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THEMATIC ARTICLE

Body composition versus anthropometric results of the Khisêdjê Indigenous of Xingu – MT/Brazil

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Abstract *This study aimed to evaluate the body composition of the Khisêdjê, an Indigenous people residing in the Xingu Indigenous Territory, and compare it to the results obtained by anthropometry. One hundred seventy-nine individuals aged above 20 of both genders were included. The nutritional status was classified per the cutoff proposed by the WHO (1995). The body composition was identified using measures derived directly from a bioelectrical impedance device (resistance – R, reactance – Xc, and phase angle – PA). Data were analyzed using the Student t-test, chi-square, Pearson correlation, and analysis of variance, and 57% of the sample was male. The mean age of the population was 37.5 years, and 48% of subjects had some overweight level (BMI $\geq$ 25,0 kg/m^2). We identified a positive correlation between BMI with waist (WC) and arm (AC) circumference, and PA measurements, and an inverse correlation between BMI and R and Xc measurements. R and Xc mean values decreased with increasing BMI. In contrast, mean PA increased with greater weight. The results suggest that being overweight among the Khisêdjê Indigenous people was associated with higher muscle mass amounts.*
Key words *Indigenous peoples, Body composition, Electrical impedance, Anthropometry, Obesity.*

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Introduction

Obesity is defined by researchers at the World Health Organization (WHO) as a disease in which excess body fat can compromise health. The diagnosis of overweight or obesity, regardless of gender and age, is usually made using the body mass index (BMI), in which values ≥ 25.0 kg/m^2 classify individuals as overweight, and values ≥ 30.0 kg/m^2 indicate different degrees of obesity. However, we should consider that one of this indicator's limitations is the impossibility of distinguishing weight from muscle mass or fat mass. Therefore, it only reflects the result of body proportions and not necessarily body adiposity[1].

Bioelectrical impedance or bioimpedance is a valuable method for identifying body composition involving simple, non-invasive, and rapid procedures. It consists of a portable device connected to the body using electrodes that send low-amplitude, high-frequency electrical currents that provide measurements of resistance (R), reactance (Xc), and phase angle (PA). Inserting this information generated by the equipment and other information, such as age, gender, weight, and height, in predictive formulas allows for calculating the fat-free body percentage, adipose mass, and intra and extracellular water. These measurements help to identify individuals at metabolic risk. However, predictive formulas should only be applied to the population for which they were developed or with very similar characteristics. Their indiscriminate use, especially regarding ethnic-racial criteria, can produce erroneous results[1-7].

Studies carried out with Brazilian Indigenous peoples from different ethnicities in recent decades indicate high overweight and obesity prevalence. However, a minority uses bioelectrical impedance to determine whether the diagnosis is really based on excess adipose or muscle tissue[8-27]. In the few cases identified in the literature in which this evaluation procedure is available[28-31], the application of formulas intended for non-Indigenous populations to determine body compartments is observed. The present study aimed to evaluate the body composition of the Khisêdjê Indigenous people living in the Xingu Indigenous Territory/Mato Grosso (MT) and compare it with the results obtained by anthropometry.

Methods

This epidemiological, cross-sectional study was conducted in the Ngôjwêre village in the middle Xingu of the Xingu Indigenous Territory (TIX). All individuals of the Khisêdjê ethnic group or residents of the Wawi Indigenous Surveillance Center – of both genders and aged 20 or over – were invited to participate in the study.

According to the population census made available by the Health and Environment Unit (Xingu Project) of the Department of Preventive Medicine of the Federal University of São Paulo (UNIFESP), the body responsible for providing healthcare to the local population since 1965, 190 individuals met the inclusion mentioned above criteria in 2010-2011. One hundred eighty-one were evaluated, and the nine subjects (four women and five men) not evaluated were not in the village when data was collected. At the end of the research, data from 179 Khisêdjê (94.2% of those eligible) were included for analysis. Two Indigenous women were excluded due to inconsistent information on anthropometric variables or body composition.

Physical examinations were performed on two trips in 2010 and 2011. All Khisêdjê who met the eligibility criteria were called and identified by the medical records used by the health team. A standard form was adopted to ensure uniformity in data recording. Anthropometry was performed by trained professionals, in duplicate, following the WHO recommendations[32]. To collect weight in kilograms (kg) and height in centimeters (cm), a portable electronic scale (LIDER brand, model P200m), with a maximum capacity of 200 kg and 50 g graduation, and a portable stadiometer (WCS brand), with a scale ranging from 20 to 220 cm, were used, respectively. Arm (AC) and waist (WC) circumferences were collected in centimeters with a flexible, inelastic fiberglass tape measure (TBW brand), with a scale from 0 to 150 cm and a resolution of 0.1 cm.

BMI was calculated by dividing weight (in kilograms) by height (in meters) squared. Values lower than 18.5 kg/m^2 were classified as underweight, values ≥ 18.5 – <25.0 kg/m^2 as eutrophy, values ≥ 25.0 – <30.0 kg/m^2 as overweight, and values ≥ 30.0 kg/m^2 as obesity[32]. The Biodynamics® Model 450 (tetrapolar) Body Composition/ Bioimpedance Monitor was used to measure

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body composition. Data were obtained for resistance – R (Ω), reactance – Xc (Ω), and phase angle – PA (°). The intensity of the electrical current of the equipment is 800 μA, and the frequency of the fixed current (single-phase) is 50 kHz[5].

The device was calibrated before data collection. The tests were performed in one of the rooms of the PHC Unit of the Wawí Base Pole in the morning. The participants were placed lying down on a stretcher, with their legs and arms away from their torso, without any type of accessory on their arms or legs, and barefoot. All test procedures were explained to the participants with the help of an Indigenous translator. The test was performed after a 30-minute rest, following all other procedures recommended by the manufacturer. Disposable electrodes were used.

Before the test, subjects were asked to fast for at least four hours to avoid drinking alcohol or coffee and engage in intense physical activity in the 24 hours preceding the test. Pregnant women were exempted from the bioelectrical impedance test. The data description used measures of central tendency and dispersion for quantitative variables and percentages for qualitative variables. The association between the outcomes of interest (nutritional status) by gender was assessed using the chi-square statistic ($p < 0.05$). The Student's t-test for independent samples was used to compare the mean values of the biological variables of the individuals by gender or age group.

Due to the unavailability of specific formulas for determining the fat-free mass and fat-mass percentages for Brazilian Indigenous populations, we decided to work with variables derived directly from the bioelectrical impedance test (R, Xc, PA). We decided to present information on the percentage of fat-free mass and fat mass only to compare the results of this research with those available for other Indigenous populations in the country.

The results found were calculated directly by the bioelectrical impedance device (Body Composition/Bioimpedance Monitor Biodynamics Model 450) by entering individual information on gender, age (in complete years), weight (kg), and height (cm). Pearson's (r) coefficient was adopted to assess the correlation between anthropometric variables (BMI, WC, and AC) and body composition (R, Xc, and PA). We adopted the analysis of variance to compare the means of the ratio of R, Xc and PA measurements by nutritional status and gender. The Bonferroni post hoc test was employed to identify significant differences between the means ($p < 0.05$). Underweight cases (n = 4) were excluded from this analysis. The Stata program[33] was used in all stages of the analysis.

This study is nested in a larger project entitled "Nutritional and metabolic profile of Khisêdjê Indigenous people", whose development was approved by the National Research Ethics Commission (CONEP) and by the Human Research Ethics and Committee (CEP) of UNIFESP (Nº 760/10). Also, to meet regulatory standards, this individual study was submitted and approved by UNIFESP's CEP (Nº 319/11). The São Paulo Research Foundation (FAPESP) (Process 2010/52263-7) funded the present study.

Results

This study evaluated 179 Indigenous people: 102 (57%) men and 77 (43%) women. Table 1 presents the demographic and anthropometric variables of the Indigenous people. The mean age was 37.5 years (standard deviation = 14.7 years), and no difference was identified between genders. Men had statistically higher means ($p<0.05$) than women for height, weight, BMI, AC, PA, and percentage of fat-free mass. Conversely, women had statistically higher averages for R, Xc, and fat mass. Regarding nutritional status, a higher prevalence ($p < 0.05$) of overweight (49.0% vs 33.3%) was observed in men, and eutrophy in women (60.0% vs 42.2%).

In the data presented in Table 2, as expected, a positive correlation is observed between the variables BMI with WC (high intensity) and AC (high intensity) and WC with PB (high intensity) in both genders. A positive correlation is also observed between PA with BMI (regular intensity in females; low intensity in males) and with WC (low intensity in both genders) and AC (low intensity in females; regular intensity in males). Conversely, an inverse correlation is observed in both genders between the variable R and BMI (low intensity in females; average intensity in males), WC (average intensity in females; low intensity in males), and AC (low intensity in females; average intensity in males). Similarly, a negative correlation is observed between the variable Xc and BMI (low intensity in both genders), WC (low intensity in both genders), and AC (average intensity in females; low intensity in males).

In Figure 1, individuals of both genders classified as eutrophic had higher means ($p < 0.05$) of the variable R than those classified as overweight

Table 1. Number, mean values , and standard deviations (or percentage) of sociodemographic and anthropometric variables of Khisêdjê Indigenous people, assessed in 2010-2011, by gender. Xingu Indigenous Park, Central Brazil, 2014.

Variables	Female			Male			P-value	Total		
	N	Mean or %	SD	N	Mean or %	SD		N	Mean or %	SD
Age (years)	77	38.2	15.5	102	37.1	14.2	0.3061	179	37.5	14.2
Age group (years)										
20-29	33	42.86			42	41.18	0.261	75	41.90	
30-39	12	15.58			27	26.47		39	21.79	
40-49	14	18.18			12	11.76		26	14.53	
50-59	6	7.79			11	10.78		17	9.50	
60-89	12	15.58			10	9.80		22	12.29	
Weight (kg)	75	53.4	9.2	102	67.1	9.9	<0.0001	177	61.3	11.7
Height (cm)	77	149.7	5.1	102	161.4	5.8	<0.0001	179	156.4	5.8
BMI (kg/m2)	75	23.8	3.5	102	25.7	3.0	<0.0001	177	24.9	3.4
Nutritional status										
Underweight	3	4.0		1	1.0		0.028	4	2.3	
Eutrophy	45	60.0		43	42.2			88	49.7	
Overweight	25	33.3		50	49.0			75	42.4	
Obesity	2	2.7		8	7.8			10	5.6	
WC (cm)	75	84.9	8.9	102	87.0	8.1	0.0540	177	86.1	8.5
AC (cm)	75	27.3	3.1	102	30.6	2.7	<0.0001	177	29.2	3.3
Resistance (Ω)	75	570.9	84.4	102	438.8	60.9	<0.0001	177	494.8	97.0
Resistance/Height (Ω/m)	75	382.2	62.7	102	272.6	42.7	<0.0001	177	319.1	75.1
Reactance (Ω)	75	75.6	9.7	102	65.6	7.8	<0.0001	177	69.8	9.9
Reactance/Height (Ω/m)	75	50.6	6.9	102	40.7	5.1	<0.0001	177	44.9	7.7
Phase angle (°)	75	7.6	1.2	102	8.6	1.2	<0.0001	177	8.2	1.3
Muscle mass (%)	75	71.4	7.8	102	83.9	7.4	<0.0001	177	78.6	9.7
Fat mass (%)	75	28.6	7.9	102	16.1	7.4	<0.0001	177	21.4	9.8

* Relative to Student's t-test or $\chi 2$; N - number; SD - standard deviation; BMI: body mass index; WC: waist circumference; AC: arm circumference.

Source: Authors.

or obese. Also, men had lower means of this variable than women.

Figure 2 shows the same decreasing trend in the Xc variable as the degree of excess weight increases. These differences, however, were statistically significant ($p < 0.05$) only when comparing eutrophy with obesity in males.

Figure 3 shows an increase in the PA means with a higher degree of overweight. A statistically significant difference occurred only between the means of eutrophic men and those overweight ($p<0.05$). As expected, higher means of measurement were observed in males than females.

When evaluated by age group categories, adults, and older adults, the variable R measurement showed a statistically significant increase ($p < 0.05$) with age both in females (adults: 560.5Ω vs. older adults: 625.2Ω) and males (adults: 432.0Ω vs. older adults: 501.2Ω). In contrast, the measurement of the Xc variable was similar ($p > 0.05$) in adults and female older adults (adults: 75.6Ω vs. elderly: 75.4Ω) and males (adults: 66.0Ω vs. older adults: 61.9Ω). As expected, the PA measurement was higher ($p < 0.05$) among adults than among female older adults (adults: 7.8° vs. older adults: 7.0°) and males (adults: 8.8° vs. older adults: 7.2°).

Discussion

The Brazilian Indigenous population has suffered several changes over the years, which have modified its health and nutrition profile. Engstrom[34] states, "The nutritional profile or situation of a population group is built on information that

Table 2. Pearson's coefficient and significance level of the correlation matrix between Body Mass Index. waist circumference. arm circumference. reactance. resistance. and phase angle of Khisêdjê indigenous people. assessed in 2010-2011. according to sex. Xingu Indigenous Park. Central Brazil. 2014.

	MBI (Kg/m²)	WC (cm)	AC (cm)	Reactance (Ω)	Resistance (Ω)	Phase angle (°)
BMI						
WC	1					
AC	0.8170***	1				
Reactance	0.8370***	0.7372***	1			
Resistance	-0.2861*	-0.1865	-0.3014**	1		
Phase angle	-0.6501***	-0.3830**	-0.6372***	0.3286**	1	
Male	0.3361**	0.1796	0.2747*	0.5260***	-0.5916***	1
BMI						
WC	1					
AC	0.8131***	1				
Reactance	0.7611***	0.6151***	1			
Resistance	-0.2430*	-0.1011	-0.2042*	1		
Phase angle	-0.4698***	-0.1726	-0.5085***	0.3688**	1	
Total	0.2318*	0.0682	0.3189**	0.4615***	-0.6351***	1
BMI						
WC	1					
AC	0.8102***	1				
Reactance	0.8048***	0.6409***	1			
Resistance	-0.3605***	-0.1840*	-0.4377***	1		
Phase angle	-0.5899***	-0.2884**	-0.7030***	0.5774***	1	
Ângulo de fase	0.3551***	0.1549*	0.4276***	0.2043**	-0.6699***	1

IMC: índice de massa corpórea; PC: perímetro da cintura; PB: perímetro do braço. Nível de significância: * p < 0.05; ** p < 0.01; *** p < 0.001.

Source: Authors.

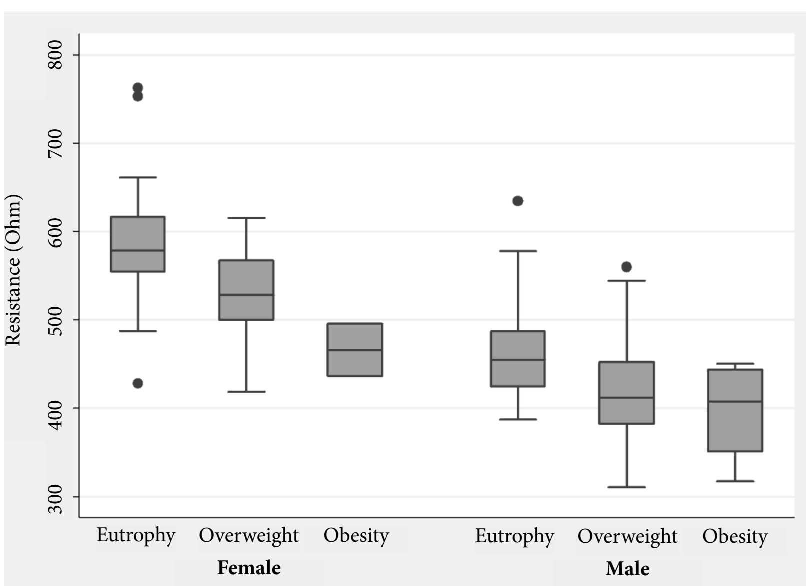

Figure 1. Mean resistance values of the Khisêdjê Indigenous people, assessed in 2010-2011, by gender and nutritional status classification. Xingu Indigenous Park, Central Brazil, 2014.

Source: Authors.

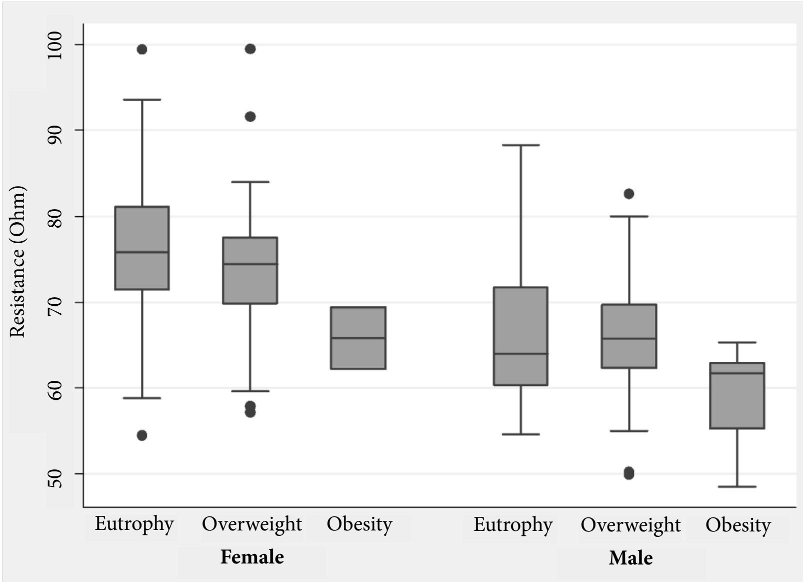

Figure 2. Mean reactance values of the Khisêdjê Indigenous people, assessed in 2010-2011, by gender and nutritional status classification. Xingu Indigenous Park, Central Brazil, 2014.

Source: Authors.

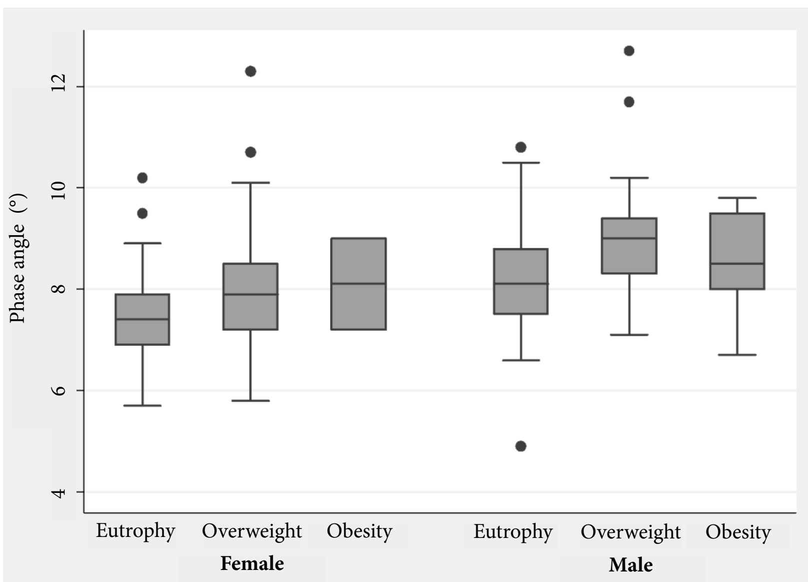

Figure 3. Mean phase angle values of the Khisêdjê Indigenous people, assessed in 2010-2011, by gender and nutritional status classification. Xingu Indigenous Park, Central Brazil, 2014.

Source: Authors.

identifies variations around a given reference of population anthropometric data, that is, the changes and deviations in the nutritional status of the population evaluated."

In the analysis of the anthropometry of the Khisêdjê population, we observed that the mean body mass index (BMI) was classified at the threshold of eutrophic parameters (24.9 kg/m^2).

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Mean values similar to those verified were mentioned among the 251 Karib Indigenous people of Mato Grosso (25.0 kg/m^2)[14] and among the 459 Mundukuru of Amazonas (25.8 kg/m^2)[31]. In contrast, higher values were found among the 363 Xikrin from Pará (28.8 kg/m^2)[23], the 925 Xavante from the São Marcos and Sangradouro/Volta Grande reserves in Mato Grosso (30.3 kg/m^2)[22], and the 207 Xavante from the Pimentel Barbosa and Etênhiritipá reserves in Mato Grosso (27.7 kg/m^2)[25].

The results of the classification of the nutritional status of the Khisêdjê show that 48.0% of those evaluated had some degree of overweight (BMI $\geq$ 25.0 kg/m^2). In specific studies with Indigenous people from different locations and ethnic groups in Brazil, prevalence rates of overweight ranged from 19.5% to 67.8%, and obesity ranged from zero to 47.3%. In the evaluation by gender, the prevalence of overweight ranged from 23.1% to 53.2% among women, and obesity ranged from zero to 76.9%. In males, the prevalence of overweight ranged from 12.5% to 61.8%, and that of obesity ranged from zero to 31.2%[8-19,21,23-31]. The BMI results for females, when compared to those found in the First National Health and Nutrition Survey of Brazilian Indigenous Peoples, a study of national and regional representation developed exclusively with women aged 14-49 years and children, were similar in the prevalence of overweight (30.3%) and lower in the prevalence of obesity (15.8%)[20].

Bioelectrical impedance has been considered an excellent method for detecting body composition. It is based on the principle that the opposition to the passage of electric current occurs differently in different body spaces. Therefore, while adiposity-rich tissues have low conductivity and, consequently, high resistance to the passage of current, lean tissues have high conductivity and low resistance. The same pattern applies to the reactance measurement. Regarding the phase angle, the highest values are found among individuals who have greater integrity of the cell membranes[2-4,6,7]. In evaluating the resistance measurement, the document "Bioelectrical impedance analysis in body composition measurement", prepared by the National Institutes of Health Technology, mentions that the values of this variable can be considered equivalent to the measurement of the muscle tissue in the subject evaluated[4].

Considering these theoretical foundations, the inverse correlation identified between the BMI variables and waist and arm circumferences with the resistance and reactance measurements (Table 2) and the reduced resistance and reactance means, per the increase in the nutritional status categories (Figures 1 and 2), suggest that the possible overweight identified in these individuals is related to excess muscle mass. Although with weak or regular intensity, the positive correlations of the anthropometric variables with the phase angle support the idea of an association between higher weights or circumferences and greater body cellularity (Table 2). These findings allow us to consider that the cutoff points used to classify nutritional status, proposed by the WHO[32], are possibly not appropriate for these Indigenous people.

The inadequate use of BMI, combined with the possibility of overweight resulting from excess muscle mass, has already been mentioned by Leite *et al.*[11] as a possible result of high physical activity levels among Indigenous people. Among the Khisêdjê, high prevalence rates of chronic non-communicable diseases have been identified over the years[35-37]. A study with this population also showed a high cumulative incidence of metabolic syndrome (37.5%), hypertriglyceridemia (47.4%), systemic arterial hypertension (SAH) (38.9%), central obesity (32.0%), overweight (30.4%), hypercholesterolemia (29.1%), low HDL cholesterol (HDLc) (25.0%), high LDL cholesterol (10.4%) and Diabetes Mellitus (DM) (2.9%), between the 1999-2000 and 2010-2011 periods[38]. Despite this fact, we found in some of these very studies[36,37] physical and anthropometric measurements compatible with a developed muscular profile, possibly linked to the high physical activity levels and conditioning identified.

Other authors have similarly suggested that single BMI cutoff points are inadequate for assessing different ethnic groups, especially for identifying overweight levels. Apparently, the relationship between BMI and body composition, fat distribution, and visceral fat content varies among ethnic groups. Consequently, the risk associated with developing metabolic diseases is also heterogeneous[39,40].

A review study conducted by Kyle *et al.*[41] indicated that predictive formulas for assessing body composition derived from bioelectrical impedance are considered primarily accurate, reproducible, and recommended for individuals with a BMI of up to 34.0 kg/m^2. According to the authors, results above this value should be cautiously evaluated. In the present study, only one individual (male) exceeded the abovementioned cutoff (BMI 34.9 kg/m^2). Despite complying with the criterion mentioned above for determining body fat percentage among the Khisêdjê, the unavailability of a specific formula for Indigenous populations, as indicated in the bibliographic literature[41,42], provides little evidence that the results obtained reproduce actual values.

Considering the aspects mentioned above and only in order to compare the data on the percentage of fat mass with studies with other Brazilian Indigenous peoples, the data were analyzed per predefined characteristics. In this comparison, the percentages of the Khisêdjê fat mass were lower than those of the Suruí of Rondônia [Suruí: 20-49 years – female (41.4%), male (22.6%); ≥ 50 years – female (37.4%) / Khisêdjê: 20-49 years – female (26.6%), male (14.6%); ≥ 50 years – female (34.9%)] except for male individuals in the age category ≥50 years (Suruí 16.5% vs. Khisêdjê 22.0%)[28]; the percentages found among the Xukuru-Kariri of Minas Gerais were similar [Xukuru-Kariri: adults (21.7%), older adults (30.2%) / Khisêdjê: adults (19.9%), older adults (31.2%)][29]; the percentages found among the Xavante of Mato Grosso were lower [Xavante: female (32.9%), male (22.7%), total (27.9%) / Khisêdjê: female (28.6%), male (16.1%), total (21.4%)][30]; and the percentages of the Munduruku of Amazonas were lower (in terms of percentage of adipose tissue) [Munduruku: low amount of adipose tissue (1.7%); normal amount of adipose tissue (36.6%), high amount of adipose tissue (61.7%) / Khisêdjê: low amount of adipose tissue (40.1%); normal amount of adipose tissue (49.2%), high amount of adipose tissue (10.7%)[31]. The studies used different bioimpedance equipment types and models, which may influence the level of precision of the measurements identified.

Indigenous peoples, like other non-Indigenous societies, have changed their lifestyles and diet, which relationship is influenced by factors such as proximity to non-Indigenous societies, access to territory, and health services, among other aspects[43,44]. The result of this context can be identified by the change in the pattern of nutritional status and the increase in cases of non-communicable diseases. A recently published meta-analysis[27], which assessed the metabolic health of Brazilian Indigenous people by analyzing 46 studies, identified 57.0% of overweight, 18.0% of obesity, 58.0% of central obesity, 53.0% of low HDLc, 40.0% of dyslipidemia, 31.0% of hypertriglyceridemia, 11.0% of SAH and 5.0% of DM. The research also showed that the prevalence of obesity among Indigenous people living in more urbanized territories was 3.5 times that identified among residents in native areas (28.0% vs. 8.0%, respectively). These results evidence the need to monitor the health situation among Indigenous peoples with their own needs and particularities.

A limitation of the research is the unavailability of specific cutoff points to classify the BMI values of Indigenous peoples and formulas for determining body composition. Despite the numerous technical limitations related to the identification of the body composition of Indigenous people, we can consider that the Khisêdjê have low body fat percentage values and that the use of BMI should not be adopted as the sole standard for assessing the nutritional status of these individuals. Also, specific cutoff points should be developed to identify the nutritional status of Indigenous peoples using BMI and developing predictive formulas for determining body composition.

Collaborations

L Mazzucchetti and SGA Gimeno: study design and planning; data retrieval, analysis, and interpretation; final version's drafting, critical review, and approval. PPO Galvão, MLS Tsutsui, KM Santos, DA Rodrigues and VF Rabelo: study planning; data retrieval; final version's critical review and approval.

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