Chapter 4

Bioelectrical impedance vector analysis in healthy population

4.1 Introduction

There are many studies using prediction equations, with BIA monofrequency techniques, looking for differences in body impedance depending on ethnicity and race, for example, Kotler et al (1996) and Sun et al (2003) in Caucasian, African, American and Hispanic subjects. Another example is Stolarczyk et al (1997) that includes Native American Indians. Some research groups have not identified significant differences between race-ethnicities (Kotler et al 1996, Chertow et al 1997) while others report racial variation (Native Americans, Hispanics and Caucasians) in the validity of BIA estimates (Stolarczyk et al 1994). Wagner et al (1997), Ainsworth (1997) and Deurenberg et al (2002) justify that the impedance equations for body composition in each ethnic must be specific due to differences in body build among ethnic groups: relative leg lengths (Deurenberg et al 2003), frame size (Deurenberg et al 1991), body build (Deurenberg et al 1995). A confounding problem with such studies is that the own errors in gold standard methods (isotopic dilution, dual-energy x-ray absorptiometry (DXA), anthropometry, etc) restrict the degree of precision and accuracy that can be achieved (Sutcliffe 1996).

The single frequency, series and parallel models, the multifrequency or Cole-Cole model, and the Hanai mixture model have not been rigorously evaluated in large population studies for accuracy and sensitivity (Ellis et al 1999).

Other researches such as Piccoli et al (1995), Roubenoff et al (1997), Ward et al (2001), Piccoli et al (2002-a), Nescolarde et al (2004-a-b) are applying the BIVA method with a specific developed software (Piccoli et al 2002-b) based on the RXc- graph (Piccoli, Pastori 2002) in healthy population with different race-ethnicity.

The aim of this chapter is to establish bivariate reference intervals for the impedance vector in the healthy Cuban population, which is a mixture of several race-ethnicities. Using the BIVA software (Piccoli et al 2002-b) the tolerance ellipses and 95% confidence ellipses will be obtained.

4.2 Subject and Methods

4.2.1 Healthy population

The measures were carried out in the "Saturnino Lora" Provincial University Hospital in Santiago de Cuba and under the supervision of medical specialists. The sample was of 1196 adult, healthy subjects living in Santiago de Cuba (689 men, 507 women, 18-70 yr, BMI 19-30 kg/m^2). Race-ethnicities of 689 men were caucasian (#1) 104 subjects, black (#2) 271, and half-caste (#3) 323. Race-ethnicities of 507 women were caucasian (#1) 168 subjects, black (#2) 142, and half-caste (#3) 197.

The patients did not have alcohol intake nor any kind of physical exercise 24 hours before measurements.

4.2.2 Equipment comparison between RJL-System and BioScan

Before measurement of the entirely healthy population the Bland-Altman method was applied between two bioimpedance analyzers: the Analyzer of Biological Impedance, model BioScan: BL – 960141 (Biologica, Barcelona, Spain) and the Body Impedance Analyzer from RJL-Systems model BIA-101 (RJL-Systems/Akern, Clinton Twp, MI, USA). Bland-Altman (1986-1999) method is the statistical method for assessing agreement between two methods to compare a new measure technique with an established one to see if they agree sufficiently for the new to replace the old. It is based on graphical techniques and simple calculations (mean difference, standard deviation of the difference, standard errors and confidence intervals 95%). We measured a small sample (N=33: M=17, F=16; 19≤BMI≤30 kg/m^2; 18≤age≤71 yr.) with both equipments. We take as reference analyzer the RJL-System.

Figure 4.1 shows the comparison using the Bland-Altman method. R value measured with the BioScan was 14.7 Ω greater than R value measured with the RJL analyzer. X_c value measured with the BioScan was 22 Ω greater than X_c value measured with the RJL analyzer.

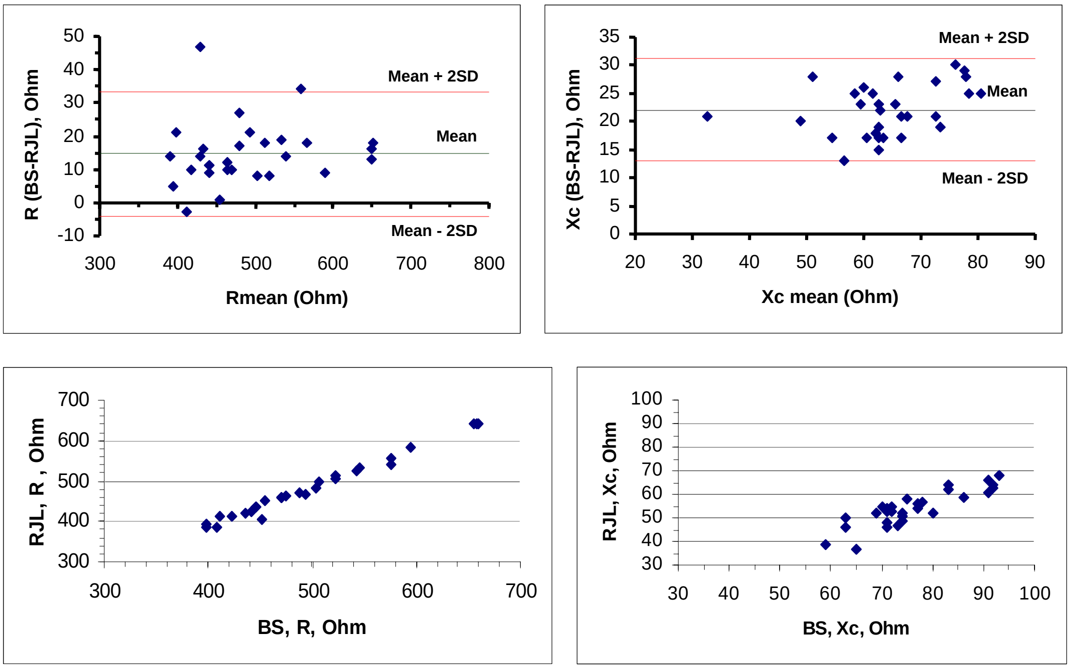

Figure 4.1- Bland-Altman method between two bioimpedance analyzer: RJL-System and BioScan

4.2.3 Bioimpedance measurement protocol

The measurement configuration were the standard distal BIA configuration to whole-body (or hand-foot) (Grimnes and Martinsen 2000) with the patient in supine decubitus position. Four electrodes: two current injectors I, and two voltage sensor V, were dorsally placed on the right hand in the third metacarpo-phalangeal articulation and in the carpus, respectively, 5 cm apart. The pair on the foot was located in the third metatarso-phalangeal and in the articulation, 6 cm apart (figure 4.2).

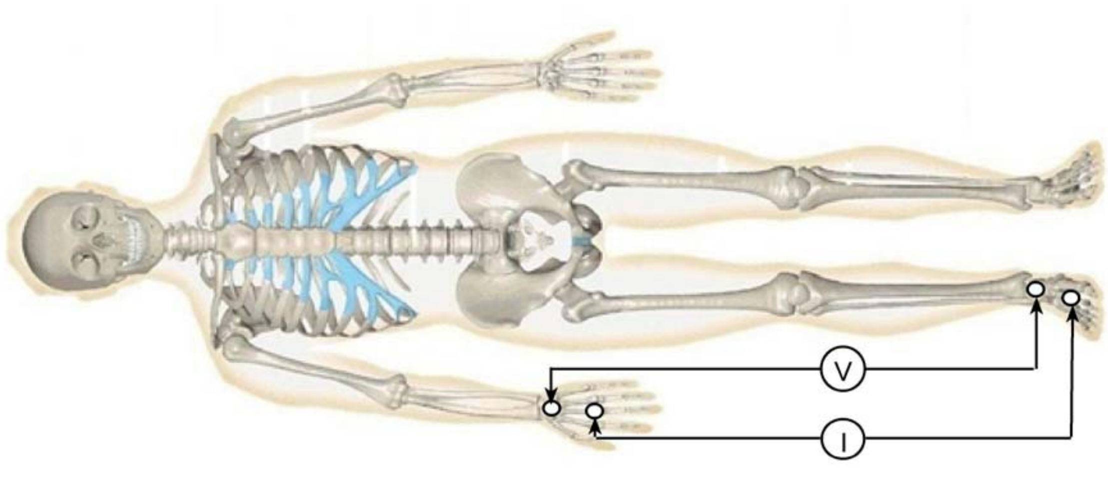

Figure 4.2- The standard electrode locations for right-side configuration

Impedance measurement is a complex number, and can be expressed in the complex impedance plane according to $Z=R+jX_c$. In the human body the reactance is negative (Grimnes and Martinsen 2000).

The measures were made with the Analyzer of Biological Impedance, Model BioScan: BL – 960141 (Biologica, Barcelona, Spain) (Figure 4.3). The study was carried out at a single frequency (50 kHz) with a current level of 800 μA. Disposable pregeled Ag/AgCl electrodes were used (3M Red Dot).

Figure 4.3- Bioimpedance analyzer. Model BioScan: BL – 960141 (Biologica, Barcelona, Spain)

4.3 Results

In Table 4.1 are shown the mean impedance vectors from the three races of Cuban population (1= caucasian, 2= black, 3= half-caste) by gender with 19≤BMI<30 kg/m^2 and age between 18 and 70 years. We show the normalized real part (R/H), the normalized imaginary part (Xc/H) and also de phase angle (PA) in degrees.

Table 4.1-Mean impedance vector components by gender and for three races of Cuban population (1= caucasian, 2= black, 3= half-caste) and the Pearson's correlation coefficient r between R/H and Xc/H.

ID-Gender	Sample Size, N	R/H (Ω/m)		-Xc/H (Ω/m)		r	-PA (°)		Height (cm)		Weight (kg)	
		Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD
1M	104	308.1	42.8	33.6	5.8	0.5	6.3	1.0	167.0	6.9	66.0	9.0
2M	271	294.2	37.7	33.7	5.1	0.7	6.5	0.8	170.6	6.7	68.7	9.5
3M	323	300.9	36.8	33.8	5.2	0.5	6.4	0.8	168.3	6.9	67.7	10
1F	168	400.0	54.5	42.0	6.9	0.6	6.0	0.9	157.2	7.5	58.9	10.9
2F	142	381.9	50.4	41.2	7.7	0.8	6.1	0.7	159.3	6.6	64.4	12.9
3F	197	397.9	52.8	41.5	7.3	0.7	6.0	0.8	156.3	6.2	61.0	11.8

4.3.1 Confidence ellipses

The confidence ellipses (95%) for the Cuban reference population by gender and race are shown in Figure 4.4. The mean values of the impedance vector components R/H, Xc/H from three race-ethnicities by gender can be found in Table 4.1. We can see that mean values of Z/H components are very similar between races by gender.

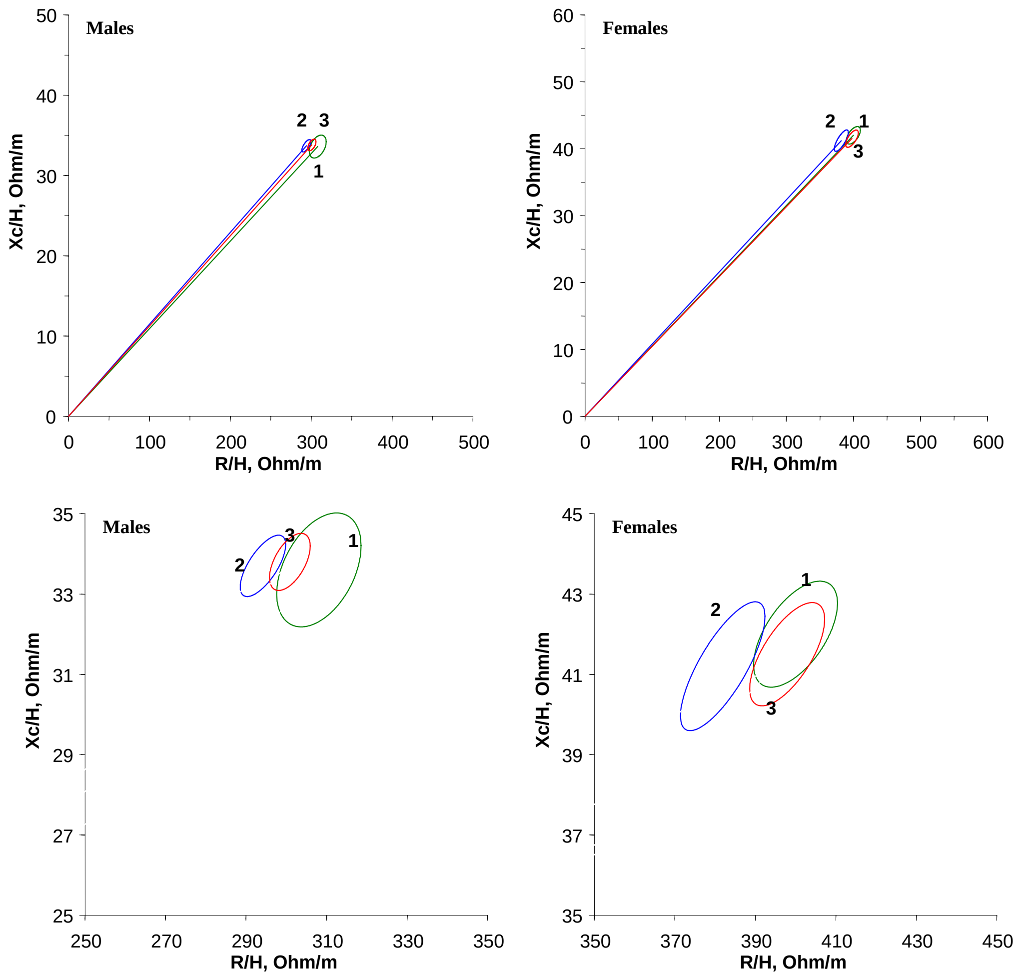

Figure 4.4 Confidence ellipses (95%) for the three races considered for the Cuban population sample (1= Caucasian, 2= Black, 3= Half-caste). The bottom figures are a zoom in of the upper figures.

4.3.2 Tolerance ellipses

Table 4.2 shows the mean values of vector Z/H (R/H, Xc/H) in the healthy Cuban reference population. The tolerance ellipses for all Cuban samples are shown in Figure 4.5.

Table 4.2- The impedance vector components, height and weight in 1196 Cuban reference population by gender and the Pearson's correlation coefficient r between R/H and Xc/H

19≤BMI<30 18 age 70	**R/H (Ω/m)**		**-Xc/H (Ω/m)**		**r**	**-PA (°)**		**Height (cm)**		**Weight (kg)**	
Sample Size, N	**Mean**	**SD**	**Mean**	**SD**		**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Females n = 507	394.1	53.2	41.6	7.3	0.7	6.0	0.8	157.5	6.9	61.2	12.0
Males n = 689	299.4	38.3	33.7	5.3	0.6	6.5	0.8	169.0	6.9	67.9	9.7

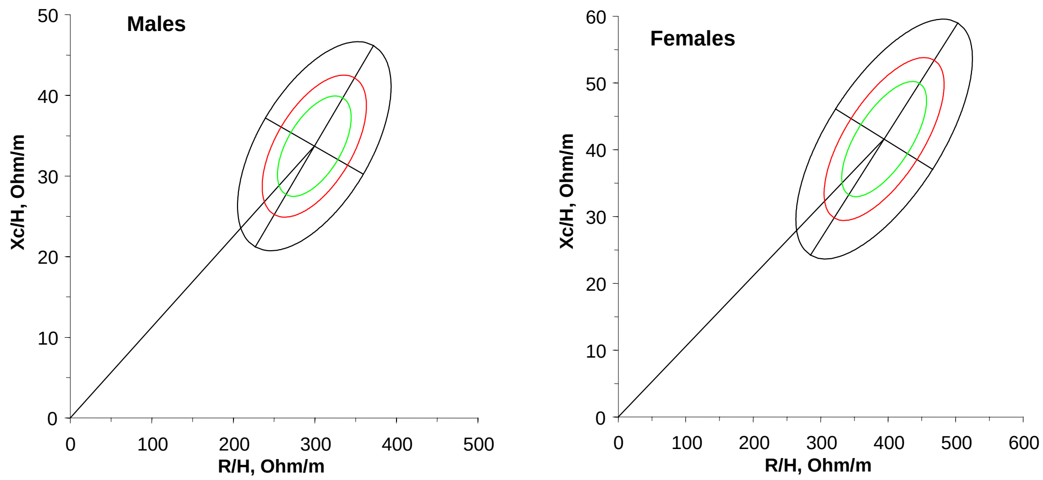

Figure 4.5 Mean impedance vectors with 50%, 75% and 95% tolerance ellipses for all the Cuban population without taken into account race-ethnicities

4.4 Discussion

Piccoli et al (2002-a) analyzed the Z/H vector in different race-ethnicities (White, Black and Mexican-American) in a US sample by gender. They found significant differences between Z/H vectors (confidence ellipses of 95%) by race-ethnicities and by gender (see Figure 4.6).

In a previous research, Ward et al (2001) studied a cross-sectional whole body impedance data, measured at 50 kHz with the BIVA method, for people of different ethnic origin (Nigerian, Indian, Chinese, Australian-Aborigine, Tongan, English, Caucasian, Samoan, and others) and they observed differences in the bioelectrical impedance parameter (confidence ellipses of 95%) by ethnic (see Figure 4.7).

As we can see in Table 4.1 and in the 95% confidence ellipses for the Cuban sample (Figure 4.4), there are no significant differences in mean values of R/H and Xc/H between the three race-ethnicities. Unlike other studies (Piccoli et al 2002, Ward et al 2000) in which significant differences were found in mean values of R/H and Xc/H between people of different ethnic-race origin (Figure 4.6 and 4.7).

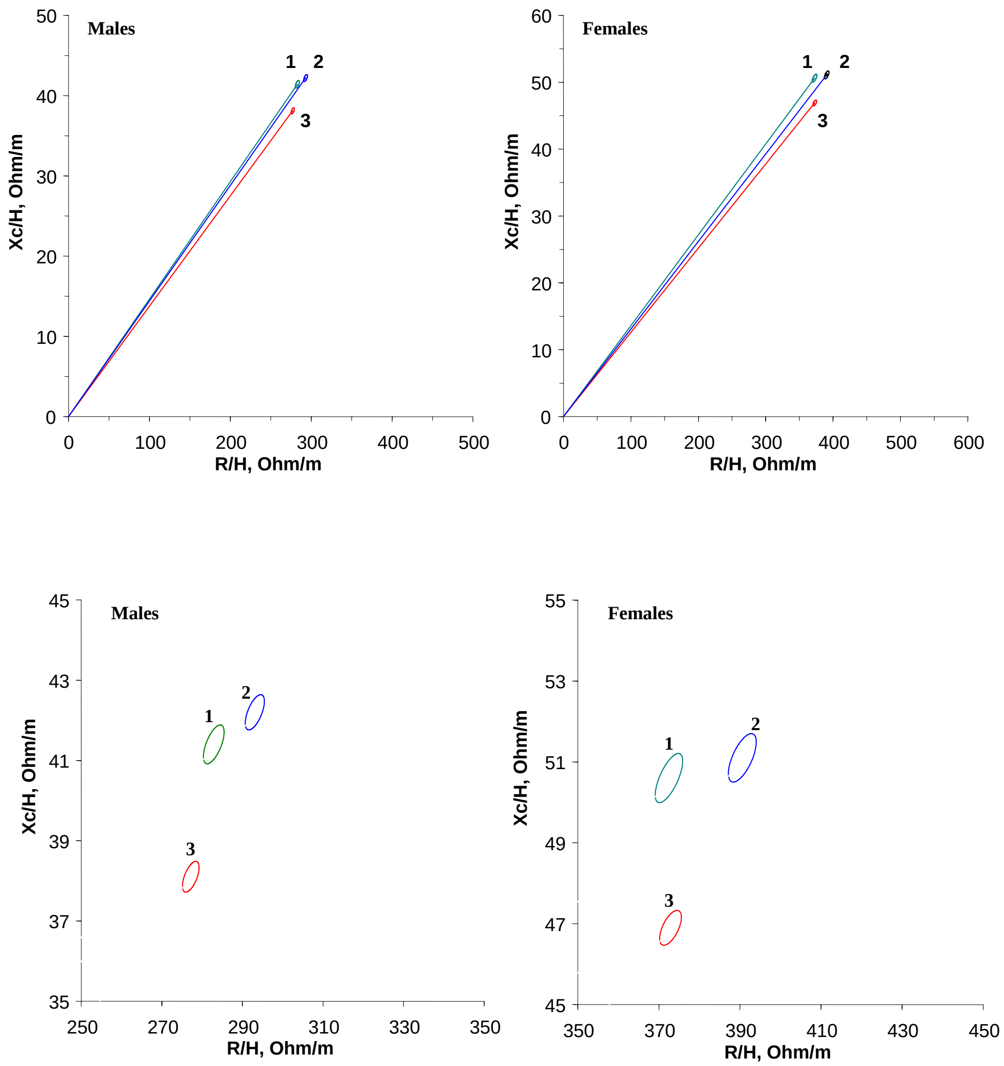

Figure 4.6-Confidence ellipses (95%) for the three races considered for the US population (Piccoli et al 2002-a) sample (1= Black, 2= Mexican-American, 3= White)

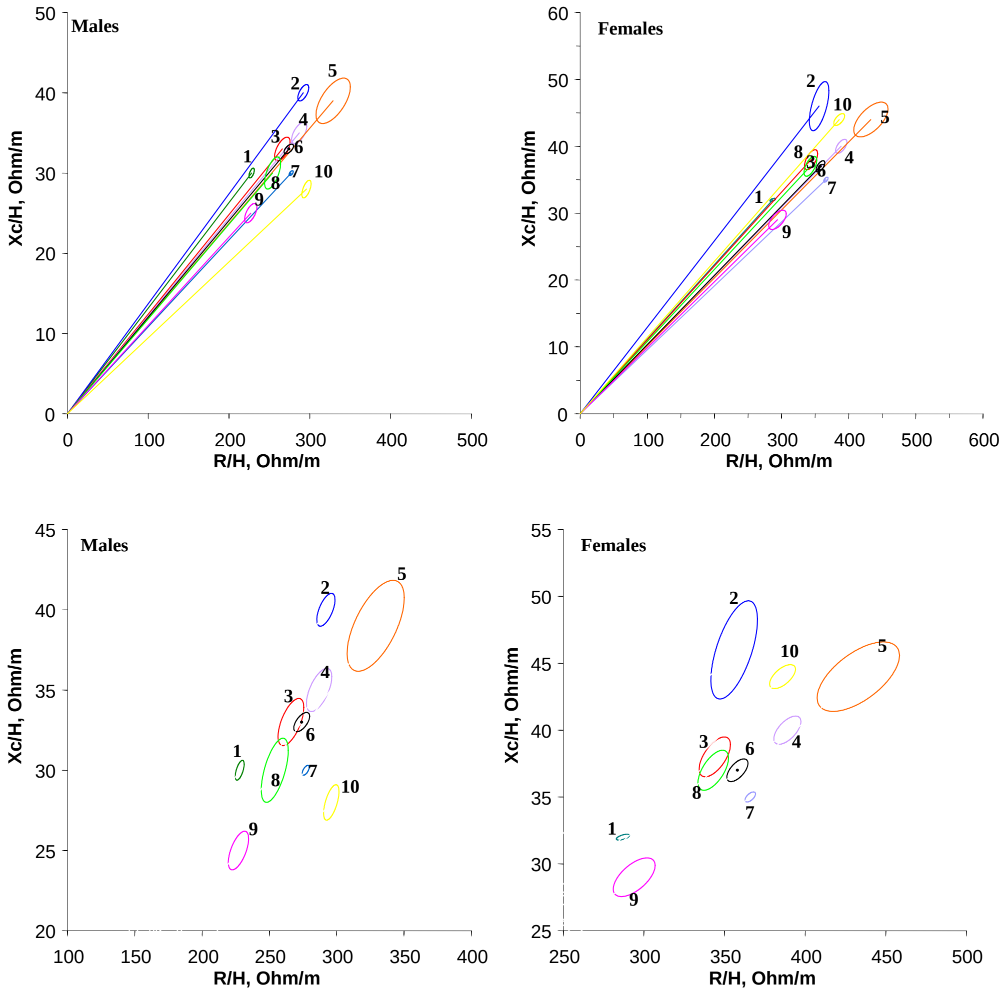

Figure 4.7-Confidence ellipses (95%) for the different ethnic-race (Ward et al 2000) sample (1= Tongan, 2= Nigerian, 3= English, 4= Chinese, 5= Indian, 6= Australian, 7= Danes, 8= Torres Is, 9= Samoan, 10= Australian-Aborigine)

4.5 Conclusion

The impedance vector Z/H of Cuban reference population is very similar in all samples by gender. The overlap in the 95% confidence ellipses could be due to the strong mixture between all the ethnicities and intercultural influences (Spanish, French, African, and Chinese). For this reason, in order to establish the normal BIVA parameters for the Cuban reference population, we propose not to differentiate by race-ethnicities and only by gender, as we can see in Figure 4.5 (Nescolarde et al 2004-a, Nescolarde et al 2004-b, Nescolarde et al 2001)

4.6 References

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