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Receiver Operating Characteristic Curve Analysis of BMI in Assessing Obesity among Adult Bengalee Males in India

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A B S T R A C T

The present study attempted to understand the appropriateness of different body mass index (BMI) cut-off points in assessing obesity. Four hundred thirty adult Bengalee males with mean age 36.48±12.23 years (mean ± SD) from West Bengal, India were studied. Height, weight and percent body fat were measured and BMI was derived following standard equation. Receiver operating characteristic (ROC) curve analysis demonstrated low sensitivity and high specificity of international (≥30 kg/m²) and proposed (≥25 kg/m²) BMI cut-off points in identifying individuals with obesity. Furthermore, these international and proposed BMI cut-off points also found to be in substantial misclassification to assess obesity as much as 32.09% and 17.44% respectively. However, based on ROC curve analysis, a BMI cut-off point of ≥24 kg/m² revealed optimal sensitivity (83.66%) and specificity (90.61%) and as well as less misclassification (11.86%) in assessing obesity among the adult Bengalee males. The present study accentuated that the international and proposed BMI cut-off points so far might not be appropriate in assessing obesity and on the other hand, lower BMI cut-off point (≥24 kg/m²) has relatively high sensitivity and specificity in assessing obesity as well. Therefore, the present study envisages the requirement of further lowering down of BMI cut-off point in assessing excess body fat in adult Bengalee males.

Key words: *Bengalee, body mass index, India, obesity*

Introduction

Obesity has reached epidemic proportions globally[1,2]. The importance of obesity as a risk factor for a number of diseases including insulin resistance, glucose intolerance, hyperlipidaemia, sleep apnea, arthritis, type 2 diabetes, cardiovascular disease, hypertension, gallstones and certain types of cancer is well documented[1,3–5]. This has resulted in an epidemic that has occurred concurrently with modernization of lifestyle[4,6]. Body mass index (BMI), as a simple, non-invasive, universally applicable method[7–9] for assessing excess body fat, used frequently to identify individuals above a certain cut-off points, denotes increased metabolic risk. In a number of studies, due to the lack of appropriate cut-off point[10–12], BMI more than equal twenty-five or thirty[7] were used to categorize Asian Indians as overweight or obese, though it is based on adult Europeans. Many studies have reported that ethnicity, age, and sex significantly influence the relationship between body fat and BMI[13–15]. Therefore, the use of this conventional BMI cut-off point might not be applicable to measure excess body fat among the adult Bengalee males. Studies also revealed that body fat and BMI may be more closely related within specific populations[15] and hence a population specific definition of obesity is urgently needed in India, characterized by vast ethnic diversity. However, it is noteworthy to mention that prevention of obesity and related non-communicable diseases might not be practicable unless obesity is measured properly. In 2000, World Health Organization[1] has proposed new ranges of measuring obesity for Asians based on risk factors and morbidities. However, the usefulness of these proposed cut-off points to a specific ethnic group depends on its predictive strength of excess body fat, this can be done by receiver operating characteristic (ROC) curve analysis by measuring its sensitivity and specificity. This is an important issue for Asian Indians, as increased health risks associated with lower BMI[9].

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In view of the above consideration, the present study attempted to understand the appropriateness of different BMI cut-off points in assessing obesity among the adult Bengalee males of West Bengal, India.

Materials and Methods

Sample

The present cross-sectional study was conducted at Kolkata, West Bengal, India. At first individuals were informed by letters, banners and oral communication through local clubs and co-operatives, mentioning any adult Bengalee males can participate in the present research program. Finally, excluding Individuals under medication, four hundred thirty adult urban Bengalee males were measured for the present study.

Anthropometric measurements

Body weight (WT) (to the nearest 0.5 kg), height (HT) (to nearest 0.1cm) were measured following standard techniques[16]. BMI (in kg/m^2) was calculated following standard equation. Percent body fat (PBF) and fat mass (FM) was measured using validated[17] bioelectrical impedance analysis (OMRON HBF-302).

Statistical analysis

Descriptive statistics for anthropometric variables were computed by mean and standard deviation. ROC curve analysis was undertaken to study the performance of BMI cut-off points as well as to understand the appropriate cut-off point of BMI in assessing obesity, while taking percentage body fat as standard. Obesity was defined as total body fat greater than twenty-five percent[8,18]. Agreements between observations were measured by kappa statistic. All statistical analysis was performed using the statistical package for social sciences (SPSS, Version 9) software.

Results

The mean and median age was 36.48 years (SD=12.23 years) and 34 years respectively, with a range of 18–72 years. The anthropometric and body fat profiles of the studied population were shown in Table 1. The results of the present study revealed that, when percent body fat (>25%) was used as a measure of obesity, 153 (35.58%)

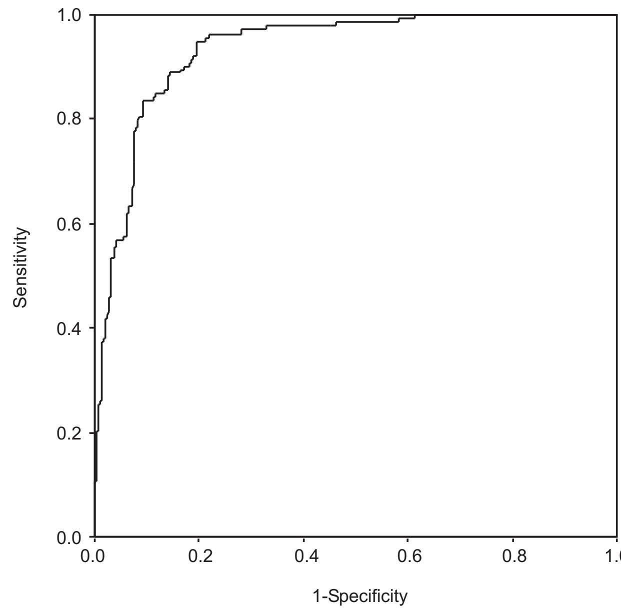

Fig. 1. Receiver operating characteristic curve to determine the appropriate cut-off point of the body mass index (kg/m^2) in assessing obesity.

males were obese. However, the results differ when international[7] (≥30 kg/m^2) and proposed[1] (≥25 kg/m^2) cut-off point of BMI were applied for the assessment of obesity, eighteen (4.2%) and one hundred fifteen (26.7%) males were found to be obese respectively. ROC curve (Figure 1) analysis was undertaken to determine the best cut-off point of BMI in assessing obesity, while taking percent body fat as standard. It would be apparent from the Table 2 that, when the cutoff points of BMI ≥30 kg/m^2 and ≥25 kg/m^2 were used to define obesity, the sen-

TABLE 1
THE ANTHROPOMETRIC AND BODY FAT PROFILES OF THE STUDY POPULATION

Variables	Mean	SD
Height (cm)	165.14	6.47
Weight (kg)	62.29	12.59
Body mass index (kg/m^2)	22.76	4.01
Percent of body fat	22.00	6.67
Fat mass (kg)	14.32	6.62

TABLE 2
PERFORMANCE COMPARISONS OF BMI CUT-OFF POINTS TO EVALUATE OBESITY IN THE PRESENT STUDY

Cut-off points	Sensitivity (95% CI)	Specificity (95% CI)	PPV	NPV	Overall misclassification
BMI ≥30kg/m^2[a]	10.46% (7.57,13.35)	99.64% (99.07,100)	94.20%	66.60%	32.09%
BMI ≥25kg/m^2[b]	62.75% (58.18,67.32)	93.50% (91.17,95.83)	84.36%	81.79%	17.44%
BMI ≥24kg/m^2[c]	83.66% (80.17,87.16)	90.61% (87.85,93.37)	83.11%	90.94%	11.86%

BMI – body mass index, PPV – positive predictive value, NPV – negative predictive value, CI – confidence interval, [a]WHO international cut-off point, [b]WHO cut-off point proposed in 2000, [c]present study sitivity was 10.46% and 62.75% respectively and specificity was 99.64% and 93.50% respectively. On the other hand if the BMI cut-off point of ≥24 kg/m² was used to define obesity instead of BMI ≥30 kg/m² and ≥25 kg/m², the sensitivity increased by 73.2% and 20.91% respectively, and specificity decreased only 9.03% and 2.89% respectively. Moreover, a BMI cut-off point of ≥24 kg/m² markedly improved the negative predictive value with comparatively marginal decrease in positive predictive value. Furthermore, lowering the BMI cut-off points from ≥30 kg/m² or ≥25 kg/m² to ≥24 kg/m² decreased overall miss classification 20.23% and 5.58% respectively with positive predictive value 83.11% and negative predictive value 90.94 %. Finally, the kappa statistic (for ≥30 kg/m² and ≥24 kg/m², kappa statistic is 0.144, $p<0.01$, for ≥25 kg/m² and ≥24 kg/m², kappa statistic is 0.786, $p<0.01$) indicate agreements between BMI cut-off points in assessing excess body fat.

Discussion

Obesity is a term applied to excess body weight with an abnormally high proportion of body fat[19]. Obesity is associated with a wide range of non-communicable chronic diseases and become a major public health problem, with increasing global prevalence[20,21]. BMI is the most commonly used anthropometric tools for assessing obesity because of its simplicity and low cost[15,22,23]. However, effectiveness of BMI to assess obesity depends on appropriate ethnic specific cut-off points. Consequently, there is evidence to suggest that in certain sub-groups of a population, BMI may be more predictive of body fatness than in other subgroups[15]. Studies[8,9] reported that the mean BMI of the healthy Asian Indian adults has been much lower than 25 kg/m², which is corroborative with the present study (mean BMI 22.76 kg/m²). In 2000 World Health Organization[1] have proposed a new cut-off point (≥25 kg/m²) of obesity for Asian Indians acknowledging the need of population specific standards and taking cognizance of the fact that co-morbidities occur at a lower BMI in Asian Indians. As far as India is concerned, few studies have been undertaken among type 2 diabetic and dyslipidaemic individuals utilizing sensitivity and specificity of BMI in assessing obesity[24,25]. Only one study[8] in the general population of northern India has been done to established appropriate cut-off point of BMI, but the study was to define overweight. To best of our knowledge, the present study is the maiden attempt among the adult Bengalee males to establish appropriate cut-off point of BMI for defining obesity. The ROC curve (Figure 1) analysis (Table 2) in the present study demonstrated low sensitivity (10.46%) and high specificity (99.64%) of the international BMI cut-off point (≥30 kg/m²) in assessing obesity[7]. However, when recently[1] proposed BMI cut-off (≥25 kg/m²) point was used, the sensitivity (62.75%) increased substantially and specificity (93.50%) decrease marginally, indicating superior performance of proposed[1] BMI cut-off point in assessing excess body fat with a 14.65% decreased in overall misclassification than using international BMI cut-off point[7]. However, the cardinal feature of the present study was the relatively high sensitivity (83.66%) and specificity (90.61%) of the BMI cut off point ≥24 kg/m² in detecting obesity. In reality, it is difficult to achieve high sensitivity and specificity simultaneously and thus relative importance of sensitivity and specificity might be taken into consideration[26]. It was apparent from the present study that, when the cut-off point of BMI was reduced and taken as ≥24 kg/m², the sensitivity and negative predictive value improved considerably. Similarly, a recent study[25] on North Indian dyslipidaemic individuals also reported that a BMI cut-off point of 24 kg/m² displayed optimal sensitivity and specificity in assessing obesity. In the present observation, only 11.86% of individuals were misclassified when ≥24 kg/m² of BMI was used as a cut-off point. Moreover, among the adult Bengalee males, there was a considerable decrease in overall misclassification with the use of ≥24 kg/m² of BMI instead of ≥30 kg/m² and ≥25 kg/m² of BMI[1,7] (11.86% vs. 32.09% and 17.44% respectively). In addition to that, kappa statistic demonstrated that, using BMI cut-off point ≥30 kg/m², only 14.4% adult Bengalee males could be diagnosed with excess body fat, while this would be 78.6% using BMI cut-off point ≥25 kg/m², instead of utilizing BMI cut-off point ≥24 kg/m². Thus, the present study revealed that the international[7] and proposed[1] BMI cutoff point might not be appropriate to assay obesity among the adult Bengalee males.

The findings of the present study indicate that a lower BMI cut-off point (≥24 kg/m²) has relatively high sensitivity and specificity in assessing obesity and therefore envisage the need of further lowering down of BMI cut-off point in assessing excess body fat in adult Bengalee males. However, owing to vast ethnic diversity in Indian population, it is important to study other ethnic groups to observe the trend found in the present study. Results obtained from such studies could be utilized to define obesity in Indians.

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ANALIZA OPERATIVNE KRIVULJE (RECEIVER OPERATING CHARACTERISTIC CURVE – ROC) INDEKSA TJELESNE MASE U ODREĐIVANJU PRETILOSTI KOD ODRASLIH BENGALACA, INDIJA

SAŽETAK

Ova studija pokušava razjasniti kako najprikladnije odrediti točku pretilosti pri različitim indeksima tjelesne mase. Uzorak je sadržavao 430 odraslih muškaraca sa prosjekom godina od 36,48±12,23. Mjereni su visina, težina, indeks tjelesne mase te postotak tjelesnih masnoća. Analiza operativne krivulje (ROC) pokazivala je malu osjetljivost i specifičnost BMI točaka od internacionalnih (≥30 kg/m^2) i predloženih (≥25 kg/m^2) u identificiranju pretilih osoba. Nadalje ove internacionalne i predložene točke određivale su pretilost u 32,09% odnosno 17,44%. Bazirano na ROC krivulji, identifikacija pretilosti prema BMI točkama od ≥24 kg/m^2 pokazuju optimalnu osjetljivost (83,66%) i specifičnost (90,61%) kao i diskvalifikaciju (11,86%). Ova studija pokazuje kako internacionalne i predložene točke ne bi trebale biti glavni pokazatelj u određivanju pretilosti. Ova studija također preporučuje da se točke indeksa tjelesne mase snize u određivanju pretilosti.