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RELEVANCE OF ANTHROPOMETRIC INDICATORS IN ASSESSING ADIPOSITY IN ADULT WOMEN

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ABSTRACT. ***Introduction:*** Although the body mass index (BMI) has been widely used as a measure of adiposity, in fact, it is a measure of excess weight relative to height, rather than excess body fat. Other measurements of adiposity, such as waist circumference, waist-hip ratio (WHR) and skinfold thickness supplement information regarding the body fatness. In order to counteract some of the limits of BMI, it has been suggested the introduction of a new way of calculating the percentage of body fat, namely the body adiposity index (BAI). ***Objectives:*** This study was conducted to analyze the relevance and relationships between BMI, IAC, waist circumference, waist-hip ratio and the percentage of adiposity in adult women. ***Subjects and methods*:** This study involved 95 adult women, who practiced physical activities in two gyms in Oradea, for 12 months, between February 2015 and June 2016. Anthropometric measurements were performed: height, weight, girths, skinfolds. It was calculated the BMI, BAI, WHR, body composition, body fat percentage (BF%) based on the five skinfolds measures. Data were statistically analyzed with SPSS, version 20.0 (descriptive analysis, comparison of means and correlations). ***Results:*** The effect of the workouts in the gyms was the significant reduction of the values of the adiposity parameters of the analyzed subjects, except for the waist-hip ratio. The relationship between BMI, BAI, waist circumference and waist-hip ratio with BF% was statistically significant, both at initial and at final evaluation, but the correlations of BF% with BMI (initially r = 0.824, final r = 0.750) and waist circumference (initial r = 0.812, final r = 0.737) were stronger than those with IAC (initial r = 0.739, final r = 0.688) and the waist-hip ratio (initial r = 0.445, final r = 0.484). ***Conclusions:*** The physical activities performed by adult women in gyms had the effect of reducing body fat. The present study shows the relevance of anthropometric parameters: current BMI-based classifications for overweight and obesity are superior to the BAI-based measurements for determining overweight and obesity; BAI overestimates body fat in individuals with a low BF%; the waist-hip ratio does not reflect the degree of overweight.

Keywords: *body adiposity index, body mass index, waist circumference, waist-hip ratio, body fat percentage, adult women*

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REZUMAT. ***Relevanța indicatorilor antropometrici în evaluarea adipozității la femei adulte. Introducere:*** Cu toate că indicele de masă corporală (IMC) a fost utilizat pe scară largă ca o măsură a adipozității, de fapt, este mai degrabă o măsură a excesului de greutate în raport cu înălțimea, decât a excesului de grăsime corporală. Alte măsurători de adipozitate, cum ar fi circumferința taliei, raportul talie-șold sau plicile subcutanate suplimentează informațiile privind grăsimea corpului. Pentru a contracara unele limite ale IMC-lui s-a sugerat introducerea unui nou mod de calculare a procentului de adipozitate, și anume indicele de adipozitate corporală (IAC). ***Scopul:*** Acest studiu a fost făcut cu scopul analizei relevanței și relațiilor dintre IMC, IAC, circumferinţei taliei, raportul talie-șold și procentul de adipozitate la femei adulte. ***Subiecţi şi metode:*** La acest studiu au participat 95 de femei adulte, care au practicat activităţi fizice în două săli de fitness din Oradea, timp de 12 luni, în perioada februarie 2015 – iunie 2016. Au fost efectuate măsurători antropometrice: înălţimea, greutatea, circumferinţele, plicile subcutanate. A fost calculat IMC-ul, IAC-ul, raportul talie-şold (RTŞ), compoziţia corporală, ţesutul adipos procentual (ŢA%) pe baza a cinci plici cutanate. Datele obţinute au fost analizate statistic cu programul SPSS 20 (analiza descriptivă, compararea mediilor, corelații). ***Rezultate****:* Efectul antrenamentelor din sălile de fitness a fost reducerea semnificativă a valorilor parametrilor adipozității subiecților analizați, cu excepţia raportului talie/șold. Legătura dintre IMC, IAC, circumferinţa taliei şi raportul talie-şold cu ŢA% au fost semnificativă statistic, atât la evaluare iniţială, cât şi la evaluare finală, însă corelațiile ŢA% cu IMC (iniţial r = 0,824, final r = 0,750) şi circumferinţa taliei (iniţial r = 0,812, final r = 0,737) au fost mai puternice decât cele cu IAC (iniţial r = 0,739, final r = 0,678) şi raportul talie-șold (iniţial r = 0,445, final r = 0,484). ***Concluzii:*** Activitățile fizice desfășurate de femei adulte în săli de fitness au avut ca efect reducerea adipozității corporale. Studiul de faţă arată relevanţa parametrilor antropometrici: clasificările actuale bazate pe IMC pentru supraponderalitate şi obezitate sunt superioare măsurătorilor bazate pe IAC pentru determinarea supraponderalităţii şi obezității; IAC supraestimează grăsimea corporală la indivizii cu un ŢA% scăzut; raportul talie-şold nu reflectă gradul de supraponderalitate.

Cuvinte cheie*: indicele de adipozitate corporală, indicele de masă corporală, circumferința taliei, raportul talie-șold, ţesut adipos procentual, femei adulte*

Introduction

The body mass index (BMI), used to predict body fat percentage for almost 200 years, is not linearly associated with body fat percentage (Gallagher, Heymsfield, Heo, Jebb, Murgatroyd & Sakamoto, 2000). It provides us information about increasing body weight, it allows comparison of body weights and identifies individuals or groups at increased risk of morbidity and mortality.

However, the accuracy of BMI in assessing body fatness is still being discussed. Widely used as a measure of adiposity, in fact, BMI is a measure of excess weight relative to height, rather than excess body fat. However, it does not differentiate between a person's fat mass and lean mass, and the distribution of body fat cannot be assessed by it.

Other measurements of adiposity, such as waist circumference, waist-hip ratio (WHR) and skinfold thickness supplement information regarding the body fatness.

Although BMI has traditionally been the chosen method by which to measure body size in epidemiological studies, alternative measures – such as body adiposity index (BAI) (Bergman et al., 2011), waist circumference (WC) (Wei, Gaskill, Haffner & Stern 1997; Welborn & Dhaliwal, 2007), and waist-hip ratio (WHR) (Bigaard et al., 2005; Janssen, Katzmarzyk & Ross, 2004) – were considered to be superior to BMI in predicting the risk of cardiovascular diseases.

According to the WHO, a healthy WHR is 0.9 or less for men and 0.85 or less for women. In both men and women, a WHR of 1.0 or higher increases the risk of a cardiovascular disease and other conditions that are linked to being overweight (WHO, 2000a, b).

Central adiposity was highlighted as a growing problem. Currently, WHO accepts that waist circumference between 80.0-87.9 cm and the WHR 0.8 in women correspond to a BMI of 25-29.9 kg/m2 (WHO, 2000a, b). Waist circumference, as an index of abdominal fat, has an increased value between 80 and 87.9 cm, and substantially increased over 88 cm, with an increased risk of developing cardiovascular diseases and diabetes (WHO, 2008).

To counteract some limits of BMI, Bergman et al. (2011) suggested the introduction of a new way of calculating the percentage of body fat, namely the body adiposity index (BAI). It can be calculated solely from anthropometric measurements – hip circumference and height of subjects (hip circumference / height$^{1.5}$ - 18) – and can be used to reflect the percentage of body fat in adults. The use of BAI has several advantages over BMI, including that it yields associations with body fat percentage for men and women and may be easier to evaluate in field studies because it does not require weight measurement (Appelhans et al., 2012).

The BAI was developed and validated on samples of Mexican-Americans and African-Americans. Several studies of BAI values for predicting fat percentage or metabolic disorders in European-American, Mexican-American and Caucasian subjects have reported controversial results: in Caucasians, BAI is a better estimate of adiposity than BMI in non-obese subjects, but less effective than BMI in obese men and women (Johnson, Chumlea, Czerwinski & Demerath, 2012; Sun et al., 2013). According to Schulze et al. (2012), BMI correlates more strongly with body fat percentage than BAI and is more highly associated with diabetes risk in Caucasians. In a Spanish-Mediterranean population, the Receiver Operating Characteristic (ROC) curve analysis showed a higher accuracy for BMI than BAI (López et al., 2012). Also, in African-American and Hispanic women, the use of BAI has no advantage over the use of BMI (Appelhans et al., 2012; Geliebter, Atalayer, Flancbaum & Gibson, 2013; Freedman et al., 2012; Gibson, Atalayer, Flancbaum & Geliebter, 2012). With Korean women, the current BMI-based classifications for obesity might be superior to BAI-based measurements for determining obesity and predicting metabolic risk (Sung, Oh & Lee, 2014). For Brazilian patients with severe obesity, BAI does not provide an accurate estimate of BF% (Belarmino et al., 2015). In case of Colombian college students, there was poor agreement between BAI- and bioelectrical impedance analysis-based estimates of BF%, and so BAI is not accurate in people with low or high body fat percentage levels (Ramírez-Vélez et al., 2017). The conclusion of a systematic analysis shows that it exists "enough evidence that the BAI does not present satisfying results, and its use is not recommended for BF% determination in adults" (Cerqueira et. al., 2018). However, although validated in a sample of adults, BAI has already been used with children and adolescents. As a method of assessing BF%, its ability to predict risk factors for cardiovascular diseases and metabolic syndromes has been tested with Chinese adults (Lam, Koh, Chen, Wong & Fallows, 2015).

Aim and obiectives of the study

The aim of this study was to analyze the effect of physical activity on anthropometric indicators of body fat, highlighting the relevance and relationships between these indicators and the percentage of body fat in adult women. The anthropometric indicators used in the study were BMI, BAI, waist circumference, waist-hip ratio and body fat percentage.

The objectives of the study were:

- evaluation of subjects regarding body fat;
- detecting cases of obesity and overweight;
- statistical analysis of anthropometric indicators: comparison of averages and determination of relationships between them;
- discussing the results.

Hypothesis

In this study we started from the assumption that the systematic practice of physical activities in gyms will help reduce the body fat percentage.

Materials and methods

Subjects

This study involved 95 adult women, who practiced physical activities in two gyms in Oradea, for 12 months, between February 2015 and June 2016. The research included only those women who showed interest, accepted the measurements and gave permission that their data should to be used in research.

Methods

Anthropometric measurements were performed after the standards described by ISAK - International Society for the Advancement of Kinanthropometry: stature (in centimeters, with stadiometer); body mass/ weight (in kg using a calibrated weighing scale); girths (in cm, anthropometry tape) in the following areas: waist, hips and it was calculated the WHR; skinfolds (in mm, with Slim Guide calipers): only at the right side of the body, 3 times each region and using the average value in the following 5 regions: biceps, subscapular, abdominal, supraspinal (or wing), thigh .

Calculation of body composition was made after formulas by the National Center for Sports Medicine from Romania (Drăgan, I. 2002; Iliescu, A. 2013; Şerbescu, C. 2007), based on the measurement of five skinfolds: biceps, subscapular, abdominal, supraspinal and thigh in mm:

- Body fat percentage (BF%) = (5 skinfolds sum(mm) x 0.15) + 5.8 + BSA(m^2)
- BSA = Body Surface Area, was estimated using Du Bois formula (Du Bois & Du Bois, 1916)

BAI was calculated according to the formula:

- BAI = hip circumference / ($height^{1.5}$) - 18.

To specify the percentage of adiposity, we used the classification of the body adiposity index for women according to Gallagher (Gallagher et al., 2000).

Data were statistically analyzed with SPSS, version 20.0 (descriptive analysis, comparison of means and correlations).

Physical activity program applied

The physical activity program consisted in combined training of Pilates, Step - aerobics and strength training in the gym, 3 times a week for 60-90 minutes, for 12 months.

Depending on individual objectives (weight loss, decrease body fat - at overweight and obese subjects, weight gain - at underweight subjects) there was a different number of repetitions, a different load and a different intensity of training were used.

There were used: dynamic repetitive exercises, with large muscles groups; hard resistive exercises; functional exercises; high intensity interval training; balance exercises (Pilates); circuit training; stretching exercises.

Muscle strengthening was conducted mainly in the following muscle groups: upper limb muscles, back muscles, abdominal muscles, lower limb muscles.

Results

The analysis of the data of the subjects participating in the study reveals that their average age was 28.45 (8.75) years, the minimum age being 18 years and the maximum 52 years. The descriptive analysis, according to the age range, is presented in Table 1. Of the 95 subjects, 41 (43.2%) were under the age of 25, 31 (32.6%) in the age range of 25-34 years, 14 (14.7%) in the 35-44 years, and 9 (.5%) were over 45 years.

Table 1. Descriptive statistics of subjects by age range (N=95)

Age Interval	Frequency	Percent	Valid Percent	Cumulative Percent	Minim	Maxim	Mean	StDev
<25	41	43.2	43.2	43.2	18	24	21.10	1.828
25-34	31	32.6	32.6	75.8	25	34	28.42	2.527
35-44	14	14.7	14.7	90.5	35	43	37.79	2.887
>45	9	9.5	9.5	100.0	45	52	47.56	2.068
Total	95	100.0	100.0		18	52	28.45	8.746

After signing the acceptance to participate in the research, we made anthropometric measurements of the participants, and BMI, BAI and the BF% were calculated. Measurements and calculations were resumed after the intervention program was completed.

At the initial assessment of BMI, 6 subjects (6.3%) were in the underweight category, 65 subjects (68.4%) in normal weight, 19 subjects (20%) were overweight, 4 subjects (4, 2%) had class I obesity, and 1 subject had class II obesity. At the final evaluation 7 subjects (7.4%) were underweight, 69 subjects (72.6%) had normal weight, 15 of the subjects (15.8%) were overweight and 4 subjects (4.2%) were overweight and had class I obesity (Table 2).

Regarding BAI, at the initial testing, 61 subjects (64.2%) were in the healthy category, 29 subjects (30.5%) were overweight and 7 subjects (7.4%) were obese. At the final evaluation, 66 subjects (69.5%) were in the "healthy" category, 23 subjects (24.2%) were overweight and 6 subjects (6.3%) were obese (Table 2).

Table 2. Frequency of overweight and obesity depending on the index and test time (N=95)

			Frequency	Percent	Valid Percent	Cumulative Percent
BMI	T1	Underweight	6	6.3	6.3	6.3
		Normal weight	65	68.4	68.4	74.7
		Overweight	19	20	20	94.7
		Obese class I	4	4.2	4.2	98.9
		Obese class II	1	1.1	1.1	100.0
		Total	95	100.0	100.0	
	T2	Underweight	7	7.4	7.4	7.4
		Normal weight	69	72.6	72.6	80.0
		Overweight	15	15.8	15.8	95.8
		Obese class I	4	4.2	4.2	100.0
		Total	95	100.0	100.0	
BAI	T1	Healthy	61	64.2	64.2	64.2
		Overweight	27	28.4	28.4	92.6
		Obese	7	7.4	7.4	100.0
		Total	95	100.0	100.0	
	T2	Healthy	67	70.5	70.5	70.5
		Overweight	22	23.2	23.2	93.7
		Obese	6	6.3	6.3	100.0
		Total	95	100.0	100.0	

Waist circumference, as an index of abdominal fat, at the baseline in 75 subjects (78.9%) was below the threshold value (below 80 cm), in 10 subjects (10.5%) it was increased, and also in 10 subjects (10.5%) was substantially increased (over 88 cm). At the final evaluation in 77 subjects (81.1%) it was below the threshold value, in 10 subjects (10.5%) it was increased, and in 8 subjects (8.4%) it was substantially increased.

Table 3. Testing the normality of the data distribution of anthropometric parameters of subjects (N=95)

Tests of normality

Variable	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Weight 1 (kg)	.159	95	.000	.910	95	.000
Weight 2 (kg)	.157	95	.000	.901	95	.000
BMI 1 kg/h^2	.137	95	.000	.913	95	.000
BMI 2 kg/h^2	.145	95	.000	.901	95	.000
BAI 1 %	.092	95	.044	.954	95	.002
BAI 2 %	.097	95	.029	.965	95	.013
BF 1 %	.182	95	.000	.907	95	.000

Tests of normality

Variable	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
BF 2 %	.199	95	.000	.824	95	.000
Hip girth 1 (cm)	.112	95	.005	.970	95	.026
Hip girth 2 (cm)	.112	95	.005	.970	95	.026
Waist girth 1 (cm)	.178	95	.000	.897	95	.000
Waist girth 2 (cm)	.181	95	.000	.894	95	.000
WHR 1	.115	95	.004	.948	95	.001
WHR 2	.084	95	.098	.949	95	.001

The comparison of the means from the two measurements was made after testing the data distribution (Table 3), and, depending on the results, parametric or non-parametric tests will be used to compare the means.

As the number of subjects is over 50, we will consider the results from the Kolmogorov - Smirnov test. According to this, for all the variables involved in this study, the distribution was not normal ($p < 0.05$), consequently the comparison of means was done using the non-parametric Wilkoxon test.

According to the data presented in Table 4 the difference is significant for all pairs of variables, and the effect size (r) is medium (for example at BMI Z = -5.729, df = 95, p = .000, r = -0.416; at BF% Z = -7.583, p = .000, r = -0.550), except for the waist-hip ratio, where the difference is insignificant (Z = -1.789, p = .074, df = 95, r = - 0.130).

Table 4. Descriptive analysis and comparison of means of anthropometrical measurement before and after intervention program (N=95)

	Descriptive statistics						**Test Statistics[a]**		**Effect size**
	Test	N	Mean	St.dev.	Min	Max	Z	p	r
Weight (kg)	T1	95	63.67	11.699	43	103	-5.578[b]	.000	-0.404
	T2	95	62.39	10.634	43	98			
BMI (kg/m^2)	T1	95	22.87	3.96	16.61	36.49	-5.729	.000	-0.416
	T2	95	22.40	3.61	16.96	34.72			
Hip (cm)	T1	95	107.16	7.694	90	130	-6.218[b]	.000	-0.451
	T2	95	108.82	9.027	90	140			
Waist (cm)	T1	95	73.13	9.625	58	104	-5.283[b]	.000	-0.383
	T2	95	72.16	8.915	59	99			
BF %	T1	95	72.16	8.915	59	99	-7.583[b]	.000	-0.550
	T2	95	22.97	5.628	13	39			
BAI	T1	95	32.55	4.59777	23.10	46.29	-6.298[b]	.000	-0.456
	T2	95	31.79	4.11807	23.33	44.35			
WHR	T1	95	.6705	.04884	.58	.83	-1.789[b]	.074	-0.130
	T2	95	.6722	.05056	.58	.83			

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks

The correlation coefficient was used to determine the relationships between the variables BMI, BAI, waist circumference, WHR and BF%. Since the data were not normally distributed, the Spearman test was used.

The correlations between the body fat percentage (BF%) and BMI, BAI, waist circumference, and WHR at the initial and final test can be seen in Table 5. It can be observed, both at the initial and at the final test, that there is a high positive relationship between BF% and these anthropometric parameters, except for the one with WHR, at which the relationship is medium (r = .445, p = .000). This means that increased values of anthropometric parameters indicate high values of the percentage of adipose tissue.

Table 5. Correlations between BMI, BAI, waist circumference, BF% and WHR before and after the intervention program (N = 95)

			Correlations				
			BMI T1	**BAI T1**	**Waist T1**	**WHR T1**	**BF T1**
Spearman's rho	BMI T1 (kg/m2)	Correlation Coefficient	1.000	.815**	.854**	.530**	.824**
		Sig. (2-tailed)	.	.000	.000	.000	.000
	BAI T1 (%)	Correlation Coefficient	.815**	1.000	.697**	.346**	.739**
		Sig. (2-tailed)	.000	.	.000	.001	.000
	Waist T1 (cm)	Correlation Coefficient	.854**	.697**	1.000	.737**	.812**
		Sig. (2-tailed)	.000	.000	.	.000	.000
	WHR T1	Correlation Coefficient	.530**	.346**	.737**	1.000	.445**
		Sig. (2-tailed)	.000	.001	.000	.	.000
	BF T1 (%)	Correlation Coefficient	.824**	.739**	.812**	.445**	1.000
		Sig. (2-tailed)	.000	.000	.000	.000	.
			BMI T2	**BAI T2**	**Waist T2**	**WHR T2**	**BF T2**
Spearman's rho	BMI T2 (kg/m2)	Correlation Coefficient	1.000	.778**	.843**	.539**	.750**
		Sig. (2-tailed)	.	.000	.000	.000	.000
	BAI T2 (%)	Correlation Coefficient	.778**	1.000	.605**	.268**	.678**
		Sig. (2-tailed)	.000	.	.000	.009	.000
	Weist T2 (cm)	Correlation Coefficient	.843**	.605**	1.000	.766**	.737**
		Sig. (2-tailed)	.000	.000	.	.000	.000
	WHR T2	Correlation Coefficient	.539**	.268**	.766**	1.000	.484**
		Sig. (2-tailed)	.000	.009	.000	.	.000
	BF T2 (%)	Correlation Coefficient	.750**	.678**	.737**	.484**	1.000
		Sig. (2-tailed)	.000	.000	.000	.000	.

**. Correlation is significant at the 0.01 level (2-tailed).

The relationship between BF (%), BMI and BAI in the two tests of the subjects (initial and final) can be observed on the dispersion diagrams presented in Figure 1.

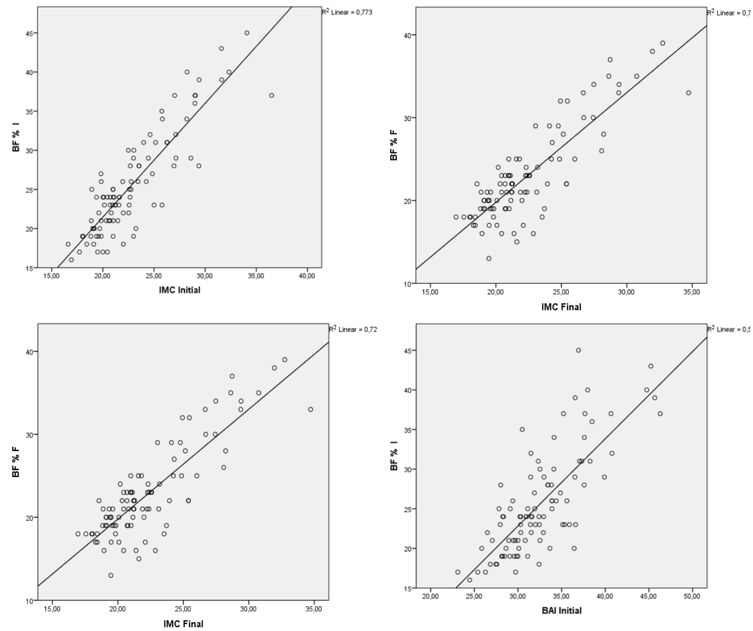

Fig. 1. Dispersion diagrams showing the relationship between BF (%), BMI and BAI before and after the intervention

Discussions

The assessment of the body composition, the estimation of the BF% based on the 5 skinfold thickness and the effect of the intervention program on the BF%, respectively the waist circumference were described in a previous article (Nagy, K. & Hanţiu, I., 2017).

According to the data presented in Table 5, the correlations of BMI, BAI, waist circumference and WHR with BF% were statistically significant, both at baseline (T1) and follow-up (T2) evaluation, but correlations of BF% with BMI (T1 *rho* = 0.824; T2 *rho* = 0.750) and waist circumference (T1 *rho* = 0.812; T2 *rho* = 0.737) were stronger than those with BAI (T1 *rho* = 0.739; T2 *rho* = 0.678) and WHR (T1 *rho* = 0.445; T2 *rho* = 0.484).

The mean WHR, both initial (0.670) and final (0.672) is below 0.8, which is the WHO-defined threshold for increased health risk for women. It is interesting that according to the WHR, only 2 subjects have moderate health risk, although the other measurements show there are several overweight and obese people (20 subjects at baseline, 16 subjects at the follow-up evaluation).

A study by Molarius et al. (1999) on waist and hip circumference and WHR in 19 populations of the WHO: MONICA project, shows that "waist circumference and waist-hip ratio, both used as indicators of abdominal obesity, appear to measure different aspects of the human body: waist circumference reflects mainly the degree of overweight, while the WHR does not". "The WHR is a ratio and as a result suffers from limitations in relation to its use in statistical analyses and its interpretation" (Allison, Paultre, Goran, Poehlman & Heymsfield, 1995). Some reports have suggested that waist circumference alone may be a better indicator of visceral fat accumulation and cardiovascular risk than WHR (Han, van Leer, Seidell & Lean, 1995; Pouliot et al., 1994). In our study we found similar results, the correlation of the WHR with BF% was the lowest of the measured parameters, in both evaluations (T1 *rho* = 0.445 and T2 *rho* = 0.484).

In the group studied by us, according to the BAI, no subject was in the underweight category, although according to the BMI, 8 subjects were classified in this category at the baseline and 7 subjects, at follow-up, this indicating the overestimation of the BAI in those with low BF%. A recent systematic review by Cerqueira and coworkers (2018) of the validity of BAI in determining the percentage of body fat in adults found similar results: BAI systematically underestimates body fat in individuals with a high BF% and overestimates in individuals with a low BF%; taking into consideration the proposal of BF% classification for men and women suggested by Heo et al. (2012), the best BAI range performance (20 – 30%) is exactly the lowest health risk range. BAI overestimation for BF% less than 20% would inappropriately classify low-BF individuals as adequate, resulting in false-negative errors in individuals who may be at risk of malnutrition. However, the greatest public health risk is the underestimation that BAI generates for those with BF% higher than 30%, which may lead to non-detection of overweight or obese individuals (false-negative results for high BF%).

Conclusions

The analysis of the relevance of anthropometric indicators of body fat led to the following conclusions:

- for the estimation of overweight and obesity, classifications based on BMI calculation are recommended;
- waist-hip ratio showed weaker correlations with BF% than BAI, waist circumference and BMI;
- BAI overestimates body fat at individuals with lower BF%;
- the waist-hip ratio does not reflect the degree of overweight;
- waist circumference, as an index of abdominal fat may be used to identify individuals who are at risk.

The conclusions of our study are similar to the conclusions of other studies.

Limitations of the study

There are two major limitations in this study that could be addressed in a future research. The first is related to the sample size: the number of subjects was not large enough to be considered representative. The second limit is the method we use to determine the body fat percentage (based on skinfolds). We consider that the results would have been more accurate if we had been able to determine the percentage of adipose tissue using bioelectrical impedance analysis or DEXA analysis.

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