loss under water. This weight loss under water is directly proportional to volume and water displaced by body.

Body Density (Db) = Body Mass (BM)/ Body Volume (BV).....(2.1.1)

% Body Fat is then calculated using 2-C or multi-compartmental body Composition model

2.1.2 Air Displacement Plethysmography: Air Displacement Plethysmography uses air displacement, instead of water displacement to measure or estimate the body volume. Early attempts at using Air Displacement Plethysmograph were not successful. In 1995, Dempter et al. overcome some of the limitations of water displacement and introduced a new system called BODPOD. BODPOD is a large fiber glass chamber that uses air displacement and pressure volume relationship to determine Body Volume. The measurement for ADP is based on Boyle's Law Principle i.e.

$P_1/P_2 = V_1/V_2$.....(2.1.2.1)

An improved software of BODPOD is based on Poisson's Law i.e.

$P_1/P_2=(V_1/V_2)^{\lambda}$ λ=1.4 for air.....(2.1.2.2)

2.1.3 Hydrometry: Hydrometry is the measurement of body water. About 60% of body weight is composed of water. As water is the most important constituent of the body; measurement of Total Body Water (TBW), Intracellular Water (ICW) , Extracellular Water (ECW) is very important for Body Composition. In this method, concentration of Hydrogen, Oxygen isotopes in body fluids eg.(saliva, blood, urine) is measured after equilibrium and used to estimate Total Body Water (TBW). Percentage Body Fat can be estimated using 2C model.

2.1.4 Dual Energy X- Ray Absorptiometry: In early 1980's researchers used a method called dual photon absorptiometry to assess Total Body Bone Mineral and Bone Mineral density. It uses the attenuation of photon beams from radioactive nuclide source to identify the bone tissues. It measures Lean tissue Mass, Fat Mass, soft tissue mass and %BF.

2.2 Field Methods:

2.2.1 Skin Fold Method: Skin fold method is a good measure of measuring the subcutaneous fat of thebody. Subcutaneous Fat of the body is measured by Skin Fold Calipers. Skin Fold Calipers take the pinch of skin at various standardized position of the body such as stomach, ankle, biceps and measures fat layer thickness. The Skin Fold measurements are converted into %BF by an equation. Some formulas require 3 other 7 equation. The accuracy of these measurements dependent upon person unique body fat distribution.

2.2.2 Additional Anthropometric method: The term anthropometric refers to the measurement of various parameters of Human body, such as circumference of various body parts and thickness of Skin fold. It helps in estimating how dense body is and thus how much lean muscle and body tissue we have in body.It works by using various measurements such as weight, height, results of Skinfold and other tests to predict Total Body Composition, especially Bone density Composition. Healthcare uses these measurements to estimate the percentage of adipose tissue one carries around.

2.2.3 Near Infrared Interactance method: This method of assessing body composition is based on the principles of absorption, reflectance and Near Infrared Spectroscopy. To estimate body composition; Computerized Spectrometer is used which has scanner and fiber active probe. This Spectrometer is placed on selected body site such as biceps and Infrared light is emitted which passes through both fat and muscle and is reflected back to probe. Body Fat absorbs light whereas lean muscle tissue reflects it. This difference between emitted and reflected light is calculated and volumes of tissue are then calculated. There is an inverse and linear relationship between optical density measures and subcutaneous fat at the bicep site and Total Body Fatness.

2.2.4 Bio Electrical Impedance Analysis: Bio Electrical Impedance Analysis measures the impedance or opposition to the flow of electric current through the body fluids, contained mainly in the lean tissue, which can be used to calculate Total Body Water (TBW), which in turn estimate the Fat Free Mass (FFM) and Fat Mass (FM). The impedance or resistance to the flow of Electric current through body tissue can be used to calculate the estimate of the analysis of Human Body Composition through BIA is based on Ohm's Law.

Assuming that the Human body is perfect cylinder at a fixed frequency signal (50 K KHz) the impedance through the body is directly related to the length of conductor and inversely related to cross sectional area: (A)
$Z = \rho(L/A)$.....(2.2.4)

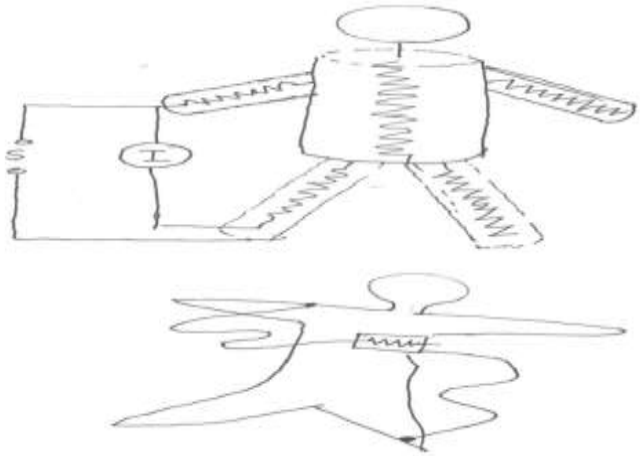


Fig1: Basic principle on which Bio Electrical Analyzer operates.

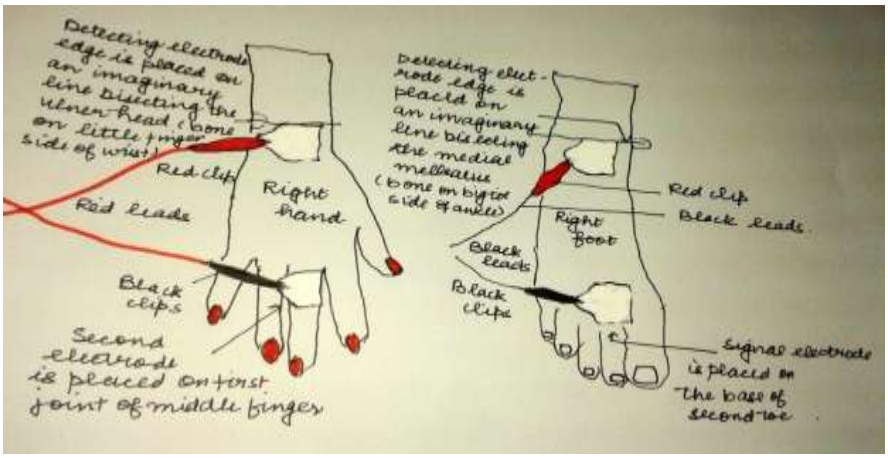
III. STATEMENT OF PROBLEM

BIA was based on the principles of Ohm's Law, so basically it was used to measure the Fat content in the lean mass tissue. Besides this, BIA treated body as a series of cylinder fixed at some frequency (50 KHZ) in the beginning. But with the modification in the design of instrument (Single electrode to multi Electrode) their utilities in determining the health status of different cohorts of individuals have increased. Modern BIA instruments now measures the flow of blood through Biological tissues at different frequencies. This in turn has helped in determining the Impedance of Body at different frequencies and from the studies it has been found that at lower frequencies cell cannot bridge the cell membrane and will pass through Extracellular space, whereas at Higher Frequencies the penetration of cell membrane occurs and cell will pass through both Extracellular Space and Intracellular Space. The study of BIA at multiple frequencies has helped in modeling the body into different compartments. So BIA is useful in monitoring different diseases of subjects.

Our Research is done on Indian subjects using BIA Analysis. For that we have used the Instrument Maltron- II BIA Analyzer at a frequency of 5KHz, 50KHz, 100 KHz and 200 KHz. Software used for developing Prediction equation is R software (version 9.2.1). The clinical measurements of subjects were done using BIA analysis wherein the whole procedure for measurement is described below and to test the validity of the procedure, a statistical method called Regression is used. We have used linear Multiple Regression Analysis to develop prediction equation at different frequencies. For that we have utilized R (version 9.2.1) software.The clinical results are then finally validated with different parameters of subjects (TBW, FFM) that were developed by prediction equations at different frequency.

IV. PROCEDURE FOR MEASUREMENT

BIA is based on the principle that biological tissues acts as conductor or insulator, and the flow of current through the body will follow the path of least resistance. The BIA measurements is performed by attaching the pair of electrodes at the right wrist and right ankle, so that a weak but constant alternating current (800μA) can be passed through the body, previously 2 electrodes were used to determine the impedance through the body, but now 4 electrodes are used for accuracy and results. The black clips are for injecting current. And voltage is measured across the clips marked red. From the voltage and current measurements, body resistance is calculated. BIA allows the determination of the FFM and TBW in subjects who do not have significant fluid and electrolyte abnormalities, by using appropriate population, age or pathology specific BIA equations.



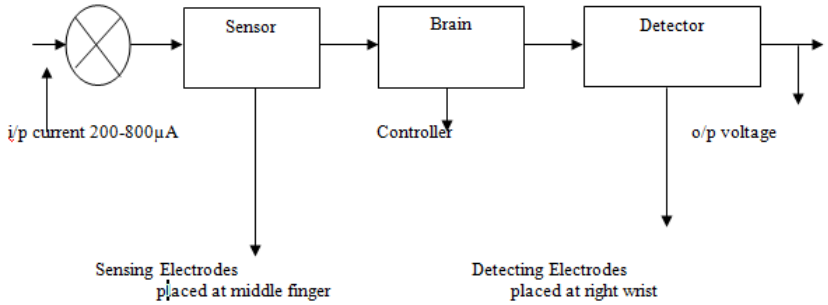


Fig2: Mode of operation of BIA Analyzer.

V. JUSTIFICATION

Body composition of different cohorts of individual from various ethnicities like African, Asian, Europeans, Americans, different cohorts of individual according to their level of physical activity like athletes, belle dancers, and health status of individuals have already been studied with different reference and field methods each with its own advantages and limitations. Besides this models have been developed to assess body composition. The oldest is Siri 2C through which %BF is determined.

5.1 Multi-compartmental study of human body: Depending upon the parameters of human body, the human body is divided into various compartments or models. This has made the study of human body parameter a lot easier and scientists an area of research to calculate %BF so that if the %BF is under or above the healthy status of an individual, the dietary and pharmaceutical measures may be done. Scientists and Researchers have been modeling Human Body into different compartments. Body is divided into different levels such as atomic, molecular, cellular, tissue and whole body level. The sum of components of each level totals the sum of whole body weight. The body is divided into different compartments to calculate the %BF of the body. Some of the methods are called as reference or laboratory methods such as Hydrodensitometry , Air Displacement Plethysmography, Hydrometry and Dual Energy X Ray Absorptiometry. The other methods which are called as Field methods such as Skin Fold Method (SKF) , Body Mass Index (BMI) , Bio Electrical Impedance method and Near Infrared Interactance methods. The Field methods are not accurate methods but in fact the indirect method of measuring Body Parameters. Researchers and Scientists have been working on analysis of Human Body Composition so that the healthy population be developed in each nation. And it will help in understanding the disease that results from improper body constitution.

5.2 Designing Multi-compartmental Models: The body fat component and Body density of Human subjects is done; by designing Multi- Compartmental model. Up to 6 compartmentalmodel have been designed, but study in this case limits in designing 4C and 6C model, because for that certain parameters of body component are needed such as bone mineral, residual mass.Modeling body into 4 compartments and 6 Compartments requires measuring the Bone Mineral content of the body . This is the reason, for measuring Bone Mineral Content DEXA is needed for measuring these components. Using BIA Analysis it is possible to divide the body into 2 compartmental model which divides the whole body into Fat and Fat Free Mass and 3C

model proposed by Siri and Lohman respectively. The former dividing the Human body into Fat, Water and Solid i.e. (Minerals + Protiens) content and later dividing the Human body into Fat, Solids (Mineral) and (Water+ Protien) content. In this study Body density and %BF of Human body is calculated by theoretical formula designed by Siri in year 1956 and 1961 and by Lohman in year 1986.

5.2.1Different Compartmental Model designed by Siri and Lohman:

5.2.1.1: ***Siri Two Compartment molecular level models:*** In year 1956 Siri partitioned the whole body into 2 parts; Fat and Fat Free Component. If the body is partitioned into Fat and Fat Free component, then formulated the formula for calculating Body Density is given as below:

$$\frac{1}{\text{Db}} = \frac{FM}{FM\text{Db}} + \frac{\text{FFM}}{\text{FFMDb}} \text{.....(5.2.1.1.1)}$$

The assumed densities of Fat is .9007 Kg/L and for Fat Free Mass component it is assumed to be 1.1 Kg/L where Db is the density of body, FM Db is the Fat mass density of the body; FFM Db is the Fat Free Mass Density of the body. Siri also formulated the formula for % Body Fat as below:

$$\%\text{BF} = \frac{497.1}{\text{Db}} - 451.9\text{.....(5.2.1.1.2)}$$

5.2.1.2:*Siri Three Compartment water molecular level models:* In year 1961 Siri modified the 2C model and divided the body into 3Compartments Fat, Total Body water and (Mineral + Protein fraction) component.Desities for the above components are assumed to be 0.9007 Kg/L, 0.9937 Kg/L and constant density for (Mineral + Protein Fraction) i.e. 1.565 kg/L.The formulated formula for calculating the body density is as given below:

$$\frac{1}{\text{Db}} = \frac{\text{FM}}{\text{FMDb}} + \frac{\text{TBW}}{\text{TBWDb}} + \frac{\text{Minerals +Proteins}}{(\text{Minerals +Proteins fraction })\text{Db}} \text{.....(5.2.1.2.1)}$$

Siri also modified the formula for calculating % Body Fat calculation as given below:

$$\%\text{BF} = (\frac{2.118}{\text{Db}} - 0.78 \times \frac{\text{TBW}}{\text{BW}} - 1.354) \times 100\text{.....(5.2.1.2.2)}$$

; where BW is the body weight.

5.2.1.3:*Lohman Three Compartment mineral molecular level models:* In year 1986 Lohman modified the Siri 3C model and partitioned body into Fat, Mineral and (Water + Protein) fraction. The assumed densities of Fat, Mineral and (Water + Protein fraction) component of the body are assumed to be 0.9007 Kg/L, 3.038 Kg/L and constant density for (Water + Protein Fraction) i.e. 1.0486 Kg/L.Lohman formulated the formula for Body Density is given as below:

$$\frac{1}{\text{Db}} = \frac{\text{FM}}{\text{FMDb}} + \frac{\text{Mineral}}{\text{Mineral Db}} + \frac{\text{Water +Proteins}}{(\text{Water +Proteins fraction })\text{Db}} \text{.....(5.2.1.3.1)}$$

Where Mineral Db is the density of Minerals in body, Water and proteins fractions have constant density of 1.0486 Kg/L as discussed earlier. Lohman also modified Siri 3 Compartment model formulas for % Body Fat calculation as given below:

$$\%\text{BF} = (\frac{6.386}{\text{Db}} + 3.961 \times \frac{\text{Mineral}}{\text{BW}} - 6.09) \times 100\text{....(5.2.1.3.2)}$$

Where, BW is the body weight.

5.3 Description of Flowchart: Here is the explanation of flowchart point wise:

1. Different Parameters of Human Body such as Age, Height, BMI, TBW, %Fat, %Fat Free Mass, Extra Cellular Water, Intra Cellular Water, Mineral, Protein, Body Density andmany other such body composition parameters like Impedance, Capacitance, and Reactance at differentfrequencies are input at the initial stage.
2. Apply the initial hypothesis; i.e. calculate the Body Density and %Body Fat of Human Body using Siri 2C model and validate the result of Body Density and %Body Fat from that measured by the instrument and see if the hypothesis is verified. Otherwise test next hypothesis.
3. Apply the next hypothesis; i.e. calculate the Body Density and %Body Fat of Human Body using Siri 3C model and validate the result of Body Density and %Body Fat from that measured by the instrument and see if the hypothesis is verified. Otherwise test next hypothesis.
4. Apply the final hypothesis; i.e. calculate the Body Density and %Body Fat of Human Body using Lohman 3C model and validate the result of Body Density and %Body Fat from that measured by the instrument and see if the hypothesis is verified.
5. Finally state the result that the result of hypothesis are verified i.e. the Body Density and % Body Fat calculated by the hypothesis are very close to the mesured result using Maltron-II BIA analyser

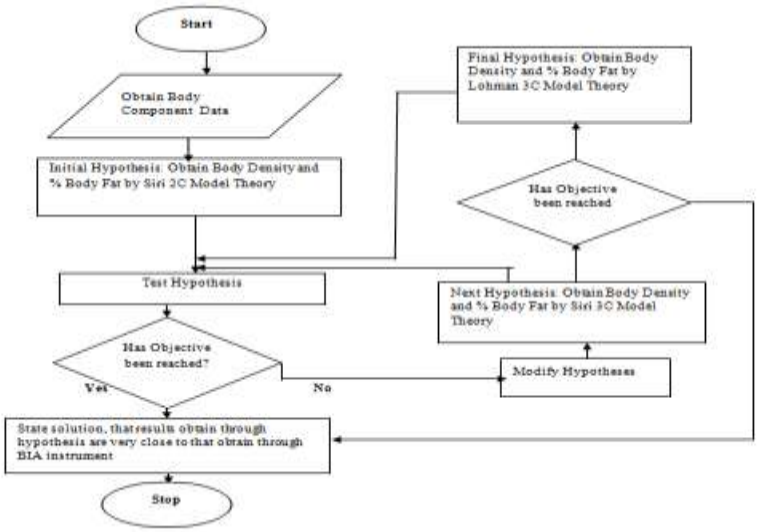


Fig3: Actual Process; testing different hypothesis of Siri 2C model, Siri 3C model and Lohman 3c model.

VI. SUMMARY FOR MULTI-COMPARTMENTAL ANALYSIS OF HUMAN BODY:

The aim of the study was to study different body composition models designed by Siri in the year 1956, 1961 and by Lohman in year 1986. And to check the accuracy of results by clinical measurements done through BIA Analysis. These results were then used to developed the prediction equation for Body Density and %Body Fat, dividing body in the same pattern used in Siri 2C model, Siri 3C model and Lohman 3C model. The clinical results were validated with Siri 2C model, Siri 3C model and Lohman 3C model and Cross validated with the developed prediction Equation. The results shows that clinical results , different models hypothesis results and predicted results for 2C model, 3C water molecular model and 3C mineral molecular models were very close.

6.1 Developing Prediction Equation: Researchers use multi- component models as a reference measure for the development of field method equation. The basic statistical concepts; that researchers have been using since earliest time; to predict and develop equation; to estimate the body composition of cohorts of individual from a specific group is regression analysis method. In Regression Analysis method, a particular variable is predicted from group of independent variables. Mainly, two types of Regression Analysis process are used to predict and develop equation:

6.1.1 Bivariate Regression Analysis: In this Analysis, what is done that 1 variable is predicted from the other known variable. Mathematically, the following prediction equation generated by the regression Analysis is used:

$Y' = a + bX$ ……..(6.1.1)

Where Y' predicted score from the particular X value, a = y-intercept, b = slope of regression line.

6.1.2 Multiple Regression Analysis: In this Analysis, what is done 1 variable is predicted from 2 and more known variable. Mathematically, the following prediction equation generated by the regression Analysis is used:

$Y' = a + b_1X_1 + b_2X_2 + b_kX_k$.....(6.1.2)

Where Y' is predicted Value of the dependent Variable. X's represent the predictor variable. a = y-intercept, b's = weight assigned to each of predictor variables.

6.2 Statistical techniques used: Generally different validation techniques are used for development of prediction equation and validating the results that they have been obtained through instrument.

In our work; multiple regression analysis have been used to predict and develop the BIA equation, the developed or predicted equation is of the form;

$Y = m_1x_1+m_2x_2+m_3x_3\ldots+m_kx_k+c$, where ($x_1,x_2,x_3\ldots.x_k$ are parameters of human body composition such as age, weight, sex, height, stature and $m_1,m_2,m_3,..m_k$ are the constant that we have determined making use of some statistical software (In our case R (2.9.2)).

Using R as a statistical tool, the linear multiple regression analysis of the data is developed at different frequencies for Indian subjects. The obtained results are then validated with the clinical data obtained through Bioelectrical Impedance Analyzer and their accuracy is checked. In this way, the study of Indian subjects, at different frequencies is carried out. It must also be seen that, that as the human body parameters

such as age, sex, Resting Energy Expenditure for the study different information about the human body composition for the subject were obtained. Thus, using R as a statistical language tool has proved helpful in the study of information about the subjects.

6.2 Mathematical Analogous System:

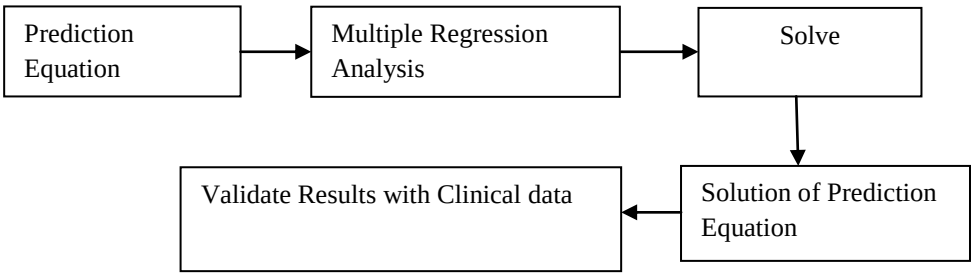


Fig4: The mathematical analogous system showing the actual process to validate the clinical data obtained through BIA analysis.

All body composition methods needs to be validated and cross- validated to test their applicability and use in the field. The Human body parameters such as TBW (Total Body Water) and FFM (Fat Free Mass) that we have obtained through BIA measurements needs therefore, to be tested that whether they are accurate or not. So; prediction equations were developed using linear Multiple Regression Analysis. The linear model of TBW(Total Body Water) and FFM (Fat Free Mass) is designed which is shown in flowchart as TBWf1,f2,f3,f4~(lm(Zif1,f2,f3,f4 +Wt.+ Sex+ Ht+ age.) and FFMf1,f2,f3,f4~(lm(Zif1,f2,f3,f4 +Wt.+ Sex+ Ht.+ age) where lm shows the linear regression model designed by taking independent variable Impedance Index at different frequencies(Zif1,f2,f3,f4) , Weight, Sex(taken as 1 for male and 0 for female) and Ht. of body of different subjects. The predicted TBW (Total Body Water) and FFM (Fat Free Mass) at different frequency are then validated with the TBW and FFM measured through BIA analysis.

6.3 Description of Flowchart: The process going on in the flowchart shown in next page can be described in following steps:

1. The human body parameters of Indian subjects 100 in no.(N=51 females and N=49 males), weight, height, Sex, age and impedances taken are input at the very first stage.
2. The impedance index of Indian subjects Zi is calculated at frequency f1=5KHz, f2=50KHz,f3=100KHz and f4=200KHz by formula (Zif1,f2,f3,f4=(Ht.2 /Z))k=1……N where k=value of height and impedance for subjects 1,2,…..,100.
3. The process of calculating Impedance Index (Zi) at frequency f1,f2,f3,f4 continues till it is calculated for all 100 subjects.
4. The linear model of TBW(Total Body Water) and FFM (Fat Free Mass) is designed which is shown in flowchart as TBWf1,f2,f3,f4~(lm(Zif1,f2,f3,f4 +Wt.+ Sex+ Ht+ age.) and FFMf1,f2,f3,f4~(lm(Zif1,f2,f3,f4 +Wt.+ Sex+ Ht.+ age) where lm shows the linear regression model designed by taking independent variable Impedance Index at different frequencies(Zif1,f2,f3,f4) , Weight, Sex(taken as 1 for male and 0 for female) and Ht. of body of different subjects.
5. The obtained prediction equation are (TBW (f1, f2, f3, f4) = a0×Zi (f1, f2, f3, f4) + a1×Wt.+ a2×sex+ a3×ht.+ a4×age+ c1)and(FFM (f1, f2, f3, f4) = b0×Zi (f1, f2, f3, f4) + b1×Wt.+ b2×sex+ b3×ht.+ b4×age+ c2)which are explained in detailed later.

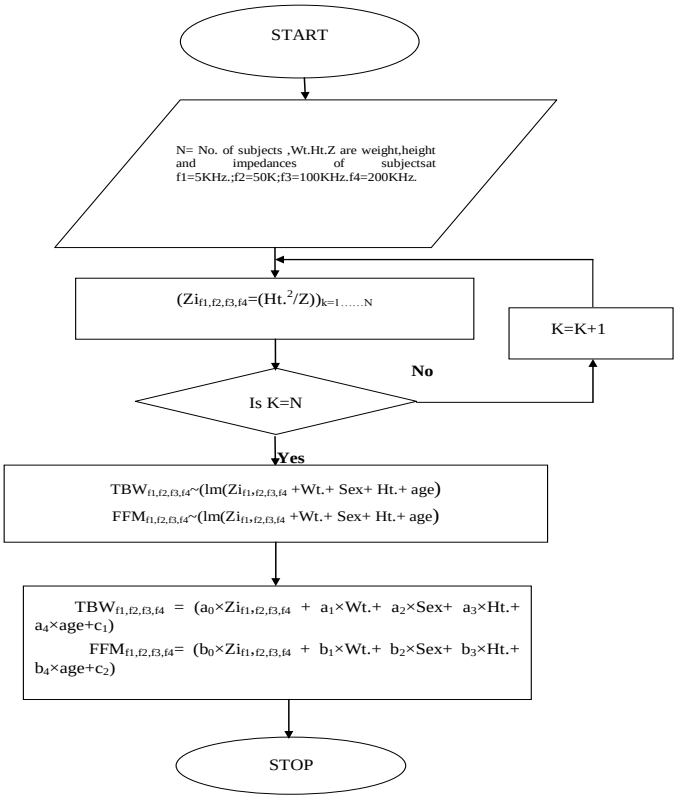


Fig5: Flowchart showing the general process to develop linear model of TBW and FFM at the frequencies of 5 KHz, 50 KHz, 100 KHz and 200KHz

6.4 Why BIA is preferred method for Body Composition Analysis? : The main goal of our work was to study various Field and reference method employed in analysis of body composition of subject. It has been found in studies that no method is free of error. Reference methods, though more accurate then field methods are very complicated to operate and are expensive. Therefore, no method can be said as gold- standardized method for *in vivo* body composition assessment. Because of all these complexity of instruments and technical skills that were required to operate them, BIA is very useful in conditions where economy and ease of operation is the main criteria for body composition analysis. BIA started as a research tool but is currently providing clinicians with data that they have no other rapid, reliable or non-invasive way of obtaining. The BIA can be successfully used to support clinical decision-making for patients with a broad range of disease states. Further studies have to be focused strongly on the significance of BIA measurement values in diseased populations. New approaches, such as segmental, multi-channel and multi-frequency analysis have greatly expanded the utility of this electrical technique and eliminated the limitations of BIA in different disease states, sex and ethnic diversity. The simplicity and non-invasive nature of a bioelectrical impedance measurement is a major operational advantage of the BIA technology. Many studies and clinical trials are going on across the world to find new variants and applications of BIA.BIA is necessary to understand the mechanisms for the changes in acute illness, fat/ lean mass ratios, extreme heights, and body shape abnormalities.

VII. DISCUSSION AND CONCLUSION POINTS

Research regarding the body composition analysis of Indian subjects is our first step to analyze the dietary habits of Indian subjects. This was also the first step to study the eating habits of males and females in Indian population. The data obtained from BIA Analysis can be utilized for various health and clinical applications research. Specialized sports training, exercise intervention, body altering programs will be given to cohorts of individual once we have their statistical data. It is also observed that Chemical Analysis of subjects will lead to better analysis of their Body composition. Another important factor, which comes into highlight after studying the Body Composition Analysis, is the amount of energy consumed by individual in Kcal for 24 hr. period in resting state. BIA determines the Resting Metabolic Rate (RMR) or Resting Energy Expenditure (REE) of the subject. It determines the metabolic rate of individual and if a person wants to lose weight, any increase in Resting Energy Expenditure (REE) should be duly noted. Resting Energy Expenditure (REE) constitute about 60-70% of Total Energy Expenditure (TEE) and hence used for Energy Requirement of

Population. Resting Energy Expenditure (REE) of subjects with similar weight and height may vary due to the reason that metabolism vary for different people.

Some of the interesting observations were made while developing prediction equation. The predicted TBW (Total Body Water) and FFM (Fat Free Mass) were very close to measured TBW (Total Body Water) and FFM (Fat Free Mass). But at high frequency results are closer to measured value because at low frequency cell cannot bridge cell membrane and will pass through Extracellular Space; whereas at high frequency penetration of cell membrane occurs and current is conducted by both Extracellular Space and Intracellular Space.

Our Research study can be extended to analyze the body composition of Indian athletes, subjects from slum areas and patients. Our study will also be helpful if we want to compare the statistical data of different countries with the subjects of our country.

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