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*Full Length Research Paper*

# Tailoring the body mass index cutoff for overweight amongst the Nepalese male population

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**Obesity/Overweight is a recognized risk factor for most of the disorders and risk stratification is based on Quetelets index, a surrogate measure of fatness. Currently used body mass index (BMI) cut-offs to classify people as overweight/obese does not accurately represent the BMI cut-offs in Nepalese population, due to differences in body structure and composition. This study was conducted to define BMI cut-offs for overweight in Nepalese male population. A cross-sectional study was conducted on 123 male individuals aged 25 to 60 years. Body weight was measured to the nearest 0.1 kg in light indoor clothing. Height was measured using portable stadiometer to the nearest 0.1 cm. Body fat percentage was measured using digital weight scale incorporating a bioelectric impedance analyzer. Receiver operating characteristic (ROC) curve analysis was applied to determine cut-offs for BMI using body fat as standard. Mean age, BMI, and body fat in study group was 47.23 years (± 8.72), 25.25 kg/m$^2$ (± 3.41) and 29.30% (± 4.79), respectively. Prevalence of overweight/obesity was 56.6% by BMI and 83.8% by body fat content. Receiver operating characteristic (ROC) curve analysis defined a BMI of 23.5 kg/m$^2$ as cut-off for overweight with a sensitivity of 86.9% and specificity of 90%.**

**Key words:** Body mass index (BMI) cut-off, overweight, body fat percentage.

## INTRODUCTION

Several studies have raised the suspicion that the body mass index (BMI) cut-off for overweight as defined by the World Health Organization (WHO) may not adequately reflect the actual overweight status (Kesavachandran et al., 2012). The disease risk stratification is commonly analyzed based on Quetelets index (body mass index, BMI), a surrogate measure of fatness (Singh et al., 2008). WHO expert committee recommended BMI cut-off points for determining overweight and obesity in Asian populations, but the cut-offs were established from the limited population and area (WHO, 2004). Several reports from Asian populations suggested the need for population specific cut-off points for BMI (Kesavachandran et al., 2012; Shah et al., 2006, 2008). Various studies have raised the suspicion that the BMI cut-off for overweight as defined by WHO may not adequately reflect the actual overweight status of all populations.Although there are few studies regarding the tailoring BMI cut-offs in the Nepalese population and these follow the different techniques usually on the basis of risk of overweight/ obesity with diabetes mellitus (Shah et al., 2006, 2008). This study was undertaken to establish the association of BMI with body fat percentage (BF%) in the Nepalese population using bioelectric impendence analyzer which is the new concept in the case of Nepal.

## MATERIALS AND METHODS

Male (123) individuals were enrolled between October 2012 and December 2012. Due to the difference in the body fat composition between male and female, only males were enrolled for the study. Only males of age above 25 years were taken, as the maximum

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body growth occurs up to the age of 25 and thereafter body remains approximately constant in healthy individuals. The individuals were people from the general community. Body weight was measured using digital weighing apparatus each time (HBF-352, Omron Health care Co., Kyoto, Japan) and recorded in kilograms to one decimal point. Height was measured using a portable stidometer; the subjects' body positions ensured their head, shoulder blades, buttocks, and heels were touching the board during measurement. Height was recorded in centimeters. BMI was calculated by dividing the body weight in kilograms by square height in meters (BMI = body weight [kg]/height [$m^2$]). Volunteers who exhibited any characteristics that might interfere with measured parameters were excluded. These included: subjects <25 years old; pregnant women; persons with any implanted electronic device; those exhibiting signs of chronic steroid use; persons with amputated limb(s), or limited ambulation, inability to lie down, or edematous limb(s); and those with chronic diseases such as liver cirrhosis, renal failure, and heart failure. All volunteers gave informed consent before their enrollment into the study.

BF% was measured using a commercially available digital weight scale incorporating a bioelectric impedance analyzer (HBF-352, Omron Health care Co., Kyoto, Japan). The reliability of the bioelectric impendence analyzer has been proved and used for measuring the body fat percentage in different studies (Vasudev et al., 2004; Chittawatanarat et al., 2011; Pathak and parashar, 2010; Kesavachandran et al., 2012).

The instrument is portable and easy to use in epidemiological field surveys. BF% was measured to the nearest 0.1%. The digital weight scale includes a hand grip and foot plate, each of which is equipped with two electrodes. The two electrodes between the left and right grip were short circuited, along with those for the left and right feet. Upon measurement, the study subject stood on the foot plate and gently grasped the two handgrips with arms held straight forward. During the measurement, the instrument records impedance from the hands to the feet, which corresponds to the whole body impedance, by applying an electric alternating current flux of 500 μA at an operating frequency of 50 kHz. Consequently, BF% was calculated from the impedance value and the pre entered personal data. Total body water was predicted from the impedance index ($height^2$/impedance) (Kushner et al., 1990; Deurenberg et al., 1995; Stall, 1996). From the total body water, the BF% was calculated as 100 × [weight-(total body water)]/weight (Stall, 1996). The calculation is done by software program based on algorithm developed and patented by Omron Health Care Co., Kyoto, Japan. Impedance was measured and total body water was predicted, which was not displayed to user, was automatically fed to the algorithm along with pre entered data and the software calculates the body fat percentage. The machine was always tested by two research assistants to verify accuracy before use. One assistant tested the machine by measuring the bioelectrical impedance analysis (BIA) results of the other assistant at least twice. The result was considered valid if it did not have an error >5. Subjects were requested to moisten the soles of their feet with a wet towel before taking a measurement. Ten minutes were given for the electrode to warm up.

Bioelectrical impedance analysis varies under different conditions, that is why (Kushner et al., 1990) before analysis, all volunteers were asked to observe the following pretest guidelines:

(1) no alcohol consumption within 24 h; (2) no exercise, caffeine, or food within 4 h prior to taking the test; (3) no water for atleast 2 h before examination. During the examination, two pairs of sensor electrocardiograph pads were placed on the patient, one on the right wrist hand and the other on the right foot and ankle. At least 75% of the electrode was required to be in contact with the patient's skin. Patient data, including gender, age, height, and weight, were entered into the machine's software before each test. Results of the measurements were recorded.

Data recorded on a predesigned proforma were entered in a Microsoft Excel spreadsheet. All the entries were double-checked for any possible keyboard error. In order to use the parametric test, the outliers were removed. In total, four outliers were removed. Normality of the data was assessed using the Shapiro-Wilk test. Outliers were checked using the normal Q-Q plot, stem-leaf display and the histogram, box plot. Descriptive statistics (mean, standard deviation, median) for all the anthropometric parameters were computed. Receiver operating characteristic (ROC) curve was drawn to determine an appropriate cut-off of the BMI, considering body fat percentage as standard (25% of the total body mass) (Dudeja et al., 2001; Kesavachandran et al., 2012).

## RESULTS

The age of subjects ranged between 25 and 60 years with a mean of 47.23±8.72 years. All the variables studied follow normal distribution after removing outliers. BMI was found to be highly correlated with body fat percentage (r=0.532, P<0.001) indicating statistical linear relationship between body fat percentage and BMI (Figure 1).

Sixty five percentage subjects showed higher body fat percentage (>25%) with BMI range between 24 and 24.9 kg/$m^2$. Even at lower BMI (<20), the high body fat percentage was found to be 22.22 percentage subjects (Table 1). High body fat percentage in the BMI range of 20 to 21.9 and 22 to 23.9 kg/$m^2$ was found to be 42 and 77%, respectively showing large number of subjects having body fat more than 25% in lower BMI range.

Curve was plotted based on ROC analysis at different cut-off values of BMI, while taking percentage of body fat as standard (Table 2 and Figure 2). Area under the curve was between 85 and 88% which is considered good fit in discriminating the population with body fat below and above 25%. Sensitivity and specificity at cut-off level of BMI at 23.5 was 86.9 and 90%, respectively.

## DISCUSSION

In this study, higher body fat percent was observed within WHO proposed normal limits of BMI. Hence, a proposal to lower the WHO normal BMI standard from 24.9 to 23.5 kg/$m^2$ was suggested for the male residents of the study location. Earlier study also showed that the diagnosis of obesity (using reference of BMI of 30 kg/$m^2$) need to be lowered to 27 kg/$m^2$ for Malaysia and Chinese and 26 kg/$m^2$ for Asian Indians (WHO, 1998). WHO and International Obesity Task Force have also suggested lowering the limits of BMI for the diagnosis of overweight and obesity (WHO, 2000). Similarly, this study also suggest for lowering of the BMI cut-off in the study population.

## Conclusion

The cut off for BMI was found to be 23.5 kg/$m^2$ for overweight with a sensitivity of 86.9% and specificity of 90% for the study population.

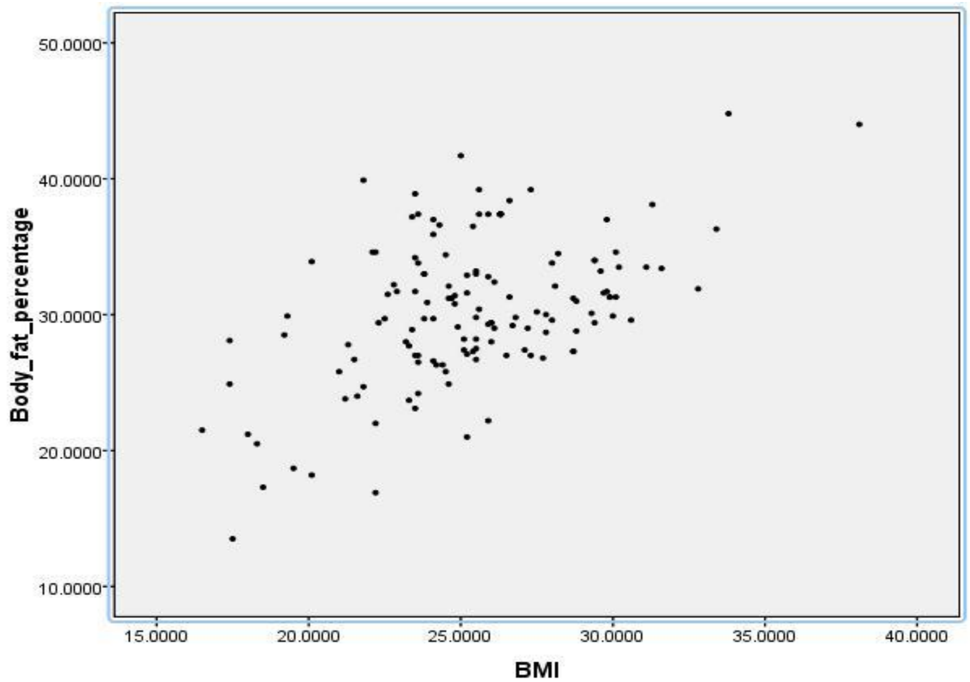


**Figure 1.** Scatter plot between BMI and body fat percentage.

**Table 1.** Body fat percentage in different categories of BMI in study subject.

| BMI category | Body fat percentages | | | |
|---|---|---|---|---|
| | Actual | | Cumulative | |
| | Total | >25 (%) | Total | >25(%) |
| <20 | 9 | 2 (22) | 9 | 2 (22.2) |
| 20-21.99 | 7 | 3 (42) | 16 | 5 (31.25) |
| 22-23.99 | 22 | 17 (77.27) | 38 | 22 (57.89) |
| 24-24.99 | 14 | 12 (85.71) | 52 | 34 (65.38) |
| 25-25.99 | 18 | 16 (88.89) | 70 | 50 (71.42) |
| 26-27.99 | 21 | 21 (100) | 91 | 71 (78.02) |
| 28-29.99 | 19 | 19 (100) | 110 | 90 (81.81) |
| ≥30 | 8 | 8 (100) | 118 | 98 (83.05) |

**Table 2.** Test characteristics (%) of BMI as a measure of overweight in study subjects considering body fat percentage as standard (BFAT% >25).

| BMI cut-off (kg/m$^2$) | Sensitivity | Specificity |
|---|---|---|
| >19.5 | 99.1 | 50 |
| >20.5 | 97.2 | 60 |
| >21.5 | 96.3 | 70 |
| >22.5 | 91.6 | 70 |
| >23.5 | 86.9 | 90 |
| >24.5 | 72.9 | 90 |
| >25.5 | 60.7 | 90 |
| >26.5 | 42.1 | 100 |
| >27.5 | 31.8 | 100 |

## Limitation of study

Sample size for the study was limited and was done only amongst the male population; so the finding cannot be generalized to the whole population of Nepal.

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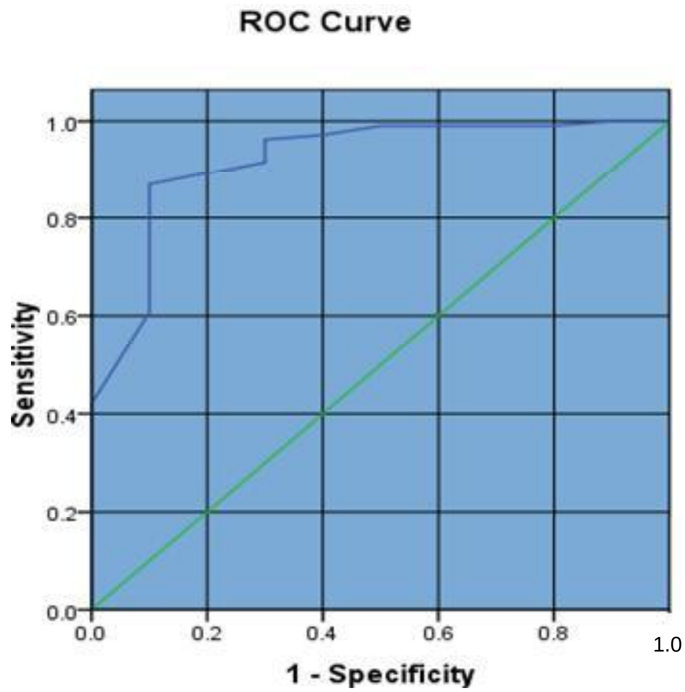


**Figure 2.** Receiver operating characteristic curve (ROC) at different BMI cut-off points using body fat as standard.

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