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Original Research Article

Optimal cut-off values for obesity using classification tree in middle-aged adults living Rio de Janeiro city

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ABSTRACT

Background: The goal present study was to identify cut-off points for body mass index (BMI) and waist circumference (WC) to predict values of obesity based body fat percentage (BF%) using classification tree in middle-aged adults living Rio de Janeiro city, Brazil.
Methods: The data was collected in a prospective cohort composed of 886 adults (443 men and 443 women) ranging from 30 to 59 years along two years (2010 - 2011) in Rio de Janeiro City, Brazil. All subjects were submitted to anthropometric evaluation and the gold standard was the percentage of body fat estimated by bioelectrical impedance analysis. The optimal sensitivity was achieved by adjusting BMI and WC cut-off values to predict obesity based on WHO criteria: BF% >25% in men and >35% in women according to the tree classification.
Results: The best cut-off for BMI and WC were 28 kg/m^2 and 99 cm, respectively, with a prediction of 99.4% overall tree sensitivity in men. For women, the best cut-off for BMI and WC were 26 kg/m^2 and 90 cm, respectively, with a prediction of 90.1% overall tree sensitivity.
Conclusions: The BMI and WC that corresponds to a BF% previously defining obesity is similar to other Western population, but different of the recommended by WHO and NCEP to BMI and WC thresholds, respectively, for defining obesity for both genders.

Keywords: Body mass index, Classification tree, Obesity, Waist circumference

INTRODUCTION

Obesity is defined by the World Health Organization (WHO) as a disease characterized by excessive accumulation of body fat.[1] It is considered a public health problem, leading to serious social, psychological and physical problems. This disease is associated with increased risk of morbidity and mortality due to metabolic changes related to chronic diseases, such as dyslipidemia, including sleep apnoea, type II diabetes mellitus, certain types of cancer, osteoarthritis, pulmonary diseases and hypertension.[2-7] The prevalence of obesity have been increasing in several countries in the past years, including Brazil, where in the period from 2006 to 2012, the prevalence of obesity in the adult population of the 27 cities covered by the VIGITEL system increased from 11.6% to 17.4%, representing an average increase of 0.89% per year.[1,8]

While the WHO recommended BMI thresholds for defining obesity and overweight are well established, it is not clear, what does an appropriate cut-off point of body fat percentage (BF%) for classifying an individual as obese. Many investigators have previously asserted that obesity is defined as a BF% greater than 25% for men and 35% for women, because the thresholds are believed to correspond to a BMI of 30 kg/m^2 in young Caucasians and, its excess of visceral adiposity is associated with incident cardiovascular disease.[9,10]

In clinical practice and in population studies the BMI is often used for quantitative diagnosis of obesity due to its simplicity and high correlation to body fatness[9] and to body mass.[10] However, an obvious limitation of this measure concerns to its inability to distinguish between fat and fat-free mass.[11] Despite this limitation, the relation between increased BMI to morbidity and mortality, constitutes sufficient reason to use this index as a nutritional indicator in epidemiological studies, particularly if associated with other more specific measures of body fat.[12-14] Nevertheless, previous studies have shown that a single BMI value represents different values for fat percentage due to the influences of ethnic and environmental characteristics of the population.[15]

The waist circumference (WC) is the most practical and cost effective measures for evaluation of obesity, high correlation with the amount of visceral fat and effectively predict cardiovascular risk.[16,17] The National Cholesterol Education Program Adult Treatment Panel III (NCEP, ATP III) defined the WC as cut-off points for men, >102 cm and for women, >88 cm.[18]

Given the seriousness of the obesity problem, the use of a reliable tool with optimal cut-off points based on BMI and WC for obesity diagnosis is very important to establish consequent public health policies, treatment protocols and to determine the correct prevalence action to minimize the risk of morbidity in obese individuals. Thus, the purpose of the present study was to identify optimal cut-off points for BMI and WC to predict values of obesity based BF% using classification tree in middle-aged adults living Rio de Janeiro city, Brazil.

METHODS

The data was collected in a prospective cohort study composed by 886 adults (443 men and 443 women) ranging from 30 to 58 years along two years (2010 - 2011) in Rio de Janeiro City, Brazil.

Volunteers were instructed to avoid strenuous activity for the 24 hours prior to each testing session, and to avoid alcohol, caffeine, smoking and the consumption of large meals for, at least, three hours prior to testing. Participants who had a history of recent acute and chronic illness, previous osteomyoarticular injuries, the use of prosthesis or cardiac pacemaker, the use any ergogenic, women during their period or pregnancy were not included.

The Ethics Committee of Institution of the Estácio de Sá University approved the study protocol (nº 0045.0.308.000-10), and informed written consent was obtained from all participants. The study was conducted according to the instructions of the Helsinki Declaration of 2008.

Anthropometric measurements

Data collection the anthropometric variables were performed by a same and experienced evaluator. For measuring both body weight and height volunteers kept barefoot, wearing light clothes and not carrying any object. The height was measured in centimeters and the body mass was measured in kilogram with certified and calibrated mechanics scale (Filizola, Brazil). BMI was calculated as the quotient of weight over squared height (kg/m^2). The WC was evaluated at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest[19] using a tape measure (Sany, Brazil). All anthropometric measurements were repeated three times (the mean value was used in the data analysis).

Body composition measures

The measure of % BF was estimated from bioelectrical impedance analysis using the BIA machine - 101A (RJL Systems, USA), standardized according to Khaled et al.,[20]. In order to reduce the influence of intervening factors to measures of body resistance and reactance, the volunteers followed the recommendations of the NIH.[21] We applied the electrodes (Ag / AgCl) on hand and right leg (electrodes injection) and at the wrist and right ankle (electrodes catchment) with a single frequency of 50 kHz, and generating an alternating current between 300-800 mA. The obesity cut-off thresholds were defined as WHO criteria: 35% and 25% for women and men, respectively.[9]

Classification tree

The classification tree is a type of supervised learning technique for recursively partitioning a feature space into several nodes, based on the relationship to discover which variable or combination of variables better predicts a given outcome and to identify the cut-off values for each variable that maximally predicts the chosen outcome.[23] Summarizing, the classification tree iteratively split variables into groups; split the data where it is maximally predictive and maximize the amount of homogeneity in each group.[23]

Statistics

The descriptive statistics were expressed as mean ± standard deviation and a power sample analysis determined the sample size. The Lilliefors test confirmed the normality of sampling distribution. The decision tree learning or CART (classification and regression 24) was used to identify cut-off points for BMI and WC to predict values of obesity in men and women. All data were processed in the SPSS 18.0 (Chicago, USA).

RESULTS

Anthropometric and physical characteristic of the subjects were very similar, as well as, the low values of standard deviation confirmed the homogeneity of the sample (Table 1).

Table 1: Descriptive characteristics of subjects.*

Variables	Men	Women
Age, (year)	32.8±13.1	35.7±14.4
Height, (cm)	175.0±7.2	162.7±6.8
Weight, (kg)	78.8±15.1	63.7±11.1
BMI, (kg/m^2)	26.2±4.7	23.5±3.7
BF% (%)	18.9±6.7	28.1±8.1
Waist circumference, (cm)	86.4±11.9	76.4±9.8

* Values are mean ± SD.

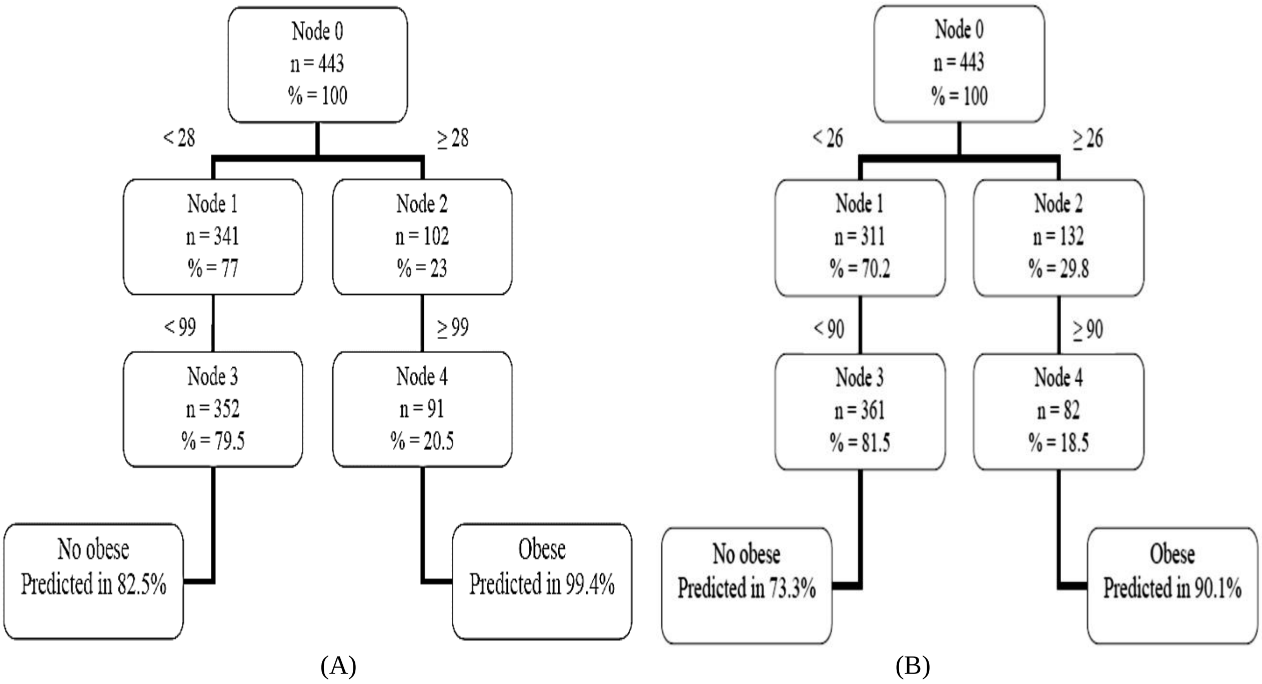

Figure 1: The tree that best predicts values of obesity in the training sample in men (A) and women (B).

The tree that best predicts values of obesity for BMI and WC in the training sample in men and women are illustrated in Figure 1. The cut-off values in men when BMI is greater than 28 kg/m^2 and WC is greater than 99 cm, the subject is classified as being obese in a prediction of 99.4% overall tree sensibility (Figure 1A). Additionally, the cut-off values in women (Figure 1B) when BMI is greater than 26 kg/m^2 and WC is greater than 90 cm, the subject is classified as being obese in a prediction of 90.1% overall tree sensibility.

DISCUSSION

The increasing prevalence of obesity worldwide is a serious health hazard with increased risk of morbidity and mortality due to metabolic changes related to chronic diseases, additionally, a high association between increased BMI and WC to the prevalence of obesity, being a nutritional indicator in epidemiological studies. [2-7,12,13,16,17] In Brazil, we don't know what is the best cut-off value to predict excess body fat and, consequently, to predict the morbidity related to this excess. Therefore, the purpose of the present study to identify cut-off points for BMI and WC to predict values of obesity based BF% in men and women using classification tree.

An important issue in this debate concerns the use of BMI to define overweight and obesity across populations. There are a number of recent studies showing that the relationship between BMI and % BF differs among ethnic groups, such as, studies with the Chinese, Indian, North American, Japanese, Thai, British, Indonesian, Polish, Spanish, Tongan, Australian, Nigerian and Jamaican populations are demonstrated that even a BMI value represents different values for fat percentage due to the influences of ethnic and environmental characteristics of the population.[15,25-33] In addition, the combination of these cut-offs values associated with disease may vary between populations.[34]

The BMI is a measure of body weight based on a person's weight and height.[1] Though it does not actually measure the percentage of body fat, it is used to estimate a healthy body weight on a person, assuming an average body composition.[11] The suggested cut-off point for obesity (BMI ≥30 kg/m^2) is based on observational studies in Europe and USA on the relationship between morbidity and mortality with BMI.[1]

Regarding the Asian population, there is disagreement, much debate has surrounded the appropriateness of these cut-off points in Asian population, the International Obesity Task Force have proposed lower cut-off point for obesity (BMI ≥25 kg/m^2) in Asian and Pacific Island populations to promote healthy lifestyles and weight control.[35,36] The body composition profile in Asian population differs from that in Caucasian populations, but these have been already associated with cardiovascular risk factors below the cut-off point of 25 kg/m^2 that defines overweight in the current WHO classification.[37-44]

Few studies have investigated the use of cut-off points in Western population, such as, in Spanish population the optimal BMI cut-off for predicting BF% were above 26 kg/m^2 in men and 24 kg/m^2 in women were associated with to 25% and 35% of BF%, respectively.[31,45,46] Already, in Mexican population showed the BMI cut-off to predict hypertension varied from 25.2 to 26.6 kg/m^2 in both men and women.[45] In accordance, our study has resulted in similar cut-off values, where showed 28 kg/m^2 in men and 26 kg/m^2 in women that corresponded to 25% and 35% of BF%, respectively. In disagreement other studies, in Guatemalan population the optimal cut-off points for BMI were slightly higher among women (27.6 kg/m^2) than men (25.9 kg/m^2) with no meaningful differences by stature.[46]

The abdominal obesity is highly correlated to insulin resistance and was also associated with an increased risk of myocardial infarction, stroke and premature death, whereas these diseases were not associated with measures of generalized obesity such as BMI.[47]

In the 2001 NCEP ATP III guidelines, abdominal obesity was defined as a WC ≥102 cm in males and ≥88 cm in females.[18] Although, these cut-offs corresponded to BMI values of 30 kg/m² based on studies performed in populations of European origin.[48] Likewise, the WC cut-offs for abdominal obesity are not uniformly applicable to all populations and ethnic groups, because variations in disease risk may occur with the same WC in different ethnic groups, as in Asian population, Ethnic Central, South American Middle East, Mediterranean and Sub-Saharan African populations and European population.[49-51]

From the usual methods employed to study the relationship between anthropometric variables and obesity, in order to provide quality, the cut-off points were assessed by applying the receiver-operating characteristic curve (ROC curve).[52] This statistical method is highly recommended in epidemiological studies, but it can describe the accuracy a variable alone to classify people into relevant clinical groups.[31,37-46,52] Therefore, we used the classification tree to discover the combination of variables (BMI and WC), and better predict a given outcome (obesity) and to identify the cut-off values for each variable that maximally predicts the chosen outcome.[23]

Future researches should permeate the limitations of present study employing a larger sample and concerning associations between the amount and distribution of body fat and cardiovascular risk factors in different ethnic groups.

In conclusion, the optimal BMI and WC cut-off values corresponding to obesity as defined by BF% in our population in men of 28 kg/m^2 and 99 cm and in women of 26 kg/m^2 and 90 cm are similar to other Western populations, but different of the recommended by WHO and NCEP to BMI and WC thresholds for defining obesity both genders. Furthermore, it is recommended specific cut-off values BMI and WC that corresponds to a BF% in this population.

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