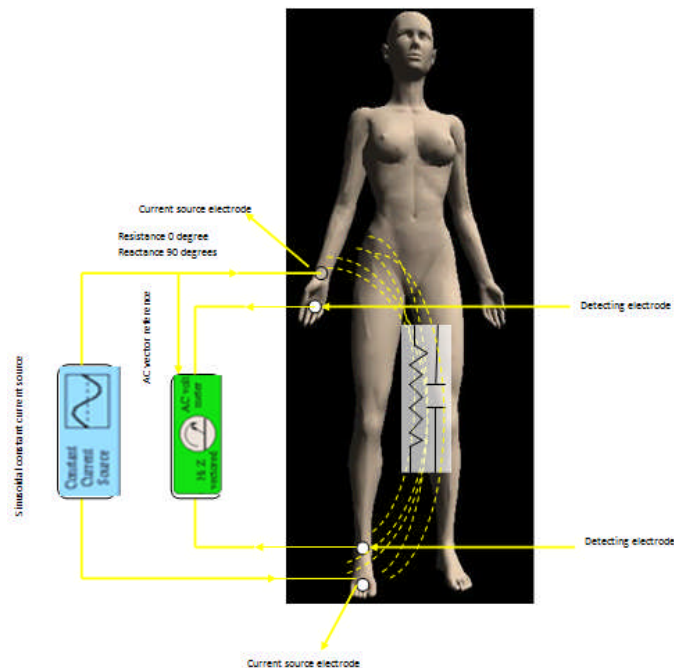


Bioelectrical impedance: General principles

The most familiar form of Bio impedance uses alternating current (A.C.). There are dozens of readily available commercial and custom-built A.C. BIA(Bioelectrical Impedance Analysis) systems differing widely in design and complexity.(6) Most systems are used to indirectly estimate the fat content of the body and measuring total body water.*(7) (8) (38)These systems typically employ A.C. electricity with a wide range of currents, frequencies, and intensities. The amount of electricity delivered to the body is usually imperceptible and far below the level that would cause cellular or tissue damage.(9) (10) Studies of A.C. BIA systems operating at 50 KHZ or higher, have revealed that these frequency A.C. electric currents flow *non-selectively* through both intracellular and extra cellular spaces (10) (see Fig. below).

Following the sending of intensity at the frequency 50 KHz (to active tactile electrodes, the system make the measurement of the resistance and reactance between 2 other passive tactile electrodes (tetra-polar mode).



Impedance

So far, only the term impedance Z has been used. The impedance is the total resistance of a biological conductor to alternating current. The impedance is made up of two components:

1. The resistance R , which is a pure (ohms) resistance of the electrolyte-containing total body water, and
2. The reactance X_c , the capacitive resistance, which arises due to the condenser-like properties of the body cells.

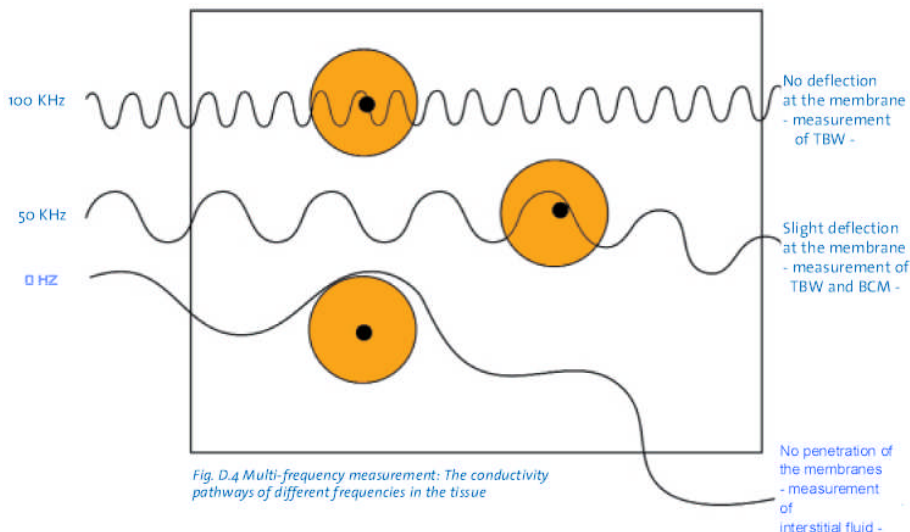
Differentiation and determination of both of these components of impedance is possible by measuring the phase angle.

Phase angle

In order to be able to differentiate between the two components resistance and reactance from the measured total resistance, modern BIA devices have phase sensitive electronics.

The principle of measurement is based upon the fact that the condensers in the alternating current circuit lead to a time delay Δt : the current maximum is in advance of the voltage maximum. Every metabolically active cell of the body has an electrical potential difference at the cell membrane of about 50-100 mV. This membrane potential allows the cell to act in an alternating electrical field like a spherical condenser. As alternating current has a sine wave, this shift is measured in $^\circ$ (degrees) and is described as a phase angle ϕ (phi) or α (alpha).

The phase angle is most meaningful at a frequency of 50 kHz. A pure cell membrane mass would have a phase angle of 90 degrees, pure electrolyte water has a phase angle of 0 degrees. The phase angle is thus directly proportional to the body cell mass BCM. In contrast to cells of the body cell mass, fat cells, which are purely storage cells, have hardly any metabolic activity, only possess a minimal membrane potential and cannot be detected by phase sensitive measurements.



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ES Teck specifications:

Predictive equations from peer reviewed journal articles, generated by correlating impedance measures against an independent estimate of Total Body Water (TBW) or Fat Free mass (FFM) with a common coefficient Ht^2/R (where H_e is the Height and R the resistance)

BC Module Predictive equation used:

- **Total Body Water :TWB**

5-19 yr Davies et al 1988

20-80 yr Heitmann 1990

Adult obese subjects: Segal et al 1988

Fat free fat mass:

7-15 yr Deurenberg et al

16-83 yr Deurenberg et al 1991

EWC

Sergi G, et al 1994

Intracellular water: TWB- EWC

Actual Impedance = $\sqrt{\text{resistance}^2 + \text{reactance}^2}$

Actual Phase Angle (PA) = $\arctan \left\{ \frac{\text{reactance}}{\text{Resistance}} \right\}$

Estimated Basal Metabolic Rate (BMR)

Harris-Benedict BMR formulas:

BMR (female) = $651.1 + (9.6 \times \text{Weight (Kg)}) + (1.8 \times \text{Height (cm)}) - (4.7 \times \text{age (years)})$

BMR (male) = $66.5 + (11.8 \times \text{Weight (Kg)}) + (5 \times \text{Height (cm)}) - (6.8 \times \text{age (years)})$

Actual Body Mass Index (BMI) = $\text{Weight (Kg)} / \text{Height}^2 \text{ (meters)}$

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