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Bioelectrical Fat Analyzer Using Microcontroller Atmega328

Saranya L[1] , Arthi C V[2], Jaanavika D[2] , Madhumitha S[2] , Vinothini R[2]
[1]Assistant Professor, [2]Student
[1,2]Department of Electronics and Communication Engineering
Karpagam College of Engineering, TamilNadu, Coimbatore, India
saranyalece@gmail.com[1], jaanudhansekar@gmail.com[2]

ABSTRACT:

Bioelectrical impedance analysis (BIA) is a useful method for determining the fat mass (FM), Fat free mass (FFM), and overall body water content (TWC) of the body. BIA plays a vital role in fitness and health care by measuring the body's compositions. It's easy for an individual to concentrate on particular part of body to reduce the body fat and make one's progress better in fitness. Adiposity leads to major deadly diseases in our body including stroke and cardiovascular diseases. BIA gives an accurate result of body's fat mass and total water content. BIA method is performed by passing very minimal amount of current about (500micro amps to 800micro amps) through different parts of body (hand, wrist, ankle and foot). The Electrolytes passes easily through water where FFM allows it quickly but FM doesn't allow electrolyte to pass, as it contains low water content and have high resistance. FFM includes calculating extracellular water, intracellular water, bone and visceral protein, where FMgivesthemassofbody'sfat. BIA is a cost effective tool to maintain one's health and fitness.

KEYWORDS:

Electrolyte, bioelectrical impedance analysis, fat mass, fat free mass.

1.INTRODUCTION:

Bioelectrical impedance analysis is a noninvasive technique which evaluates body compositions by measuring bodyfat percentage (BF%) and total body water content. Obesity plays a major role in cardiovascular diseases, which leads to high mortality rate among people. Body mass index (BMI), hip circumference, waist circumference, waist to hip ratio, waist to height ratio, and skin fold thickness are all anthropometric measurements used in BIA. Bioelectric Impedance Analysis determines the electrical impedance, or opposition to the flow of an electric current through the body [1].

Dual energy x-ray absorptiometry (DXA), under water weighing (UWW), and isotope dilution are some other methods for determining body fat (eg. deuterium O18). These measures are costly and time consuming, therefore not practically applicable for large epidemiological and field studies, where BIA is an accurate measure which gives result based on BF% and cost efficient. BIA follows an electrical measure by passing very minimal current at fixed frequency from the source (electrode) through organism, by getting changes in impedance we can observe the fall and rise in voltage which gets noticed in sensor. By reactance change, we can evaluate TBW by calculating constant hydration rate which estimates FFM, in general lean tissues contains low reactance which allows current to pass easily as itcontains high water content and electrolytes. Whereas fat, bones and skin contains less water content and electrolytes which shows high reactance towards passage of current. These changes in resistance and reactance alternate the current which leads to the changes in phase angle. Compared to other measures of BIA , phase angle gives accurate results in impedance analysis, which has also been used in nutritive tests, and takes its role in predicting

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HIV, cancer and peritoneal diseases. Compared to other measures including DXA, BIA gives standard results on BF%.

2. EXITING SYSTEM:

2.1 SKIN FOLD CALIPER:

This method uses skinfold thickness to measure the BF% by a hypothesis fat which is distributed throughout the body. It takes measurement in triceps, waist, thigh and biceps. Even though they are easily affordable it is not applicable for people above 50 years and gives measurement error of about 3.5-5%. The reading is given in millimeters and compared to a chart with age and gender to arrive at body fat percentage [2].

2.2 DUAL X-RAY ABSORPTIOMETRY(DXA):

DXA is a whole body scanner which measures BF%, by passing two different energies of x-ray to the body which gives result on soft tissue and bone density. It is expensive and unavailable to general public, its error range upto2.5-3.5%. Dual X-ray absorptiometry was investigated as a method for evaluation of the strength of closed tibial fractures. In 40 goats, a closed midshaft fracture was created in the left tibia. [3]

2.3 UNDER WATER WEIGHING:

It measures the density of the body. Weight is measured for a person under water and on land, this difference in measurement being applied in equations to calculate the density which gives BF%. Its error rate below 2% but it's hard for a person to hold breathe under water. Participants must not eat or engage in strenuous exercise for at least 4 hours before their scheduled appointment. They should avoid ingesting any gas-producing beverages for at least 12 hours before the test. Participant must wear swim suits [4].

2.4 BIOIMPEDANCE SPECTROSCOPY:

This method is similar to BIA whereas it uses high current with different frequencies and measures the same fluid contents as in BIA. But device is not easily available to the people. BIS detects medically meaningful fluid shifts as low as 36 ml in a limb [5].

3. PROPOSED SYSTEM:

In BIA method, we use fixed frequency with minimal amount of current (500 micro amp-800 micro amp) is being passed between electrodes through different parts of body. By this process we observe certain changes in our body's resistance, through sensor we observe voltage fluctuations, by substituting these results on equations we get BF%. Muscle has high water content, and it is highly conductive, while fat has lower water content and is not highly conductive. Based on the strength of the impedance along with height and weight metrics, the BIA scale will estimate fat-free body mass and body fat percentage [6].

$$\text{Male} = (0.0923 * \text{weight}) + (0.1605 * \text{age}) - (0.0263 * \text{voltage})$$
$$\text{Female} = (0.1871 * \text{weight}) + (0.58 * \text{age}) - (0.092 * \text{voltage})$$

This method involves measuring resistance and impedance of body with help of alternative current which results in change of phase angle.

$$\text{Arc tangent} = ((Xc / R) * (180° / \pi))$$

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The phase angle is critical in assessing the body's composition.

$$Z = R + jXc; \quad (1)$$

$$|Z| = \sqrt{R^2 + Xc^2} \quad (2)$$

$$\varphi = tan^{-1}\left(\frac{Xc}{R}\right) \quad (3)$$

$$R = \rho\left(\frac{l}{S}\right) \quad (4)$$

$$C = \varepsilon\left(\frac{S}{d}\right) \quad (5)$$

$$\theta = -\arctan(Xc/R) \times 180/\pi$$

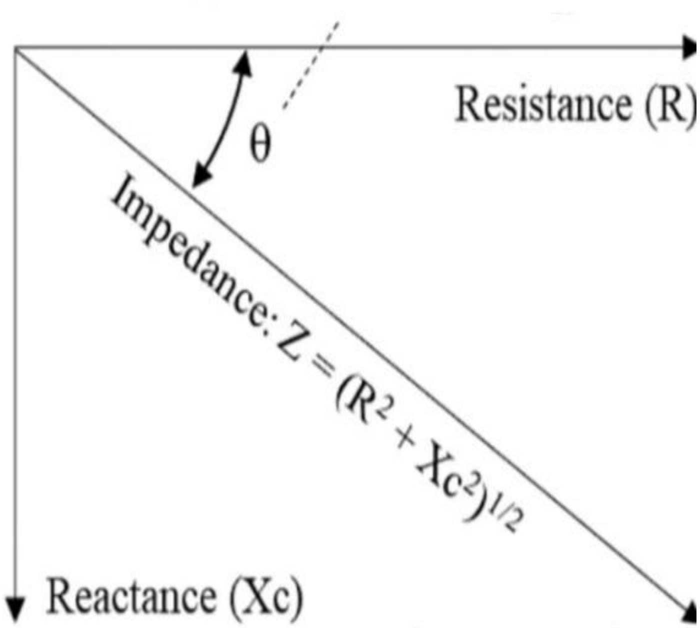

Fig 1: Phase angle arc component

Resistance of conductor(R), length (L), and capacitance C of a flat parallel plate capacitor with surface region S at distance d are all included in the above equations. In the above equations, R and C are based on geometrical parameters (L, D, and S), which are connected to the measuring device used, and physical parameters, such as resistivity p and dielectric constant, which are directly related to the form of substance to be measured (biological tissue). A simplified electrical model of bio impedance and the device used to calculate it is shown in Figure 2. The resistance of extracellular fluids is represented by RE,

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the resistance of intracellular fluids is represented by RI, and the capacitance of the cell membrane is represented by Cm. Electrode act as a medium which connects human body and device through skin. The unit calculates the current when producing excitation voltage to the electrodes.

A digital-to-analog converter (DAC) generates the excitation signal, which is attached to a downstream driver. The DAC is programmed by a microcontroller, allowing the amplitude and frequency of the signal to be adjusted. A Trans-impedance amplifier (TIA) is used to measure current and it is attached to a high-resolution analog-to-digital converter (ADC) for accurate measurements. The microcontroller processes the collected data and extracts the information required for the research. Analysis of bio impedance information obtained at 50 KHz electric current is known as single-frequency bio impedance analysis (SF-BIA) [7].

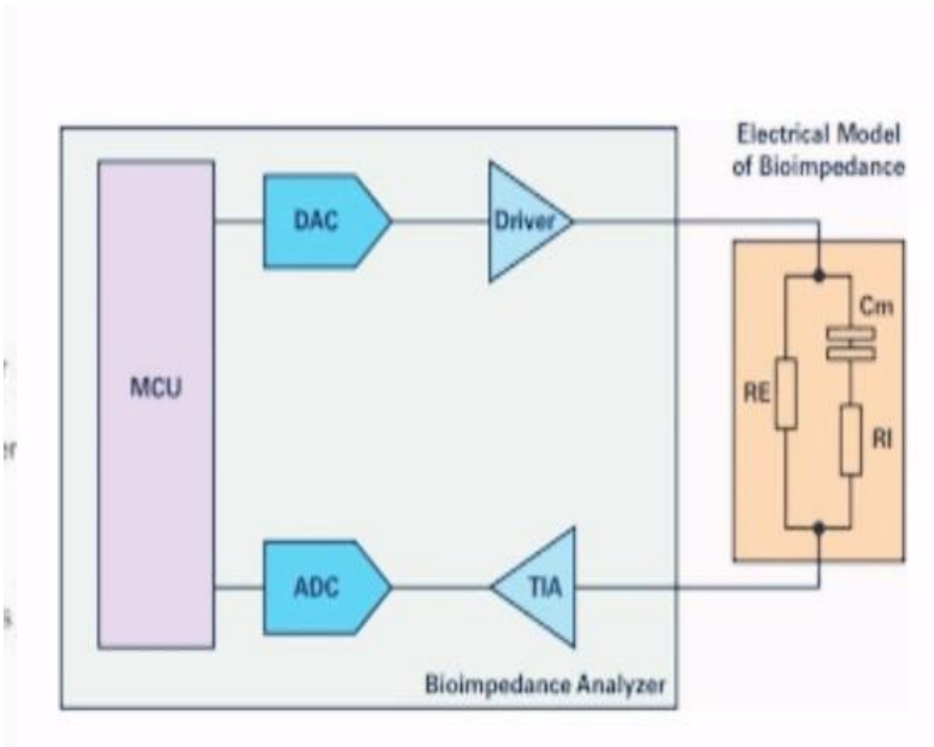

Fig 2: Bio impedance bioelectrical model

4. RESULTS & DISCUSSIONS:

The aim is to develop a single frequency bio-impedance device for clinical use. The body fat analyzer worked at a safe current of ~l0μA and a frequency of 50 kHz, causing no damage to the test subjects. The non-invasive electrodes used in the body fat analyzer produced body fat percentage with a 4% error margin. It is possible to extend the device by modifying to work with conductive handles rather than electrodes which would by easy to handle them in gym to achieve proper results.

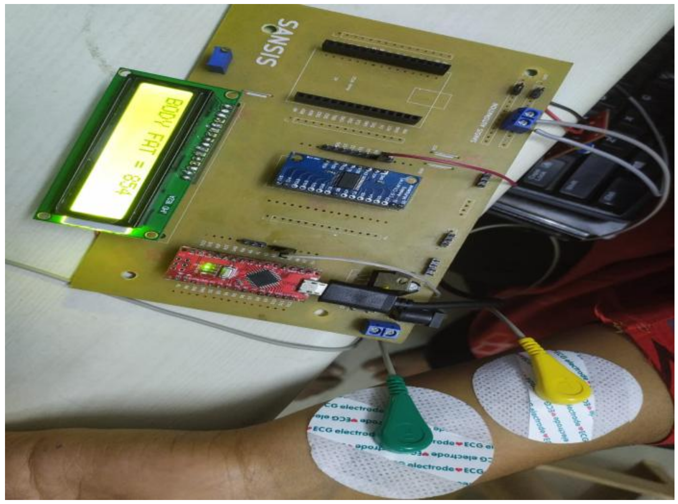

Fig 3: Hardware output of the bioelectrical fat analyzer

5. CONCLUSION:

The project's main goal is to measure BF percent, which is then divided into slim, ideal, medium, and obese categories depending on the results. This framework offers a bio impedance hardware and software interface approach that could be very helpful in clinical applications. By implementing multi-frequency bio-impedance analysis can achieve accurate result .As different frequency provides different weighted sum of total body water& fat free mass, Accuracy can be achieved by analyzing on multiple frequencies and comparing resistance & reactance measures from each frequency.

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