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Diagnostic Accuracy of Body Mass Index (BMI) When Diagnosing Obesity in a Saudi Adult Population in a Primary Care Setting, Cross Sectional, Retrospective Study

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Muath Alammar[1]
Suad Alsoghayer[2]
Kossay El-Abd[2]
Abdullah Alkhenizan[2]

[1]Department of Family Medicine, Shaqra University, Shaqra, Saudi Arabia; [2]Department of Family Medicine & Polyclinics, King Faisal Specialist Hospital and Research Centre, Riyadh, Saudi Arabia

Background: Obesity is a risk factor that leads to many chronic diseases and, unfortunately, its prevalence in Saudi Arabia is on the rise. To successfully manage obesity and its complications, patient must be accurately diagnosed. This study aims to investigate the diagnostic accuracy of body mass index (BMI) when diagnosing obesity within the Saudi population using body fat percentage (BF%) as the gold standard.
Materials and Methods: This is a cross-sectional study that includes a calculated sample size of 942 subjects. Subjects were recruited from family medicine clinics that were linked to King Faisal Specialist Hospital and Research Centre (KFSH&RC) in Riyadh, Saudi Arabia from January 2005 to March 2016. BF% was estimated using DEXA scan. The diagnostic accuracy of BMI was assessed by using the WHO and the American Association of Clinical Endocrinologists and American College of Endocrinology (AACE/ACE) reference standard for obesity of BF% >25% in men and >35% for women.
Results: Findings indicate, out of the study population, 29% of men and 53% of women are obese using BMI-defined obesity cut-off point 30 kg/m^2. The prevalence of obesity was 83.9% and 97.3% in men and women, respectively, using BF%-defined obesity, which corresponds to BMI cut-off of 24 kg/m^2. Even when considering the highest acceptable BF% based on the mean age of our participants (33% for men and 43% for women), the BMI cut-off to diagnose obesity should not exceed 27 kg/m^2 among men and women in Saudi Arabia.
Conclusion: The accuracy of BMI 30 kg/m^2 to diagnose obesity among the Saudi population is limited. We have to lower the BMI cut-off point to improve its sensitivity as a screening tool for obesity. Our study suggests that the BMI cut-off point among Saudis and possibly the Arab population should not exceed 27 kg/m^2 for both sexes.
Keywords: obesity, BMI, DEXA, body fat, diagnostic accuracy, Saudi population

Introduction

Obesity is a universal health problem, and its prevalence is rising in many parts of the world.[1] This worldwide epidemic has been linked to increased risk of many chronic and serious diseases such as diabetes, hypertension, coronary artery disease, stroke, cancer, and premature death.[1,2] Yet, obesity is one of the most preventable causes of death.[3] Therefore, accurate obesity diagnosis is essential in identifying obese patients, managing their condition and preventing its potential complications.

Correspondence: Abdullah Alkhenizan
Department of Family Medicine & Polyclinics, King Faisal Specialist Hospital and Research Center, MBC 62, PO Box 3354, Riyadh 11211, Saudi Arabia
Tel +966 11-4647272 Ext. 31860
Fax +966 11- 4423055
Email akhenizan@kfshrc.edu.sa

Body mass index (BMI), defined as body weight in kilograms divided by the square of height in meters (kg/m^2), is the most widely-used method to diagnose obesity. There are different methods that can be used to determine the amount of body fat, such as dual-energy X-ray absorptiometry (DEXA) scan, deuterium dilution, underwater weighing, and skinfold thickness measurements.[4] The percentage of total body fat is more important as a risk factor of chronic diseases than the body weight.[5] Among different ethnic groups and populations, BMI does not take into consideration the amount of body fat and its distribution inside the body, neither it does differentiate between subcutaneous and visceral fat.[1]

The World Health Organization (WHO) and the National Institute of Health (NIH) recommend BMI cut-off point for diagnosing obesity to be ≥30 kg/m^2, which corresponds to a total body fat of 25% for men and 35% for women.[4,6,7] The current BMI standards for obesity diagnosis have been derived from studies conducted in the Caucasian population.[1,4] However, after an in-depth studies focused on the Asian population were presented to the WHO, cut offs were adjusted for this specific population due to a higher BF % when compared to the Caucasian population.[8] The Arab population could potentially have a different cut off for BMI.

The prevalence of obesity in Saudi Arabia is high (35.6%).[9] Still, there are no published studies to evaluate the diagnostic accuracy of BMI using validated measurements of body fat, such as DEXA scans, among the Arabs or the Saudi populations.[8,10]

A large meta-analysis including 32 studies and 11,924 evaluated the BMI cut-off point for obesity diagnosis among various ethnic groups showed that the relationship between BF% and BMI cut off is different among the different ethnic groups.[5] This result emphasizes the need to correlate BMI cut-off for diagnosing obesity with BF% for Arabs in general and the Saudi population in particular.[5]

The goal of this study is to assess the diagnostic accuracy of BMI using BF% obtained from DEXA scan reports as a gold standard to diagnose obesity among the Saudi adult population.

Materials and Methods

This was a retrospective cross-sectional study that included a calculated sample size of 889 subjects. Using obesity prevalence in Saudi Arabia – age adjusted – 35.5%.[9] Obesity is observed to be substantially higher among females with a prevalence of 44% [95% CI 43.0–45.0], compared to males with obesity prevalence of 26.4% and this difference was statically significant (p<0.0001). Using the proportion of 26.4% and with 95% confidence to control the error of estimation to within 5% error margin, the calculated sample size we need is 298 males. Also, by using the proportion of 44% and with 95% confidence to control the error of estimation to within 5% error margin, the calculated sample size we need is 591 females. Despite that, we included all patients – 941 subjects – who did DEXA scan as screening. The study population was recruited from family medicine clinics linked to KFSH&RC, located in Riyadh, the capital of Saudi Arabia. These family medicine clinics provide primary care services for a catchment population of 50,000 patients. Electronic health records of all Saudi patients aged 18 and above who was referred from family medicine services for a screening DEXA scan completed between January 2005 and March 2016 were thoroughly reviewed. We excluded patients who were referred by all other services other than family medicine.

The measurement of BF% was collected using DEXA (Lunar Prodigy; GE Medical Systems). DEXA scans result in information about a patient's bone mineral density, lean body mass, and fat mass. BMI value was also obtained from DEXA report.

The BF% obtained from DEXA scan was used as a gold standard to assess the accuracy of BMI as a screening tool to diagnose obesity. The diagnosis of obesity based on measured BF% was defined as BF% >25% and >35% for men and women, respectively.[6] Patients were classified according to the standard BMI cut-off 30 kg/m^2 to obese and non-obese subject. The highest age-adjusted BF% for the study population was estimated using the standardized formula; BF% = 1.2 * BMI + 0.23 * Age – 10.8 * Sex – 5.4 (men = 1, women = 0).[11]

This research project was conducted in accordance with the guiding principles for experimental procedures written in the Declaration of Helsinki of the World Medical Association and was approved by the Research Ethics Council at King Faisal Specialist Hospital and Research Centre. It complied with the policies of the Research Advisory Committee (RAC) at KFSH&RC and the laws of the Kingdom of Saudi Arabia (RAC# 2161–093). The Research Ethics Committee (REC) approved a waiver of consent as this study was a retrospective data collection that did not present more than minimal risk of harm to the subjects and the waiver did not adversely affect the rights and welfare of the subjects.

Statistical Analysis

Descriptive statistics for continuous variables were reported as mean ± standard deviation and categorical variables were summarized as frequencies and percentages. The definition of obesity as the percentage of body fat (BF%) >25% in men and >35% in women was used as recommended by the WHO to determine the diagnostic accuracy of BMI to detect obesity as opposed to the standardized cut-off point to define obesity as a BMI ≥ 30 kg/m^2. Sensitivity, specificity, positive and negative predictive values were calculated to assess the diagnostic accuracy of different BMI cut-off points with their respective 95% confidence intervals (CIs). Receiver operating characteristic (ROC) curves were plotted to calculate the best BMI cut off using the BF% definition of obesity. Spearman correlation coefficient (r) was obtained to evaluate the relationship between BMI and BF%. Data were statistically analyzed using version 9.4 of SAS (SAS Institution Inc., Cary, NC, USA).

Results

We recruited 941 subjects including 348 (37%) men and 593 (63%) women. The mean age among men was 56 (18–94 years) and 55 (24–93 years) among women. All of our participants were from Arab ethnic group. Mean BMI was 27.1 kg/m^2 (± 5.3 SE) for men, and 30.8 kg/m^2 (± 5.6 SE) for women. The mean BF% was 32.6% and 46.7% for men and women, respectively (Table 1).

The prevalence of obesity using BMI (≥30 kg/m2) as the cut-off point was 29% among men and 53% among women. The prevalence of obesity was much higher using BF% reaching 83.9% and 97.3% among men and women, respectively. When we adjusted BMI cut-off based on the highest acceptable BF%, which corresponds to 33% in men and 43% in women based on the mean age of the study population, using the standardized formula, obesity prevalence was 52% and 72.7% in men and women, respectively (Table 2).

Diagnostic Performance of BMI

The sensitivity and specificity of BMI cut-off ≥30 kg/m^2 to diagnose obesity was calculated using the BF% as the gold standard. In men, sensitivity was poor (34%, 95% CI, 29–40) while specificity was good (98%, 95% CI, 90–99). Similar results were found in women with poor sensitivity (55%, 95% CI, 51–59) and good specificity (93%, 95% CI, 69–99).

The regression line between BMI and BF% showed a significant positive correlation in both men (R^2=0.614) and women (R^2=0.495) (Figure 1). We used the receiver operating characteristic (ROC) curves to estimate the best BMI cut-off point correlating with standard BF% (25% in men and 35% in women) and the highest acceptable BF% (33% in men and 43% in women) (Figure 2) and (Figure 3) of the study population. The best BMI cut-off point to diagnose obesity using the BF% as the gold standard was 24 kg/m^2 with area under the curve of 0.92 in men and 0.90 in women. This cut-off point (BMI ≥24 kg/m^2) had better sensitivity and good specificity to diagnose obesity defined by BF%. In men, sensitivity was (85%, 95% CI, 80–88) and specificity was (85%, 95% CI, 73–93). The same changes were also seen in women with better sensitivity (91%, 95% CI, 88–93) and specificity (81%, 95% CI, 54–96). However, using the highest acceptable BF% based on the study population, the best BMI cut-off was 27 kg/m^2 with area under the curve of 0.88 in men and 0.89 in women.

Table 1 Characteristics of the Study Population

	Men N=348	Women N= 593
Age (Mean)	56.6	55
BMI (Mean)	27.1	30.8
BF% (Mean)	32.6%	46.7%
Chronic diseases	67%	76.6%
Diabetes	36.2%	36.9%
Hypertension	42.2%	40.8%
Hyperlipidemia	44.5%	49.2%

Table 2 The Prevalence of Obesity Using BMI, BF% and Adj-BMI

	Men N=348	Women N= 593
Obesity		
By BMI		
Obese (BMI ≥30)	29.2% (102)	53% (314)
Not obese (BMI <30)	70.8% (247)	47% (279)
By BF%		
Obese (BF% ≥25 Men, ≥35 Women)	83.9% (292)	97.3% (577)
Not obese (BF% <25 Men, <35 Women)	16.1% (56)	2.7% (16)
By Adj-BMI		
Obese (BMI ≥27)	52% (181)	72.7% (431)
Not obese (BMI <27)	48% (167)	27.3% (162)

Discussion

Obesity is known as one of the burdening diseases on health care system as it's affecting the mortality and morbidity rate of patients.[1,2] Many leading causes that increase its prevalence, such as genetic, environmental, socioeconomic status,

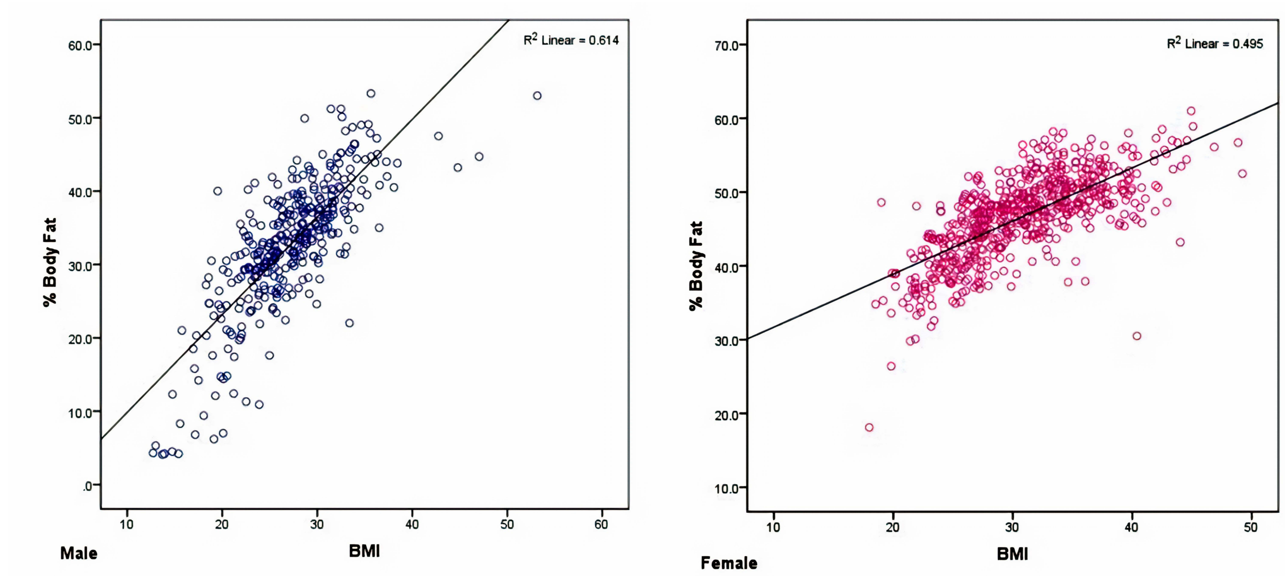

Figure 1 Correlation between BMI and BF% in men and women.

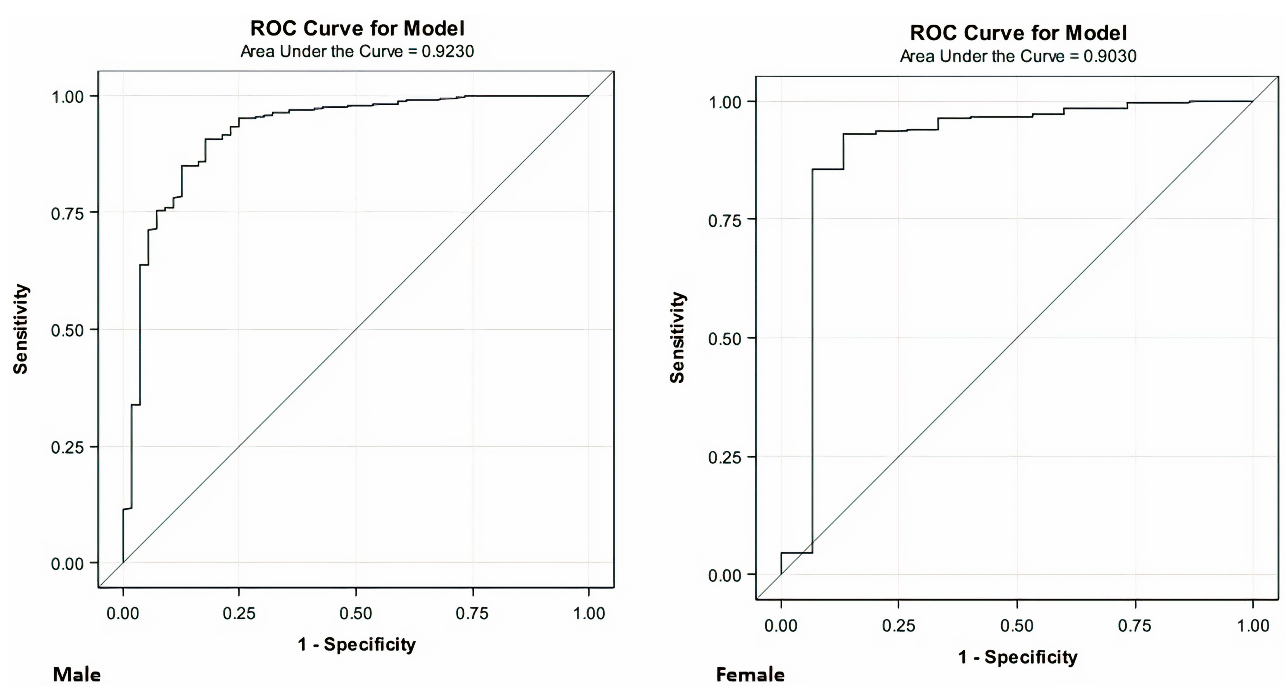

Figure 2 Receiver operating characteristic curves (ROC) for BMI to detect BF%-defined obesity (25% in men and 35% in women).

behavioral, cultural, and decrease physical activity.[1] Now a days, Saudi Arabia become one of the highest prevalent countries in obesity.[9] That's mean Saudi population has a great risk of morbidity and mortality from illnesses related to obesity which need a more accurate tool for a diagnosis. The percentage of body fat is the most accurate prognostic factor of chronic diseases than BMI or body weight.[5]

Our study highlights the limitation of using the current BMI cut-off (≥30 kg/m2) in diagnosing obesity among the Saudi and possibly Arab population. It also shows that the cutoff point of BMI ≥ 30 kg/m^2 has poor sensitivity as a screening tool for diagnosing obesity among Arabian ethnic group. If we use BMI with its current cut-off values, we can potentially miss more than half of BF%-defined

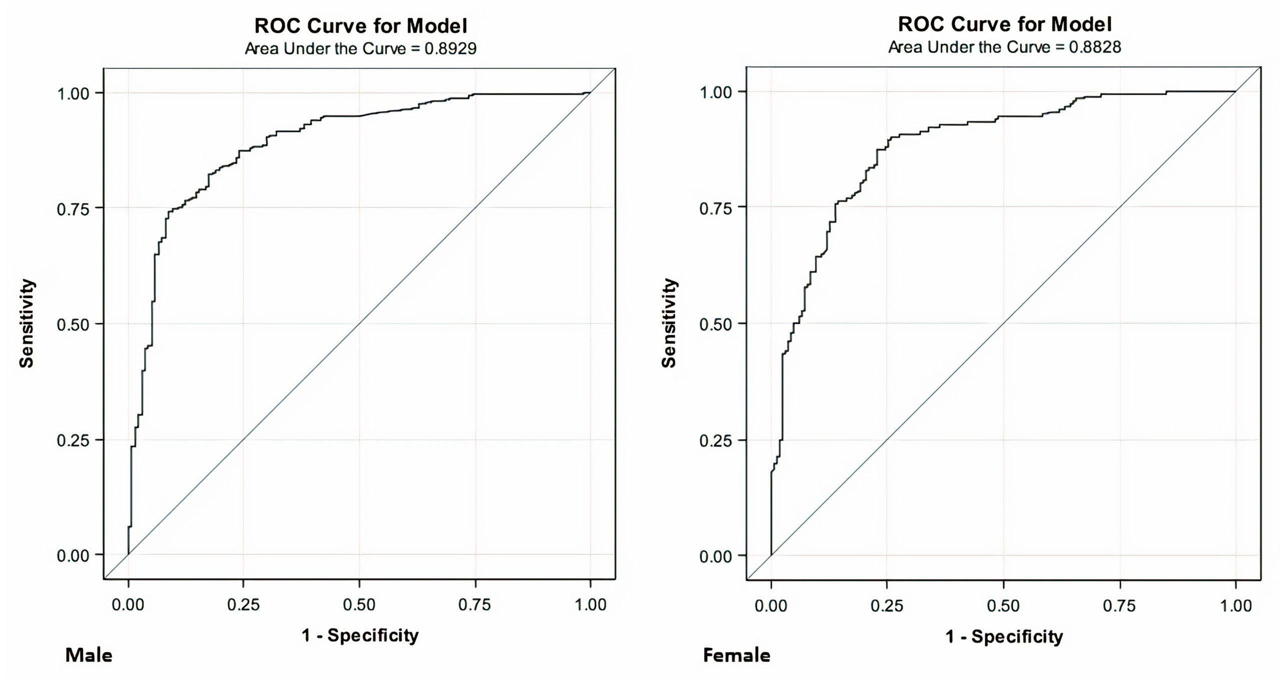

Figure 3 Receiver operating characteristic curves (ROC) for BMI to detect BF%-defined obesity (33% in men and 43% in women).

obese individuals in Saudi Arabia. Our findings are consistent with the findings of other studies which showed that the cutoff point of BMI differs among different ethnic groups.[12–16] For example, a population based study in a Vietnamese community showed study participants to have higher BF% than Dutch Caucasians.[13] Two other studies showed that Asians at the same BMI level have a higher BF% compared to white Caucasians of the same age and sex.[14,15] Based on these studies, WHO suggested lowering BMI cut-off for obesity to 27 for Asian populations due to a higher BF% compared to white Caucasians.[8]

This is the first study in the Kingdom of Saudi Arabia and the Arab world that evaluates the diagnostic accuracy of BMI across various age groups in a primary care setting. All previous studies testing the diagnostic accuracy of BMI were limited to a small sample size, narrow age range or did not use the gold standard measurement tool.[17–20]

In this study, we found that using the current BMI cut-off value in diagnosing obesity in the Saudi population is inaccurate. While we can still use BMI as a screening tool for obesity, we recommend using a lower cut-off point. Our study also showed how BMI ≥ 30 kg/m^2 significantly underestimates the prevalence of obesity. Based on our findings, using the current BMI cut-off value to diagnose obesity in Saudi population would mislabel more than half of the patients with obesity to be “Normal”. This means that those obese patients may not be aware of their need to improve their health and reduce their weight early on to avoid obesity-related illnesses.

Limitations

1. This is the first study in the region to evaluate the accuracy of BMI as a screening tool.
2. DEXA scan was done as a screening test for osteoporosis, BF% was extracted from their report. In the future, we need to recruit patients for BF% screening.
3. Further researches needed to look for the association of the new cut off point and obesity related illnesses such as Diabetes.

Conclusion

The accuracy of BMI 30 kg/m^2 to diagnose obesity among the Saudi population is limited. We have to lower the BMI cut-off point to improve its sensitivity as a screening tool for obesity. Our study suggests that the BMI cut-off point among Saudis and possibly the Arab population should not exceed 27 kg/m^2 for both males and females.

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Disclosure

The authors report no conflicts of interest in this work.

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