



APPLICATION OF BIOIMPEDANCE IN BIOLOGICAL FIELD

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ABSTRACT

Bioimpedance analysis used it because it is a (not involving cutting into the body), low cost and a commonly used approach for (the percentage of fat, bone, water, and muscle in the human body) measurements and test/evaluation of medicine-based condition. There are a variety of methods applied for (understanding/ explanation) of measured bioimpedance data and a wide range of uses of bioimpedance in (the percentage of fat, bone, water, and muscle in the human body) guess and (process of figuring out the worth, amount, or quality of something) of medicine-based status. This paper reviews the main ideas of bioimpedance measurement ways of doing things including the frequency based, the setting apart and distributing based, equations for (the percentage of fat, bone, water, and muscle in the human body) test/evaluation

Keywords: Bioimpedance analysis-spectroscopyanalysis

INTRODUCTION

The history of bioimpedance measurements ranges back to the beginning of the last century[1, 2]. Thom seet[3]explored the utilization of bioimpedance measurement in total body water estimation using needle electrodes. Nyboer [4] applied quad surface electrode readings for bioimpedance measurements to

estimate the fat free mass of the human body Hoffer [5] introduced the association between total body impedance and total body water content in reference to tritium dilution techniques. Since this time, a great variety of impedance measurement principles have been adopted from other fields like material science or

telecommunication. AC-bridges and network analyzers but also electrochemical measurement equipment was widely employed. Only a few devices designed to meet the requirements of bioimpedance measurement were marketed. However, in recent years, specialized equipment for bioimpedance measurement became more and more available [6].

Increasing attention is being given to investigations of the electrical properties of biological materials. There are several reasons for this, which include an increasing awareness of the possible physiological effects associated with the absorption by tissues of electromagnetic fields (Pethig & Kell, 1987)[7]

Bioimpedance

Refers to the electrical properties of a biological tissue, measured when current flows through it. This impedance varies with frequency and different tissue types, and varies sensitively with the underlying histology in bioimpedance depend on two basic properties that resistance and capacitance.

Resistance (R) is a measure of the extent to which an element opposes the flow of electrons or, in aqueous solution as in living tissue, the flow of ions among its cells. The three fundamental properties governing the flow of electricity are voltage, current and resistance.

The voltage may be thought of as the pressure exerted on a stream of charged particles to move down a wire or migrate through an ionized salt solution the current is the amount of charge flowing per unit time, the current two types

(D.C) direct current (A.C) alternative current. Resistance is the ease or difficulty with which the charged particles can flow they are related by

Ohm's law:

$$V \text{ (voltage, Volts)} = I \text{ (current, Amps)} \times R \text{ (resistance, Ohms } (\Omega))$$

The capacitance physically corresponds to the ability of plates in a capacitor to store charge direct current cannot pass through a capacitor. A.C. can pass because of the rapidly reversing flux of charge the effect in terms of the ease of current passage depends on the frequency of the applied current—charges pass backwards and forwards more rapidly if the applied frequency is higher the purposes of bioimpedance, a useful concept for current travelling through a capacitance is 'reactance' (X). The reactance is same to resistance—a higher reactance has a higher effective resistance to alternating current. Like resistance, its value is in Ohms, but it depends on the applied frequency, the relationship is

$$\text{Reactance (Ohms)} = 1 / (2 \times \pi \times \text{Frequency (Hz)} \times \text{Capacitance (Farads)})$$

when a current is passing through a purely resistive circuit the voltage recorded across the resistor will (happen at the same time) exactly with the timing or phase of the applied (electric current that switches between positive and negative) as one would expect when current flows across a capacitor the voltage recorded across it falls behind the charging and discharging of the plates of the capacitor.

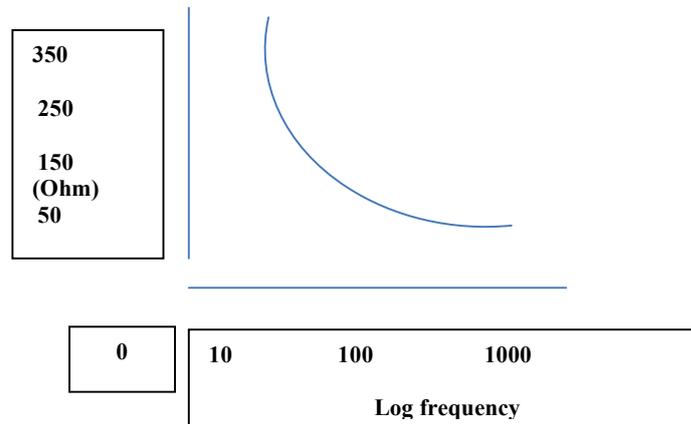


Figure 1: Reactance of Inf capacitor over 50- 1000 KHz

The idea current A.C. source passes current across a resistor or capacitor. The current delivered by the source is displayed on the upper trace. The voltage measured over the components is displayed on the lower trace. When this is across a resistor, it is in phase—when across a capacitor, it lags by 90° and is said to be ‘out-of-phase’. When the circuit contains a mixture of resistance and capacitance, the phase is intermediate between 0 and 90°, and depends on the relative contributions from resistance and capacitance. As a constant current is applied, the total combination of resistance or reactance, the impedance can be calculated by Ohm’s law from the amplitude of the voltage at the peak of the sine wave.

Physical phenomena

The electrical properties of biological tissues are currently categorized based on the source of the electricity, *i.e.*, active and passive response. Active response (bioelectricity) occurs when biological tissue provokes electricity from ionic activities inside cells, as in electrocardiograph (ECG) signals from the heart and

electroencephalograph (EEG) signals from the brain. Passive response occurs when biological tissues are simulated through an external electrical current source[4]. The Measurements of the electrical properties of biological materials have provided important contributions to the biophysical and physiological sciences. For example, Höber [2] measured the electrical impedance of red blood cell suspensions up to 10 MHz and, finding that their impedance decreased with increasing frequency, concluded that the cells were surrounded by a poorly conducting membrane and that they contained a cytoplasm of relatively low resistivity among the first indications of the ultra-thin nature of this membrane were those provided by Fricke[8]who obtained a value of 0.81 $\mu\text{F}/\text{cm}^2$ for the red blood cell membrane. On assuming a value of 3 for the dielectric constant of the membrane material, Fricke derived a membrane thickness of 3.3 nm. Quantitative details of the molecular size, shape and hydration content of protein molecules were provided by the dielectric measurements of Oncley. Cohn & Edsall, 1943 and these were

extended in the laboratories of Hasted[9], Grant[10]and Schwan [11] to provide more details of the physical nature of protein hydration. As examples of how electrical and dielectric studies continue to provide new knowledge to the biophysical and physiological sciences, we can quote the studies of the diffusional motions of lipids and proteins in cell membranes by Kell and Harris [12] studies of the influence of hydration on enzyme activation and molecular mobility [13].

When we want to know body fat by measurement electrical resistance between hands and feet the basis of the technique is that the major components of the body are firstly muscle, which has a low resistivity, and then fat which has a high resistivity. If you regard the body as a cylinder then the total resistance will depend upon the length and the area of cross-section of the body and also the average resistivity of the muscle and fat. We can estimate the length and cross section from body height and weight and hence estimate the average resistivity from which the ratio of fat to muscle can be estimated the body as just having resistance was a simplification, because measured resistances are usually found to decrease with the frequency of the alternating current used to make the measurements the body has an electrical impedance that falls with increasing frequency it's found when we have both resistive and capacitive components when taking into account that tissue consists of cells and that these are bounded by high resistivity membranes and

hence there is a capacitance between the inside and outside of every cell. The capacitance across cell membranes is remarkably high with values of about one micro Farad per square centimetre. The capacitance of cell membranes seems to offer a reasonable explanation as to why bioimpedance falls with increasing frequency – at least in the frequency range from about 100 Hz up to 1 MHz. At much higher frequencies we have to look for other explanations such as molecular absorption. the impedance of a network of resistors and capacitors can indeed exhibit an impedance measurement that rises with frequency. If the network includes three or more RC combinations then the total phase shift at some frequencies will be greater than 180°.An alternating voltage applied between ground and one point of the network can give rise to a larger alternating voltage between another point in the network and ground. we found this to be most surprising but it is correct and it can often explain instabilities in the use of operational amplifiers[14].

Types of Bioimpedance

1. Single Frequency of Bioimpedance Analysis (SF-BIA)

Analysis of bioimpedance information obtained at 50 KHz electric current is known as single-frequency bioimpedance analysis (SF-BIA). SF-BIA is the most used and is one of the earliest proposed methods for the estimation of body compartments, It is based on the inverse proportion between assessed impedance and TBW, that represents the conductive path of the electric current [4, 15]SF-BIA predicts the

volume of TBW that is composed of fluctuating percentages of extra cellular fluid (ECF) which is almost equal to 75% of TBW, and ICF that represent the rest[4]SF-BIA instruments have been used to assess TBW and FFM using the derived Equations

$$|Z| = \sqrt{R^2 + X^2}$$

$$\phi = \tan^{-1}\left(\frac{X}{R}\right)$$

2. Multiple Frequency Bioimpedance Analysis (MF-BIA)

Analysis of bioimpedance that is obtained at more than two frequencies is known as multiple-frequency bioimpedance analysis (MF-BIA). MF-BIA is based on the finding that the ECF and TBW can be assessed by exposing it to low and high frequency electric currents, respectively thomaseet [3] has proposed TBW and ECF estimation using 100 and 1 kHz based on the

Cole model [16] the [17]. stated that technically a bioimpedance analyzer [17] should use frequency range between 5–1000 kHz.[18]state that low frequency in MF-BIA is generally less than 20 KHz and high frequency is more than 50 KHz[19]

3. Bioimpedance Spectroscopy (BIS)

Analysis of bioimpedance data received/got using a broad band of frequencies is known as *bioimpedance spectroscopy (BIS)*. The BIS method is based on the determination of *resistance at zero frequency (R_o)* and *resistance at infinity frequency (R_{inf})* that is then used to predict ECF and TBW respectively. The use of 100 and 1 kHz, respectively, was earlier proposed by Thomasset (Thomasset, 1962) who applied the basics of Hanai’s mixture [20] and Cole’s module [21, 22] as explained by the Cole-Cole plot.

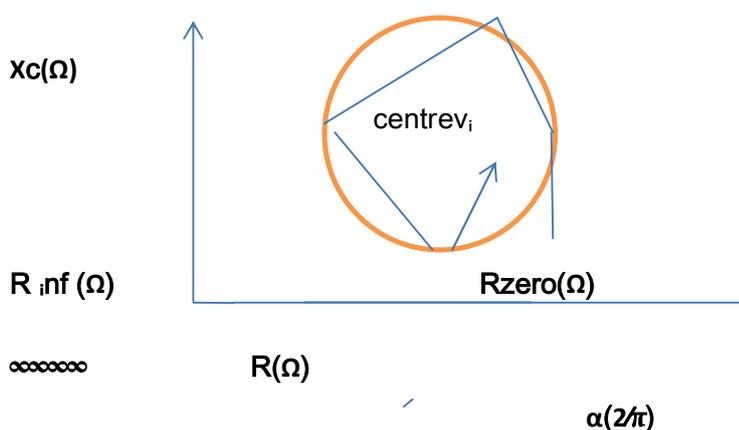


Figure 2: Cole –Cole module plot and cole module parameters The determinations of cole module parameters (R_o,R_{inf},α,Fc)

Application of bio bimpedance

People concerned with health understand one should perform regular assessments of Body composition, nutrition, hydration and weight

management in order to track changes and progress. We can useful by using bioimpedance in medical application

- Assessing Body Composition.

- Assessment of overweight and obesity patients.
- Assessing malnutrition.
- Body Composition assessment in elderly.
- Eating disorders and effects of fasting.
- Effectives of weight loss.
- Medical Research.
- Monitoring Diabetes Patients

BioimpedanceOf The Skin

The works of bioimpedance on the skin it's very important because it's so the challenging. It is important to know the impedance of the skin when measuring the electrocardiogram because if your amplifier input impedance is not high enough, undesirable attenuation will occur. A typical skin impedance is about 500 k Ω for 1 cm². But Rosell et al. (Rosell, Colominas, Riu, Pallas-Areny, & Webster, 1988) showed that at 1 Hz there is a wide spread for different subjects from 10 k Ω to 1 M Ω . And as the frequency increases to 1 MHz, impedance decreases to about 300 Ω . Then impedance changes with time. Olson et al. (Olson, Schmincke, & Henley, 1979) showed that impedance decreases steadily or exponentially with time constants of several hours. Lozano et al (Lozano, Kaczmarek, & Santello, 2009). Note that impedance varies with body location and is much lower on the tongue than elsewhere on dry skin Bahr et al. (Bahr et al., 2014) show that impedance decreases from 1 M Ω to 200 k Ω in 1 min during a hot flash. De Talhouet et al. (De Talhouet & Webster, 1996)

showed that impedance drops from 500 k Ω to 5 k Ω after 12 skin strippings using Scotch tape.

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