Best published equation for the calculation of Body Fat in a sample of Colombian young males using Bioelectrical Impedance Analysis

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Abstract—**With the worldwide epidemic growth of obesity prevalence, nutritional assessment has become of paramount importance, both clinically and epidemiologically. Bioelectrical Impedance Analysis (BIA) is an alternative for the calculation of % Body Fat (%BF), but, so far, it requires population specific predictive formulae [1]. Until these are developed for the Colombian population, we wanted to know which of the published formulae could be best used in our region. Six of them were selected to calculate %BF from BIA measurements taken at 50 kHz with a Xitron 4000B Bio-Impedance Analyzer and the results compared against %BF calculated from skin fold (SF) measurements with a Skyndex I calliper, according to Durnin and Womersley [2]. Subjects were 68 healthy young male volunteers (average age: 20.03 y, range 18.04 – 24.85 y), recruited among students at the University of Caldas-Manizales-Colombia. The Bland and Altman method [3] was used to determine the agreement between BIA and SF for the calculation of %BF. Best results were obtained with the van Loan and Mayclin [4] formula (mean difference -0.84, percentage points with 95% confidence interval -5.91 and 4.24), but they suggest the necessity of developing our own predictive formulae if we are to use BIA and SF interchangeably.**

Keywords—**Body fat, bioelectrical impedance analysis, Colombian young males, body composition, nutritional assessment.**

I. Introduction

With the worldwide epidemic growth of obesity prevalence [5], nutritional assessment has become of paramount importance, both clinically and epidemiologically. Although Body Mass Index (BMI) is universally used as a screening method for the assessment of nutritional status [6], body composition more than BMI is a primary determinant of health [7]. If we consider that obesity is technically defined in terms of adiposity [8], rather than the relation of weight over height, body composition methods are thus a desirable alternative for nutritional assessment. It is known, for instance, that BMI underestimates the prevalence of overweight and obesity when compared to methods based on body composition such as skin fold (SF) measurements [9]. Although the SF method is considered as an excellent field method to use in lean participants, it is not suitable for older and obese individuals and it also requires a considerable amount of technical skill [10].

Bioelectrical impedance analysis (BIA) is safe, non-invasive, easy to use and inexpensive, and has been suggested as a more useful method than BMI for the determination of adiposity [9]. Because BIA formulae have to be validated in terms of age, gender and ethnicity [1], until we develop our population specific formulas, we wanted to see if any of the published ones could be used interchangeably with SF.

II. Subjects and methods

Subjects for this study were 68 young male volunteers recruited among first-year students at the University of Caldas-Colombia. Their physical characteristics are given in Table 1. Approval of the University Ethics Committee and written informed consent were obtained.

BIA measurements were taken at 50 kHz with a Xitron 4000B Bio-Impedance Analyzer, and %BF was calculated from skin fold (SF) measurements with a Skyndex I calliper, according to Durnin and Womersley [2]. The formulas used for our calculations are shown in Table 2. %BF was calculated as (body mass (BM = weight) – fat free mass (FFM))*100/BM.

The Bland and Altman [3] method was used to determine the degree of agreement between BIA and SF for the calculation of %BF. The plots were obtained with MatLab from MathWorks.

Table 1 Physical characteristics of the subjects[1]

n	68
Age (y)	20.0 ± 1.8 (18.0, 24.9)
BM (weight in kg)	58.6 ± 8.0 (44.2, 77.1)
Height (cm)	170.0 ± 6.0 (1.6, 1.9)
BMI (kg/m^2)	20.2 ± 2.2 (15.8, 26.3)
%BF	16.5 ± 4.5 (9.5, 28.6)
Resistance (Ω)	549.0± 56.4 (433.0, 731.3)
Reactance (Ω)	69.9 ± 11.2 (21.0, 111.0)

[1] All values are x ± SD; minimum and maximum in parenthesis.

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Table 2 BIA formulae used in this study

Author(s)	n	Subjects	Formula
Lukaski *et al*., 1986 [11]	47	men 18 - 50 y	$(0.756Ht^2/R) + (0.110BM) + (0.107Xc) – 5.463$
Van Loan and Mayclin, 1987 [4]	123	men 18 - 64 y	$(0.00085Ht^2) + (0.3736BM) – (0.02375R) – 0.1531A) +17.7868$
Segal *et al*., 1988 [12]	1567	men & women 17 - 62 y	$(0.00132Ht^2) + (0.3052BM) – (0.04394R) – 0.1676A) + 22.66827$
Deurenberg *et al*., 1991 [13]	927	men & women 18 - 64 y	$(0.34Ht^2/R) + (0.1534Ht) + (0.273\ BM) – (0.127\ A) + 4.56$
Lohman, 1992 [14]	306	men & women 18 - 30 y	$(0.476Ht^2/R) + (0.295BM) + 5.49$
Kyle *et al*, 2001 [15]	343	men & women 22 - 94 y	$(0.518Ht^2/R) + (0.231BM) + (0.130Xc) – (4.229S)$

[1] All formulae give an estimation of FFM. Ht = height in cm, R = resistance in Ω, BM = body mass = weight in kg, Xc = reactance in Ω, A = age in years, S = sex: men = 1 women = 0 .

III. Results

Figures 1 – 6 are Bland-Altman plots [3] where the limits of agreement between percentage body fat calculated with each of the selected formulae and percentage body fat calculated with skin folds measurements using the Durnin and Womersley [2] formula are represented. Mean difference for each data set is also shown.

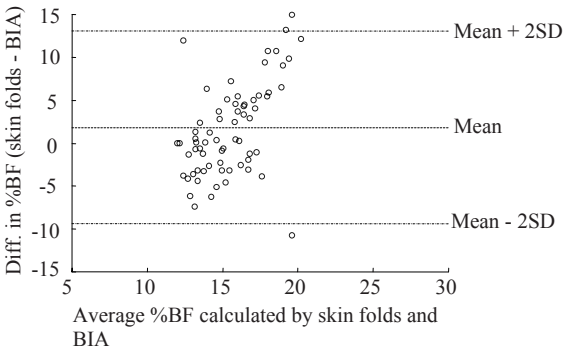

Figure 1 Bland-Altman plot for the formula by Lukaski *et a*l [11]

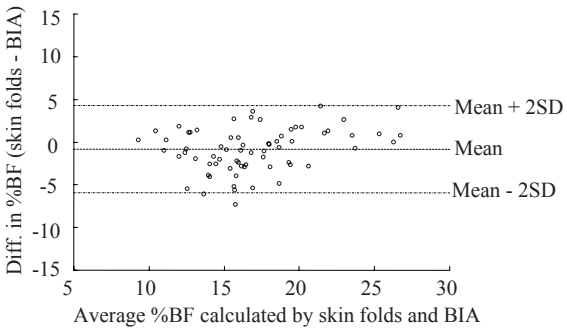

Figure 2 Bland-Altman plot for the formula by van Loan and Mayclin [4]

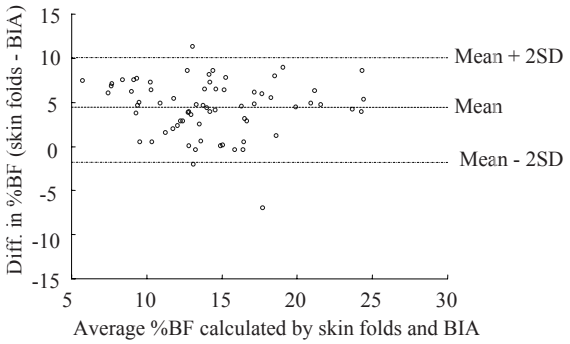

Figure 3 Bland-Altman plot for the formula by Segal *et al* [12]

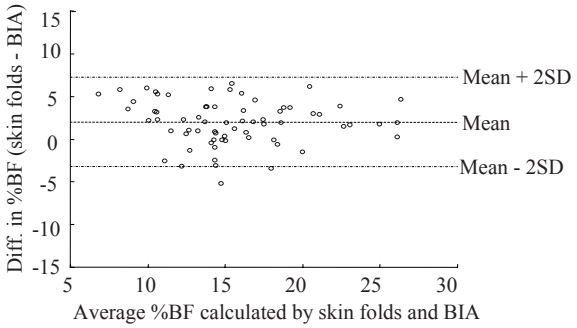

Figure 4 Bland-Altman plot for the formula by Deurenberg *et al* [13]

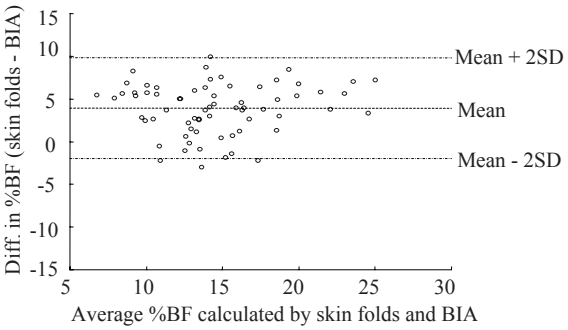

Figure 5 Bland-Altman plot for the formula by Lohman [14]