

Specific bioelectrical impedance vector analysis.

Guide for users.

Theoretical background

In electrophysiological terms, resistance (R) per unit volume correlates negatively with the quantity of body fluids through which the current flows, while reactance (Xc), i.e. the capacitive reactance in biological tissues where cell membranes behave as capacitors, correlates positively with body cell mass.

Specific bioelectrical impedance vector analysis (*sp*BIVA) is a method for the evaluation of body composition (Buffa et al., 2013; Marini et al., 2013). The technique is an analytical variant of bioelectrical impedance vector analysis (in the following, classic BIVA), conceived by Piccoli et al. (1994).

Classic BIVA enables a semiquantitative evaluation of body cell mass and body water using an empirical approach that relies on comparing bioelectrical values (R and Xc, Ohm; at 50 kHz and 800 μ A), normalized for height (m), with standard reference values (tolerance ellipses). The comparison between bioelectrical values of different groups can be realized by means of confidence ellipses and Hotelling's T^2 test.

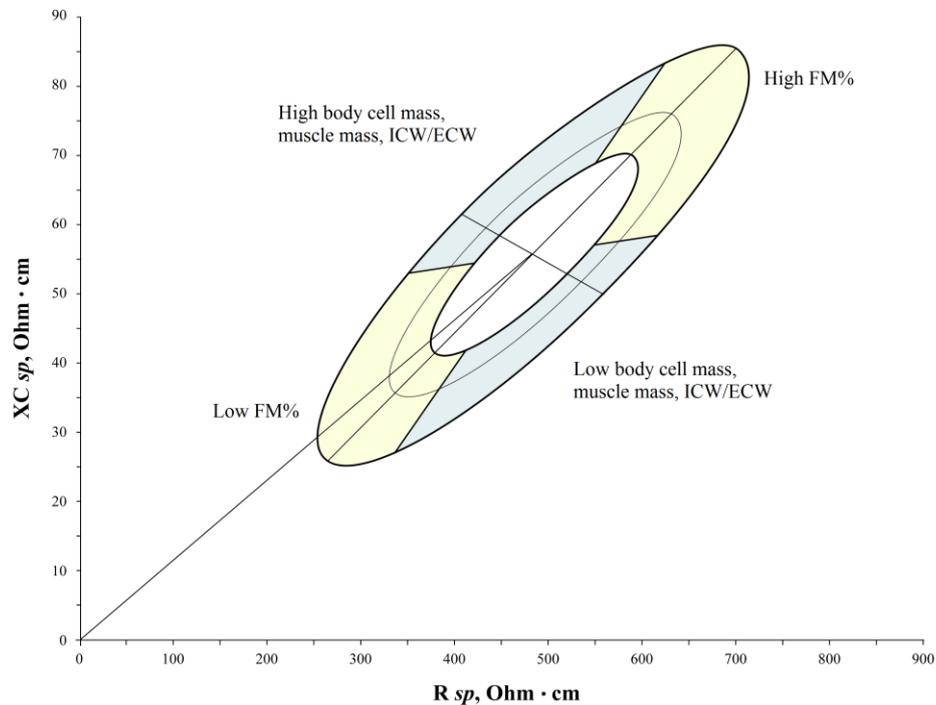
The innovation of *sp*BIVA with respect to the classic procedure is that bioelectrical values are normalized by cross-sections of the body, besides than by height. The theoretical basis is the Ohm's law, according to which R is directly proportional to the conductor's length (L) and inversely proportional to its cross-section (A), so that: $R = \rho L/A$, and resistivity, $\rho = R A/L$.

In *specific* BIVA, R and Xc values are multiplied by a correction factor (A/L) in order to obtain an estimate of resistivity (or *specific* resistance, R_{sp}), and reactivity (or *specific* reactance, X_{csp}). This correction is intended to reduce the influence of body size and shape, and to increase the sensitivity of *specific* bioelectrical values to the tissues' properties. Phase angle is unaffected by the correction. The analytical details for the calculation of correction factor can be retrieved in [Buffa et al. 2013](#) (Appendix S1 and Figure S1).

Specific bioelectrical values can be analyzed with the same approach of classic BIVA, by means of **tolerance ellipses** and **confidence ellipses**.

Specific **tolerance ellipses** are probability graph showing the 50%, 75%, and 95% percentiles of the bioelectrical values of the reference population. Buffa et al. (2013) and Marini et al. (2013) demonstrated that:

- the major axis of the ellipse refers to variations of the relative quantity of fat mass (FM%), with higher values towards the upper – right pole;
- the minor axis refers to variations associated with changes of phase angle, indicative of body cell mass and muscle mass in particular (left side: more mass; right side: less mass), and to variations of intracellular/extracellular water ratio (ICW/ECW), with lower values toward the right lower area.



Specific tolerance ellipses

Confidence ellipses represent the area around the sample mean within which the “true mean” is expected to lie, with a probability of 95% . Confidence ellipses allow the inter-group comparison, that can be also performed statistically by means of MANOVA or Hotelling's T^2 test. In general, groups represented by not overlapping confidence ellipses are significantly different.

An updated list of articles on specific BIVA can be found in the home page (Literature).

The *specific* BIVA software

There are three main sections: specific BIVA calculus, specific BIVA tolerance, specific BIVA confidence.

Specific BIVA calculus

In this section, individual values of resistance and reactance, anthropometric values, and other required or optional information can be inserted. *Specific* bioelectrical values and body mass index are automatically calculated.

The “Add to subjects” function allows the selection of cases to be moved into the “subject” sheet of the “*Specific BIVA tolerance*” section.

Specific BIVA tolerance

This section comprises three sub-sections: reference population, point graph, subjects.

Reference population

The software includes the *specific* bioelectrical reference values for: the U.S. American adults (Buffa et al., 2013) and the healthy elderly Italian population (Saragat et al., 2014); the Italo-Spanish young adults (Ibáñez et al., 2014). New reference values can be added by mean of the “New reference population” function.

Subjects

Cases retrieved from BIVA calculus can be selected for their graphical representation within the tolerance ellipses.

Point graph

An appropriate population has to be chosen from the list “Reference population”, and groups of cases can be plotted on the corresponding tolerance ellipses.

Specific BIVA confidence

This section *comprises* two sub-sections: “Groups” and “Mean graph”.

Groups

The “Groups” section allows adding data of new groups. The ‘draw’ option can be used to select the groups to be analyzed. Using the “Mean graph” section, mean values and confidence ellipses of selected groups are plotted in the Cartesian plane defined by R_{sp} and X_{csp} .

The R_{sp} - X_{csp} graphs (both tolerance and confidence *specific BIVA*) can be modified (title, subtitle, legends, axes range) and saved as png, jpeg, pdf, or svg files.

References

Piccoli A, Rossi B, Pillon L, Bucciante G. A new method for monitoring body fluid variation by bioimpedance analysis: the RXc graph. *Kidney Int.* 1994;46:534-9.

Buffa R, Saragat B, Cabras S, Rinaldi AC, Marini E. Accuracy of specific BIVA for the assessment of body composition in the United States population. *Plos One.* 2013;8(3):e58533.

Marini E, Sergi G, Succa V, Saragat B, Sarti S, Coin A, Manzato E, Buffa R. Efficacy of specific bioelectrical impedance vector analysis (BIVA) for assessing body composition in the elderly. *J Nutr Health Aging.* 2013;17(6):515-21.

Saragat B, Buffa R, Mereu E, De Rui M, Coin A, Sergi G, Marini E. Specific bioelectrical impedance vector reference values for assessing body composition in the Italian elderly. *Exp Gerontol.* 2014;50:52-6.