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A comparative study of methods for diagnosis of obesity in an urban mixed-race population in Minas Gerais, Brazil

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Abstract

Background: Obesity is defined as an excess of total body fat and may be assessed by different methods. The objective of the present study was to establish the discriminatory power of anthropometric data in determining obesity.

Methods: The subjects comprised 685 individuals, aged 20–79 years, sampled from a population-based survey. The following indicators were used: body mass index (BMI), waist circumference (WC) and total body fat percentage estimated with both Siri's equation (%BF Siri) and foot-to-foot bioelectrical impedance analysis (%BF BIA). Sensitivity and specificity of different cut-off points for each method were determined using %BF BIA as reference.

Results: Of 685 participants, 57.6% were aged $\geq$40 years, 69.9% were women and 72.6% self-referred themselves as non-white. To classify obesity based on sex and age among women aged $<$40 years, the cut-off points were BMI of 26.0 $kg\,m^{-2}$, WC of 84.0 cm and %BF Siri of 34.0%; in those aged $\geq$40 years, the cut-off points were 28.0 $kg\,m^{-2}$, 90.0 cm and 37.4%, respectively. The cut-off points among men aged $<$40 years were BMI of 26.3 $kg\,m^{-2}$, WC of 86.0 cm and %BF Siri of 22.5%, and in those aged $\geq$40 years, 26.3 $kg\,m^{-2}$, 89.0 cm and 24.5%, respectively. BMI was the method with the largest area under the curve (AUC) independent of sex and sex/age, yet no differences were observed in AUC between BMI and WC ($P > 0.05$). Classifying according to skin colour did not change cut-off points in any indicator.

Conclusion: BMI and WC better discriminate obesity among women and men aged $\geq$40 years from a mixed-race population.

Keywords
Obesity
Body fat percentage
Anthropometry
Sensitivity
Specificity
Area under the curve

Total body fat, which is one part of body composition, plays an important role in epidemiological studies because it is a known risk factor for non-communicable diseases[1,2]. Several different methods have been used for its assessment, among which hydrostatic weighing, dual-energy X-ray absorptiometry (DEXA), body mass index (BMI), waist circumference (WC), skinfold thickness and bioelectrical impedance stand out.

Hydrostatic weighing and DEXA are considered the gold standards. However, they have the disadvantages of low applicability and high cost for population studies. On the other hand, BMI, WC, skinfold thickness and bioelectrical impedance are cheaper and quite reliable[3–5] but provide different information about body composition. BMI assesses individuals based on their total body mass; WC classifies central adiposity; and skinfold thickness estimates body fat based on the assumption that subcutaneous fat thickness comprises a constant proportion of total body fat[3,5,6].

Bioelectrical impedance has also been used recently to estimate body composition. It is based on the knowledge that lean body mass conducts electricity better than adipose tissue, showing an inverse relationship with body resistance under an electric current[3]. Two techniques are used: bipolar (conventional) and portable bioelectrical impedance analysis (BIA).

In the first method, the evaluator should be trained in order to ensure the correct placement of electrodes on the subject's feet and hands, a factor of paramount importance for accuracy and reproducibility of body component estimates[3]. However, the latter technique costs less, does not require much time for measurements, and recent

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studies have shown it to be valid and applicable to epidemiological investigations[7–9].

Although DEXA is considered the gold standard, among portable instruments the Tanita® excels in providing foot-to-foot BIA and has shown a high correlation with both conventional bipolar BIA and DEXA. Furthermore, the classification of body fat percentage takes into account sex and age differences[10].

The literature reports that body composition can be determined by several factors characterising a population, such as age, sex and race[6,11–13]. Studies on body composition according to sex and age in mixed-race populations are scarce[14–16]. Ouro Preto City has a mixed-race population, probably resulting from a high concentration of African Diaspora descendents brought to the city from the 16th to the 18th century, and it has a high percentage of non-white people (63.14%) living in the urban area[17]. Therefore, its inhabitants present a unique opportunity to investigate indicators for the diagnosis of obesity in population groups with such characteristics.

In the light of diverse methodologies available to assess body composition and total body fat[3,7,9], the objective of the present study was to verify the sensitivity, specificity and discriminatory power of anthropometric measurements obtained by different methods in determining obesity in a mixed-race population group.

Materials and methods

Study population and sample

This study included 685 participants aged 20–79 years from a population sample of 930 residents aged 15 years or more, randomly sampled in a medium-sized town – Ouro Preto – in the Southeastern region in Brazil during 2001. It is part of a cross-sectional study aimed to investigate the prevalence of risk factors for cardiovascular disease in this population.

The sampling frame was based on the following assumptions: infinite population, systemic arterial hypertension prevalence estimation at 25%[18], 3% precision, 95% confidence level and estimated loss of 20%.

Anthropometric and body composition measurements

The measurements were performed according to standard recommendations on subjects with an empty bladder who had fasted for 12 h. Measurements were taken between 07.00 and 10.00 hours by the same previously trained team.

Total body fat percentage (%BF) was measured by means of foot-to-foot BIA using Tanita® BF542 scales with an electric current of 500 μA and a fixed frequency of 50 kHz, with 0.5% precision. BMI (kg m^{-2}) was calculated as weight (in kg), obtained on the scales mentioned above (which had a capacity of 136 kg and weight increments of 0.2 kg), divided by the square of height (in m)[3,19]. Height was measured without shoes to the nearest 0.1 cm using a portable stadiometer with fixed tape, with the head in the Frankfurt plane. WC (cm) was measured at the natural waist, which is the midpoint between the lower costal arch and the iliac crest, using a non-elastic measuring tape with a precision of 0.1 cm[19]. Triceps, biceps, subscapular and suprailiac skinfold thickness (mm) was measured on the non-dominant side of the body by means of a CESCORF® apparatus, with a precision of 0.1 mm. Three measurements were carried out on each skinfold, and the mean was considered for analysis[19]. Body density was estimated according to sex and age using the Durnin and Womersley equation. %BF was also calculated based on body density by means of Siri's equation (referred to as %BF Siri below). All participants ($n = 685$) who complied with all anthropometric measures were included in the analysis.

Definition of obesity

Excess body fat was defined by means of the criterion established by Gallagher *et al.* for African American populations[10], following the recommendations of the manufacturer of the Tanita® BF542. Men and women with body fat excess were classified by age, and their %BF was, respectively: ≥38% and ≥26% for age 20–30 years; ≥39% and ≥27% for age 40–59 years; and ≥41% and ≥29% for age 60–79 years.

Statistical analysis

Analysis of correlation, using the Pearson chi-square test, was carried out between Tanita® %BF and the anthropometric and body composition variables. Using bioelectrical impedance measured by the Tanita® scales as the reference (referred to as %BF BIA below), we calculated the sensitivity (probability of detecting truly obese individuals) and specificity (probability of detecting truly not obese individuals) for various obesity discriminating points by plotting on the receiver operating characteristic (ROC) curves by sex, sex and age, and sex and skin colour. Age was categorised according to the median distribution of the dataset (<40 years: younger adults, ≥40 years: older adults) and self-referred skin colour as white and non-white.

The areas under the curves (AUC), 95% confidence intervals and standard errors were tested using the Wilcoxon test[20]. The method of Hanley and McNeil[21], within the 95% confidence interval, was used to compare the areas under the ROC curves for each anthropometric variable.

The project was approved by the Institutional Review Board of the Federal University of Ouro Preto under the protocol 26/2001.

Results

Of 685 participants, 479 (69.9%) were females and 206 (30.1%) males, 57.6% were ≥40 years old, and 72.6% self-referred themselves as non-white. Table 1 describes their

Table 1 Demographic, anthropometric and body composition features according to sex, Ouro Preto City, Brazil

Variable	Females		Males	
	n	Mean ± SD	*n*	Mean ± SD
Age (years)	479	46.0 ± 15.2	206	42.7 ± 15.4
Height (cm)	479	157.1 ± 7.1	206	170.8 ± 7.1
Weight (kg)	479	64.8 ± 13.5	206	70.7 ± 12.7
BMI (kg m^{-2})	479	26.3 ± 5.3	206	24.2 ± 3.9
Stratified by age				
< 40 years	177	24.6 ± 5.5	97	23.5 ± 4.1
≥ 40 years	302	27.4 ± 5.0	109	24.9 ± 3.6
P-value (*t*-test)		<0.01		0.02
%BF BIA	479	33.5 ± 8.2	206	20.0 ± 7.9
Stratified by age				
< 40 years	177	32.0 ± 8.4	97	18.6 ± 8.8
≥ 40 years	302	34.4 ± 8.0	109	21.3 ± 6.8
P-value (*t*-test)		<0.01		0.01
%BF Siri	474	35.4 ± 5.9	206	20.4 ± 6.6
Stratified by age				
< 40 years	174	33.6 ± 6.1	97	19.6 ± 7.3
≥ 40 years	300	36.5 ± 5.5	109	21.1 ± 5.8
P-value (*t*-test)		<0.01		0.11
WC (cm)	475	85.2 ± 13.7	205	85.9 ± 11.8
Stratified by age				
< 40 years	174	79.8 ± 12.8	96	81.7 ± 10.8
≥ 40 years	301	88.3 ± 13.3	109	89.6 ± 11.5
P-value (*t*-test)		<0.01		<0.01

SD – standard deviation; BMI – body mass index; %BF BIA – percentage total body fat estimated by foot-to-foot bioelectrical impedance analysis; %BF Siri – percentage total body fat estimated by Siri's equation; WC – waist circumference.

demographic, anthropometric and body composition characteristics by sex and age.

Females had the following anthropometry (mean ± standard deviation, SD): age, 46.0 ± 15.2 years; height, 157.1 ± 7.1 cm; weight, 64.8 ± 13.5 kg; BMI, 26.3 ± 5.3 kg m^{-2}. Stratified by age, younger women presented significantly lower mean BMI (24.6 kg m^{-2}) than older women (27.4 kg m^{-2}). %BF Siri (35.4 ± 5.9) was higher than %BF BIA (33.5 ± 8.2), especially among older females. Regarding WC, among all females the mean value (85.2 ± 13.7 cm) was above normal levels, although younger subjects presented mean average WC (79.8 cm) near to normal limits.

In males, anthropometry (mean ± SD) was as follows: age, 42.7 ± 15.4 years; height, 170.8 ± 7.1 cm; weight, 70.7 ± 12.7 kg; BMI, 24.2 ± 3.9 kg m^{-2}. Stratified by age, men aged <40 years had a mean BMI of 23.5 kg m^{-2}, significantly lower than that (24.9 kg m^{-2}) of men aged ≥40 years. %BF BIA (20.0 ± 7.9) was similar to %BF Siri (20.4 ± 6.6); slight but non-significant differences ($P = 0.11$) were observed when mean %BF Siri was compared with mean %BF BIA among younger male adults. Mean WC for all men (85.9 ± 11.8 cm) was below normal levels but a significant increase with age could be observed: from 81.7 cm in younger males to 89.6 cm among older males.

Table 2 shows the correlation between anthropometric measurements and %BF BIA, by sex and sex and age. The correlations ranged from 0.74 to 0.87 for females, and from 0.67 to 0.93 for males. BMI was the method that presented the best correlations with the reference method, except for females aged <40 years, whose WC correlation ($r = 0.87$) was greater than with the reference method. Nevertheless, stratifying by sex independent of age verified that the correlation found between WC and %BF BIA showed no significant differences between sexes ($r = 0.80$).

Sensitivity and specificity of several cut-off points for obesity, according to the reference method used and by sex and age, are presented in Table 3. For diagnosis of obesity, it was observed that the cut-off points showing greatest sensitivity and specificity for BMI were 27.5 kg m^{-2} for females (sensitivity = 90.3%, specificity = 82.6%) and 26.3 kg m^{-2} for males

Table 2 Correlation between anthropometric measurements and %BF BIA according to sex, Ouro Preto City, Brazil

Index	Females			Males		
	n	*r*	95% CI	*n*	*r*	95% CI
BMI (kg m^{-2})	479	0.82	(0.78–0.84)	206	0.90	(0.87–0.93)
Stratified by age						
< 40 years	177	0.80	(0.74–0.85)	97	0.93	(0.90–0.95)
≥ 40 years	302	0.82	(0.78–0.86)	109	0.87	(0.81–0.91)
%BF Siri	474	0.76	(0.72–0.80)	206	0.75	(0.68–0.80)
Stratified by age						
< 40 years	174	0.79	(0.73–0.84)	97	0.79	(0.70–0.85)
≥ 40 years	300	0.74	(0.68–0.79)	109	0.67	(0.55–0.76)
WC (cm)	475	0.80	(0.77–0.83)	205	0.80	(0.74–0.84)
Stratified by age						
< 40 years	174	0.87	(0.83–0.90)	96	0.88	(0.83–0.92)
≥ 40 years	301	0.77	(0.72–0.81)	109	0.73	(0.63–0.81)

CI – confidence interval; BMI – body mass index; %BF Siri – percentage total body fat estimated by Siri's equation; WC – waist circumference.

Table 3 Values of sensitivity (Sens) and specificity (Spec) of the cut-off points for obesity, according to reference method and reference standards, Ouro Preto City, Brazil

Index	Females			Males		
	Cut-off point	Sens (%)	Spec (%)	Cut-off point	Sens (%)	Spec (%)
BMI (kg m^{-2})						
Ouro Preto	27.5	90.3	82.6	26.3	90.5	86.6
Reference*	30.0	60.4	94.2	30.0	33.3	98.8
Stratified by age						
< 40 years	26.0	97.9	88.5	26.3	95.0	93.5
≥ 40 years	28.0	90.8	77.7	26.3	86.4	81.6
WC (cm)						
Ouro Preto	86.0	91.0	75.7	89.5	92.9	79.1
Reference†	88.0	82.7	79.5	102.0	33.3	98.8
Stratified by age						
< 40 years	84.0	89.1	93.7	86.0	100	86.8
≥ 40 years	90.0	87.4	75.7	89.0	100	65.5
%BF Siri						
Ouro Preto	37.0	78.9	73.6	21.9	92.9	66.5
Reference‡	35.0	92.5	57.8	25.0	61.9	86.6
Stratified by age						
< 40 years	34.0	97.8	67.2	22.5	100	75.3
≥ 40 years	37.4	82.8	67.1	24.5	68.2	79.3

*World Health Organization[22].
†National Institutes of Health[23].
‡Lohman[3].

(sensitivity = 90.5%, specificity = 86.6%). The cut-off point of $\geq 30\,\mathrm{kg\,m^{-2}}$ suggested by the World Health Organization (WHO)[22] and the US National Institutes of Health (NIH)[23] showed low sensitivity (60.4% and 33.3% for women and men, respectively) but high specificity (94.2% for women and 98.8% for men).

Stratified by age, for young females the BMI cut-off point of $26.0\,\mathrm{kg\,m^{-2}}$ corresponded to sensitivity = 97.9% and specificity = 88.5%; and for older females the cut-off point of $28.0\,\mathrm{kg\,m^{-2}}$ had sensitivity = 90.8% and specificity = 77.7%. For young and older males, the BMI cut-off point of $26.3\,\mathrm{kg\,m^{-2}}$ corresponded to sensitivity and specificity of 95.0% and 93.5%, and 86.4% and 81.6%, respectively.

For WC, the discriminating point for diagnosis of total body fat excess in women was 86 cm (sensitivity = 91.0%, specificity = 75.7%), whereas in men it was 89.5 cm (sensitivity = 92.9%, specificity = 79.1%). Using the values recommended by the NIH (88 cm and 102 cm), sensitivity of 82.7% and 33.3%, and specificity of 79.5% and 98.8%, was calculated for women and men, respectively.

Stratifying by age, the WC cut-off with best discrimination for women aged <40 years was 84.0 cm (sensitivity = 89.1%, specificity = 93.7%) and for those aged ≥ 40 years was 90.0 cm (sensitivity = 87.4%, specificity = 75.7%). For men, cut-offs of 86.0 cm (sensitivity = 100%, specificity = 86.8%) and 89.0 cm (sensitivity = 100%, specificity = 65.5%) were found, respectively.

Considering %BF Siri, the best discriminating points were 37.0% (sensitivity = 78.9%, specificity = 73.6%) for all females and 21.9% (sensitivity = 92.9%, specificity = 66.5%) for all males, which varied with age in both sexes. The cut-offs were: for women <40 years, 34.0% (sensitivity = 97.8%, specificity = 67.2%) and ≥ 40 years, 37.4% (sensitivity = 82.8%, specificity = 67.1%); and for men <40 years, 22.5% (sensitivity = 100%, specificity = 75.3%) and ≥ 40 years, 24.5% (sensitivity = 68.2%, specificity = 79.3%). These levels were very similar to those recommended by Lohman, i.e. 35% for women and 25% for men.

Figure 1 shows the ROC curves and their respective AUC by sex using %BF BIA as the reference method. It can be observed that AUC was larger for BMI and WC and smaller for %BF Siri, for both sexes. Comparing the curves, in females BMI had better discrimination than WC or %BF Siri ($P < 0.05$), while WC and %BF Siri were quite similar ($P = 0.10$). In males BMI also showed larger AUC, and this was similar to that of WC ($P = 0.31$) and statistically different from that of %BF Siri ($P = 0.01$). On the other hand, AUC for WC and %BF Siri were similar ($P = 0.11$).

Stratifying according to age, the methods that presented greater AUC were BMI and WC independently of sex. Among females aged <40 years and ≥ 40 years, it was observed that AUC for BMI was similar to that for WC ($P = 0.16$ and 0.15, respectively) but differed from AUC for %BF Siri ($P = 0.01$ for both); whereas WC was similar to

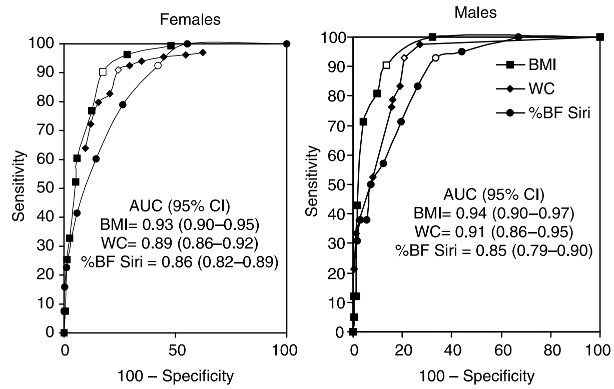

Fig. 1 Receiver operating characteristic curves of anthropometric predictors in the urban population of Ouro Preto City, Brazil aged 20–79 years, by sex (AUC – area under the curve; CI – confidence interval; BMI – body mass index; WC – waist circumference; %BF Siri – percentage total body fat estimated with Siri's equation)

%BF Siri in AUC ($P = 0.13$ and 0.16, respectively). On the other hand, among males aged <40 years, no differences were observed between AUC for BMI and WC ($P = 0.88$), BMI and %BF Siri ($P = 0.14$) and WC and %BF Siri ($P = 0.14$). Among males aged ≥ 40 years, AUC for BMI was similar to that for WC ($P = 0.95$) and greater than AUC for %BF Siri ($P = 0.055$), while AUC for WC and AUC for %BF Siri were different ($P = 0.04$) (Fig. 2).

Defining the balance points based on sensitivity and specificity, we observed similarities between cut-off points by either sex or sex and skin colour. This may be explained by the high percentage of non-whites found in this study population (72.6%). Regarding morbid obesity, prevalent in 0.99% of our population, the exclusion of this group did not change any cut-off point indicators.

Discussion

In the present study, BMI, WC and %BF using Siri's equation showed good discriminatory power for diagnosis of obesity with specific cut-off points for age and sex/age in an urban mixed-race population. Compared with the reference method (%BF determined by foot-to-foot BIA), BMI and WC were the methods revealing greatest accuracy for the entire population, except for males aged <40 years, whose estimates did not differ regarding the method adopted. BMI and WC had similar discriminatory power, according to the ROC areas under the curve, independently of age and sex.

Age and sex are well-known and relevant factors to determine anthropometric indicator cut-off points, especially if we take into account body fat composition and distribution. Marked changes in body composition are observed in men and women as they get older, and there is a trend to increase fat mass to the detriment of lean mass[24–30] in populations of different races[31–33].

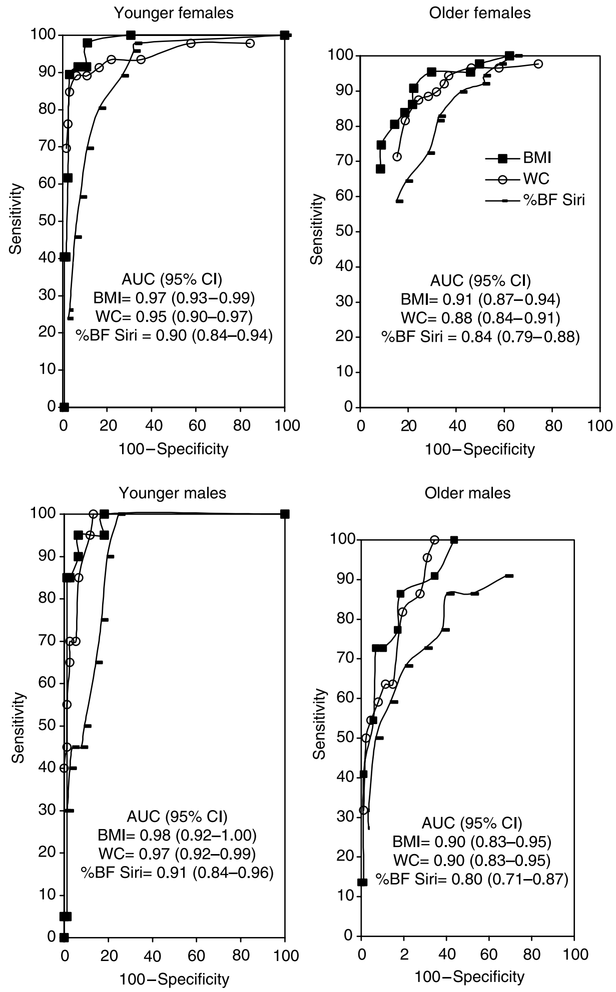

Fig. 2 Receiver operating characteristic curves of anthropometric predictors in the urban population of Ouro Preto City, Brazil aged 20–79 years, by sex and age (AUC – area under the curve; CI – confidence interval; BMI – body mass index; WC – waist circumference; %BF Siri – percentage total body fat estimated with Siri's equation)

Accumulation of fat particularly in the abdominal region has been observed in postmenopausal women[6,34,35]; hence, in our study, BMI and WC had similar discriminatory power in this population. In other words, higher BMI could be attributed to increased adiposity in the abdominal region.

Nevertheless, lower estimates of BMI cut-off points compared with international standards were observed in this study, according to sex and sex/age. Similar results were reported by other authors in studies of specific population groups, in whom the cut-off points varied according to sex and age[15,28,36–38]. When the values recommended by the NIH[23] and WHO[22] were used to define obesity, we observed an increase in specificity for men and women (98.8% and 94.2%, respectively) and a significant drop in sensitivity (33.3% and 60.4%, respectively). The rise in the number of false-negatives, i.e. obese individuals who were not considered as such, led to an underestimated rate of obesity of 57.2% and 29.9% for men and women, respectively, regardless of age. Similar underreporting of estimates was found by Frankenfield *et al.*[26] using the same cut-off points recommended by the WHO to estimate obesity in white individuals.

WC is a fat centralisation predictor, deemed a robust body adiposity indicator[2], and in our study it showed good correlation with total body fat ($r \geq 0.80$) for both sexes, except for individuals aged ≥ 40 years ($r = 0.77$ for females and $r = 0.73$ for males). Similar results were obtained by Lemos-Santos *et al.*[39] in a Brazilian male adult population ($r = 0.83$–0.89). Also, WC was the anthropometric variable that ranked second in discriminatory power for both sex and age; and no differences were observed in the AUC of BMI and WC. These findings may suggest that the excess of body fat could be a result of increased adiposity in the waist in our population.

Similar to BMI, WC showed a tendency to lower cut-off points compared with those recommended by the NIH[23], as also observed by Taylor *et al.*[40]. We found in men that the recommended cut-off point of 102 cm was highly specific and not very sensitive, whereas in women the cut-off point was slightly lower than that recommended by the literature (88 cm), thus again leading to underreported obesity estimates.

With regard to %BF estimated by Siri's equation, we verified a smaller correlation ($r = 0.67$–0.79) with the foot-to-foot BIA method in both sexes and according to sex/age, when compared with BMI and WC. This estimator also presented a smaller AUC. %BF estimated by means of skinfold thickness using the equation based on the two-compartment body model has been criticised by some authors regarding its agreement with other methods[41,42], as well as for methodological suitability in its generalised use of equations for body density prediction from Caucasian and Asian populations applied to other populations[12,42,43]. Some authors discuss about a possible systematic underreporting of obesity. These claims could corroborate our finding of underreporting of obesity, even using a cut-off point recommended by Gallagher *et al.*[10] for the African American population per sex and age. It is important to emphasise that our population group had ethnic characteristics and body distribution features that were distinct from those of so-called African American individuals. However, it is worth mentioning that there are no specific equations for body density prediction in Brazil, which justifies this study.

Moreover, the %BF Siri cut-off points that maximised the combination of sensitivity and specificity for females (37.0%) and males (21.9%) were higher for women and lower for men, with high sensitivity and low specificity, compared with those recommended in the literature[3].

Several issues related to methods to assess body composition, the standards used and the ethnic diversity of population groups studied could be discussed. Body composition assessment methods are indirect procedures that are not free from errors, but technical and operational feasibility should be a decisive factor when choosing methods in epidemiological studies. In the present study, the reference standard adopted was foot-to-foot BIA because it presents a good correlation with DEXA, the gold standard. Furthermore, it is considered the best reference method in nutritional epidemiology for use in population-based studies because of its high accuracy and low cost[4,44]. However, limitations to its use have to be acknowledged and concern some clinical conditions of subjects such as hydration status, exercise level, physiological or pathological status. All of them can lead to an over- or underestimation of fat mass[45,46]. This may be a particular problem in subjects with morbid obesity[46,47]. In our study we tried to minimise all of these factors by the strict study protocol during data collection and in the analysis. For the latter we excluded all patients with morbid obesity (0.99% of our sampled population) and the cut-points did not change by age and sex.

Ethnic diversity may also be a determining factor for body composition and, naturally, for the standard used for comparisons[12,31]. Asian, black and Hispanic populations apparently have a higher fat deposit in the trunk than in the limbs, and more subcutaneous fat in the upper part of the body, than Caucasian individuals[15,31,48]. That we observed no significant differences in the cut-off points of the diverse methods used when classifying the sample according to skin colour might be explained by the high percentage of non-whites in the population of Ouro Preto (72.6%). This fact is due to colonisation of the city during the gold extraction period, therefore hindering comparisons, but enabling an anthropometric study in a population known for its multi-race characteristic[17,49]. It should be mentioned that skin colour definition and race in Brazil should not be dissociated from social conditions and schooling, as appropriately reported in the literature[14,50].

It must be pointed out that developing reference standards to define obesity in the field of epidemiology is still a problem. It is recommended that the cut-off points should be specific for a given population, due to variations in body composition related to age, sex, level of physical activity and ethnic group[6,12,28,31,51]. Indeed, these factors may too have influenced our results, since the reference standard used to classify %BF BIA in the population of Ouro Preto was that proposed by Gallagher *et al.*[10].

In conclusion, the present results suggest that the discriminatory capacity of tests for obesity varies according to sex and age. BMI and WC had better discriminatory power for obesity among women, regardless of age, as well as among older adult males. The methods did not differ among young adult men. These findings corroborate the claim that it is necessary to use different reference standards for body fat for each sex and age[6,10,36]. Thus, more accurate studies aiming to define body fat prediction formulas for multi-race populations, like that of Ouro Preto, Brazil, are required.

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