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Original article

Evaluation of body adiposity index (BAI) to estimate percent body fat in an indigenous population

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SUMMARY

Background & aims: The aim of this study was to evaluate the usefulness of Body Adiposity Index (BAI) as a predictor of body fat in Xavante Indians and to investigate which anthropometric measures of adiposity best correlate with body fat in this population.
Methods: We evaluated 974 individuals (476 male), aged 42.3 ± 19.5 years. Percentage of body fat (%BF) determined by bioimpedance analysis (BIA) was used as the reference measure of adiposity. Bland–Altman analysis was used to assess the agreement between the two methods: BAI and BIA. Associations between anthropometric measures of adiposity were investigated by Pearson correlation analysis.
Results: BAI overestimates %BF (mean difference: 4.10%), mainly at lower levels of adiposity. Significant correlations were found between %BF and all measurements, being the strongest correlation with BAI. However, stratified analyses according to gender showed that among men waist circumference has the strongest correlation ($r = 0.73$, $p < 0.001$) and among women BAI ($r = 0.71$, $p < 0.001$), BMI ($r = 0.69$, $p < 0.001$) and waist circumference ($r = 0.70$, $p < 0.001$) performed similarly.
Conclusion: BAI can be a useful tool to predict %BF in Xavante Indians, although it has some limitations. However, it is not a better predictor of adiposity than waist circumference in men or BMI and waist circumference in women.

1. Introduction

Obesity, a complex and multifactorial condition, is characterized by excess of body fat and involves genetic predisposition and environmental factors. Its prevalence has increased over the last decades being recognized as a major public health concern.[1] Obesity, particularly abdominal obesity, is associated with an increased risk of type 2 diabetes, cardiovascular disease, non-alcoholic fatty liver disease, premature mortality and certain types of cancer.[2,3]

Body mass index (BMI) is the most used tool to identify overweight or obese individuals. According to World Health Organization (WHO) overweight is defined as BMI between 25 and 29.9 kg/m^2 and obesity as BMI $\geq$ 30 kg/m^2.[1] However, these cut-off values may be inappropriate for some ethnic groups since using this anthropometric index it is not possible to distinguish body fat from lean mass.[4–6] Other indirect adiposity measures such as waist circumference, waist-hip ratio, waist-to-thigh ratio are used to diagnose abdominal obesity. Recently, Bergman et al. developed a new index, body adiposity index (BAI), as a parameter of adiposity.[7] This index could estimate percent body fat in both men and women without the need of statistical correction. Following this initial report other studies investigated the performance of BAI in predicting body fat.[8–12] However, depending of the population studied, results have been inconsistent.

Xavante is an indigenous population living in Mato Grosso State, Central Brazil. They are one of the largest native groups in Brazil, comprising approximately 10,000 individuals.[13] This indigenous people are experiencing a rapid and significant increase in fatness in the last decades.[14,15] Consequently, diagnosis and treatment of

Abbreviations: BAI, body adiposity index; BMI, body mass index; WHO, World Health Organization; CONEP, Brazilian National Ethics Commission; WHR, waist-to-hip ratio; %BF, percentage of body fat; BIA, bioelectrical impedance analysis.

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overweight and obesity is an important health issue in this population.

The aim of this study was to investigate the usefulness of BAI as a predictor of body fat in Xavante Indians. Furthermore, we tested which anthropometric measure of adiposity best correlated with body fat in this population.

2. Methods and procedures

2.1. Study population

A cross-sectional study was performed in the Xavante population from two indigenous reserves (Sangradouro and São Marcos) located in Mato Grosso State, central region of Brazil, from January 2009 to January 2012. For this current analyses, were excluded pregnant women, subjects with missing data and aged less than 18 years. The study sample consisted of 974 individuals (476 male, 498 female), aged 42.3 ± 19.5 years (range 18–99 years).

The Indian leaders and the study participants were informed about the purposes of this research and gave their written consent. Participants that were illiterate gave their approval through fingerprint signature. A Xavante health agent worked as an interpreter when necessary. This study was approved by Ethics Committee of Escola Paulista de Medicina, Universidade Federal de São Paulo and Brazilian National Ethics Commission (CONEP).

2.2. Anthropometrical measurements and calculations

All measurements were made in the morning with subjects wearing light clothes and barefoot. Weight was measured using a portable digital scale and height using a stadiometer. BMI was calculated as the ratio of weight (kilograms) to the square of height (meters). Measures of circumference were made using an inelastic tape. Hip circumference was measured at the level of the greater trochanter and waist circumference at the midpoint between the lowest rib and the iliac crest. Waist-to-hip ratio (WHR) was calculated by dividing the waist circumference (cm) by the hip circumference (cm). BAI was calculated as proposed by Bergman et al.: BAI = (hip/height^{1,5}) − 18 (7). Percentage of body fat (%BF) was determined by bioelectrical impedance analysis (BIA) (BioDynamics BIA 450 Body Composition Analyzer, Seattle, WA, USA) and was used as the reference measure of adiposity.

2.3. Statistical analysis

Differences in continuous variables between groups were evaluated by unpaired *t*-test. Paired *t*-test was used to test differences between %BF by BIA and BAI. Univariate associations between

Table 1
Characteristics of study subjects as a whole and by sex.

	Total (n = 974)	Men (n = 476)	Women (n = 498)	P
Age (years)	42.3 ± 19.5	42.7 ± 19.3	41.8 ± 19.6	0.47
Height (m)	1.6 ± 0.08	1.67 ± 0.05	1.54 ± 0.05	0.0001
Weight (kg)	78.6 ± 15.2	83.5 ± 14.2	73.9 ± 14.8	0.0001
Waist (cm)	97.1 ± 10.9	95.5 ± 10.5	98.5 ± 11.1	0.0001
Hip (cm)	101.2 ± 9.8	99.7 ± 8.3	102.6 ± 10.9	0.0001
WHR	0.96 ± 0.05	0.95 ± 0.06	0.96 ± 0.05	0.24
%BF	27.6 ± 7.8	22.5 ± 6,1	32.5 ± 5.8	0.0001
BMI (kg/m^2)	30.2 ± 5.1	29.7 ± 4.5	30.7 ± 5.6	0.003
BAI	31.7 ± 5.9	28.07 ± 3.7	35.2 ± 5.5	0.0001
BMI ≥ 30 (kg/m^2)	448 (46%)	277 (47.6%)	261 (52.4%)	0.001

Data are expressed as mean ± SD or *n* (%).
P values are given for comparison between men and women.

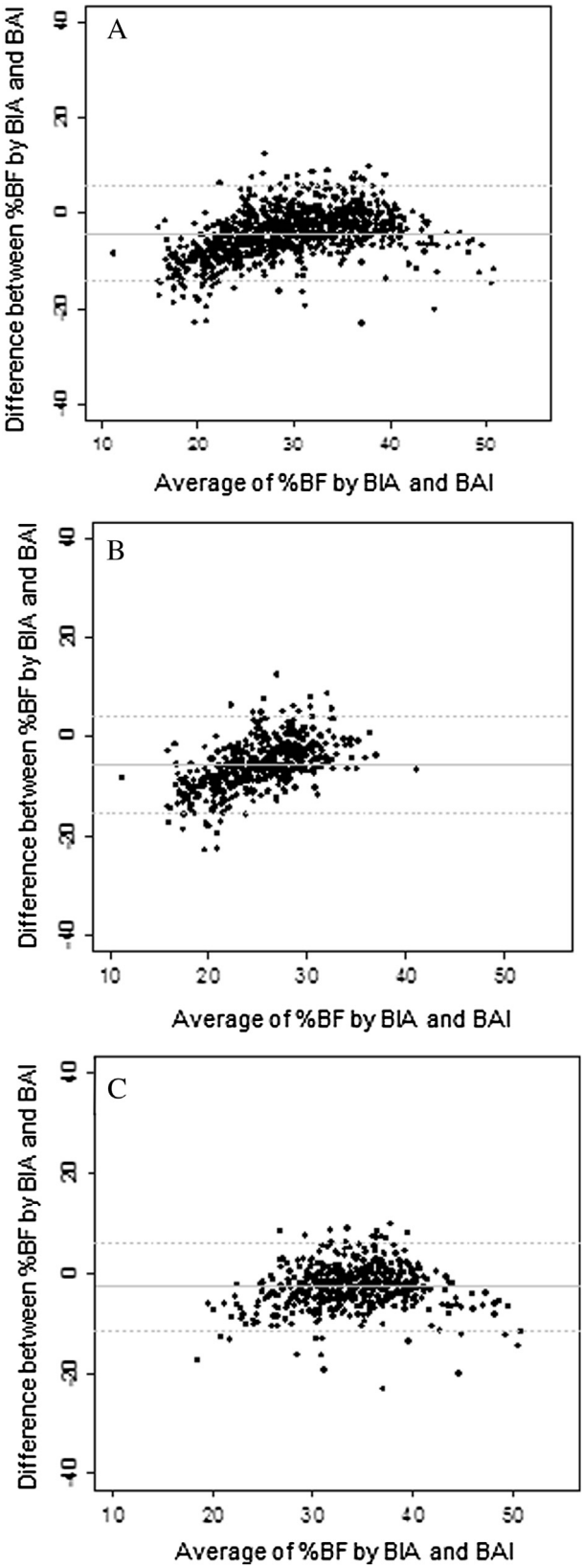

Fig. 1. Bland Altman plots of %BF assessed by bioelectrical impedance (BIA) and BAI among all the participants (A), men (B) and women (C). The differences between the two methods is plotted against the average of them. The solid line represents the mean value from the two methods and dashed lines mean ±2SD.