

Research Article

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Estimation of Body Fat Mass (in%) as a Measure of Obesity among UG Medical Students and its Correlation with Clinical Markers of Obesity (BMI)

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Abstract

Background & objectives: This study was conducted to assess the burden of overweight and obesity among UG medical students by measurement of body fat mass percentage (BF%) and to evaluate the validity of BF% as a clinical marker of obesity by its correlation with BMI.

Methods: The research was conducted as a cross sectional, observational study using the principle of Bioelectric Impedance Analysis for measurement of body fat

Results: There were 237 males (55.5%) and 187 females (44.5%) among the study participants. The burden of overweight and obesity among the students was found to be 26% and 9.8% respectively according to WHO global BMI criteria whereas it was 18.8% and 35.7% respectively, if the Asian criterion was used. This abnormality was pervasive across all the four years of UG MBBS students. The startling finding is that students who were labeled as 'Normal' using the BMI criterion were found to be obese by BF% assessment (43%) and even 'Underweight' students were found to have more than normal levels of BF% (15.2%). Measurement of waist circumference (WC) showed that 146 (34.8%) of the students had WC higher than normal. Likewise, 145 (34.5%) of the students had Waist-Hip Ratio higher than normal. Abnormalities of all above parameters put the students at risk of NCDs.

Conclusion: The study shows a high burden of overweight and obesity in medical students. Using body fat percentage as a clinical marker of adiposity is more desirable than using BMI only to screen clinical obesity.

Keywords: BMI; Body fat mass; Epidemiological investigations; Hip circumference; Obesity; Overweight; Waist circumference; Waist hip ratio

Introduction

Overweight and obesity lead to serious health consequences and increases the risk of morbidities and mortalities due to NCD (Non-communicable diseases). Increase in body fat alters the body's response to insulin, potentially leading to insulin resistance, and also creates a pro-inflammatory state, leading to the risk of thrombosis [1,2]. India is currently experiencing an epidemic of Type 2 Diabetes Mellitus and related disorders [3,4]. The measurement of obesity (prevalence) in populations has thus become an important index of risk assessment of predisposition to NCDs. It has thus become very important to screen all adults and adolescents for obesity in order to ensure positive health. Body Mass Index (BMI) is the most commonly used measure of obesity. It is commonly used as an important clinical marker of adiposity even though it is a surrogate measure of body fat since the index directly does not measure body fat. In young people who have muscular bodies and hence higher weight for a given height may have a higher BMI even though there is no extra adiposity. In such cases assessment of BMI to screen overweight or obesity may have pitfalls.

Moreover, the relationship between body fat and BMI differs in different populations [5]. It has been demonstrated that Indians have different body fat and BMI relationships compared to Caucasians and African Americans and Indians tend to have more adipose tissue for a given BMI [6-8]. This even prompted WHO to revise the BMI cut-off for Asians to define overweight and obesity [9,10]. Thus the use of BMI in an individual person is limited by its inability to discriminate between fat and lean body mass i.e. fat free mass (FFM). Therefore, estimation of body fat mass as a percentage of the total body weight is an alternative and direct measure of abnormal body adiposity. Various tools are available for assessment of body fat mass like hydrostatic

weighing, air displacement plethysmography, dual-energy x-ray absorptiometry [DEXA], CAT scan, MRI and bio-electric impedance analysis [BIA] and measurement of skin fat by calipers. Among these BIA is the least invasive and perhaps the most convenient to use tool for body fat percentage assessment.

Aims and Objectives

1. To assess the burden of overweight and obesity among UG medical students of our college by measurement of body fat mass (in%)
2. To evaluate the validity of body fat mass (in%) as a clinical marker of obesity by its correlation with BMI

Methodology

The study which was designed as a cross sectional, descriptive study was completed within a duration of two months after obtaining due ethical clearance at PRMMCH, Baripada. Assuming a prevalence of 50% obesity among the UG MBBS students a minimum 384 MBBS students was calculated as the minimum desired sample size. The study was conducted in the clinical anthropometry lab of the department of Community Medicine of our college using Bioelectric Impedance

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Analysis (BIA) machine for measurement of body fat% and weight, measurement tape for waist and hip circumference and stadiometer for assessing the standing height of the study subjects. All healthy students who consented to participate in the study were included in the study provided they were not disqualified by any of the exclusion criteria.

The assessment of the students was done in batches of 10 to 20 students each. After recording the socio-demographic details, the anthropometric measurements were recorded using the equipments listed above. For body fat percentage measurement by bioelectric impedance analysis (BIA) machine, the students were advised to come on empty stomach (8-12 hours overnight fasting) with minimal clothing and remove all metallic objects from their person like coins, mobiles, hair clips, etc, which is known to interfere with the measurements.

For the BIA measurements (i.e body fat%), the OMRON Karada body composition monitor HBF-375 was used. The BIA machine also gave the reading of body weight in kilograms. The anthropometric measurements of waist and hip circumference (in centimeters) were assessed by using SECA 201 measuring tape. Height in centimeters was measured using a commercially available stadiometer (Prestige). The data which was collected was tabulated and analyzed as per the standards for BMI recommended by the World Health Organization (WHO) and their modified version recommended for Asians particularly Indians. Statistical significance of the results was evaluated by appropriate comparisons and statistical tests.

Exclusion criteria

1. All students who were suffering from any illness (acute or chronic) which does not permit anthropometric evaluation.
2. All students with any loco motor disability which prevented accurate estimation of standing height measurement by stadiometer.
3. All students who had implants or prosthetics (either electrical or non-electrical) on their person.

Results

The medical college has an intake capacity of 100 students per year with an additional capacity for 25 students in EWS (Economically Weaker Sections) category since 2019 onwards. Therefore, the college has an enrollment capacity for 100 students in 4th year MBBS and 125 students each in first, second and third year respectively adding to 475 students in total.

From the first year MBBS 108 students, 119 students from 2nd year MBBS, 116 students from 3rd year MBBS and 77 students from

final year MBBS, adding up to a total of 420 students from all the four years consented to participate in the study. Thus the research had the participation of 88.4% of the enrolled students.

There were 237 males (55.5%) and 187 females (44.5%) among the study participants. From among them 169 students (40.2%) were from a rural background and the rest 251 students (58.2%) from an urban background. Analysis of the religious faith of the students revealed that 408 were Hindus (97.1%), 7 were Muslims (1.7%) and the remaining 5 study participants (1.2%) were Christians.

The mean age of the students was 20.72 ± 1.69 , 21.26 ± 1.20 , 22.32 ± 1.2 and 23.34 ± 1.4 for the first year, second year, third year and final year students respectively. The overall mean age of the students was 21.8 years across all the four years of the students (21.8 ± 1.6) with a minimum age of 18 years and a maximum age of 27 years.

The anthropometric measurement of the study subjects is summarized in (Table 1).

The criteria for categorizing BMI are based on two widely accepted standards. The first one is the WHO global standards which classifies BMI as Underweight (< 18.5), Normal ($18.5 - 24.9$), Overweight ($25.0 - 29.9$) and Obese (≥ 30). The breakup of the data on BMI computed from the anthropometric measurements on the study subjects reveals that 33 (7.9%) students were underweight, 109 (26%) students were overweight, and 41 (9.8%) students were obese while the remaining 237 (56.4) students were having normal BMI. Thus the primary research question about the burden of overweight and obesity among the UG medical students was found to be 26% and 9.8% respectively according to WHO global criteria of assessing obesity by using BMI.

The second set of standard is by the WHO for classifying BMI in Asians and in Indians [9,10]. This standard classifies BMI as Underweight (< 18.5), Normal ($18.5 - 22.9$), Overweight ($23.0 - 24.9$) and Obese (≥ 25). When the dataset was reanalyzed with the Asian standards the underweight group remained unchanged (7.9%) but there was a remarkable reduction in the normal fraction as well as the overweight fraction i.e. normal (56.4% to 37.6%) and overweight (26% to 18.8%) as compared to the WHO global standards. The obese fraction rose sharply from 41 to 150 students i.e 9.8% to 35.7%. Thus the burden of overweight and obesity among UG MBBS students of our college was found to be 18.8% and 35.7% respectively, if the Asian criterion for BMI was used.

It is already a well-established fact that all the risk factors for non-communicable diseases (NCDs) operate on a continuum of risk

Table 1: The anthropometric measurement of the study subjects.

Parameter Unit	Height (cms)	Weight (kgs)	BMI (Kg/ m ²)	Body fat (%)	Waist Circum. (cms)	Hip Circum. (cms)	W/H ratio
Overall (n=420)	163.8 $\pm$ 9.51	64.2 $\pm$ 13.25	23.9 $\pm$ 4.25	26.5 $\pm$ 7.36	82.4 $\pm$ 10.22	95.7 $\pm$ 8.88	0.86 $\pm$ 0.05
Year wise							
1 st year MBBS	164.6 $\pm$ 10.0	65.0 $\pm$ 13.68	23.9 $\pm$ 4.34	26.5 $\pm$ 6.90	82.3 $\pm$ 10.8	96.7 $\pm$ 9.26	0.85 $\pm$ 0.06
2 nd year MBBS	163.7 $\pm$ 8.6	65.0 $\pm$ 13.93	24.1 $\pm$ 4.27	26.2 $\pm$ 7.43	82.2 $\pm$ 10.1	95.1 $\pm$ 9.01	0.86 $\pm$ 0.05
3 rd year MBBS	163.8 $\pm$ 9.4	63.3 $\pm$ 13.54	23.7 $\pm$ 4.66	26.0 $\pm$ 7.79	82.6 $\pm$ 10.76	95.03 $\pm$ 9.39	0.86 $\pm$ 0.05
4 th year MBBS	162.9 $\pm$ 10.2	63.1 $\pm$ 11.01	23.7 $\pm$ 3.45	27.6 $\pm$ 7.25	82.5 $\pm$ 8.7	96.1 $\pm$ 7.17	0.85 $\pm$ 0.05
Sex Wise							
Female	153.6 $\pm$ 6.19	58.3 $\pm$ 11.7	23.9 $\pm$ 4.52	32.1 $\pm$ 4.73	80.8 $\pm$ 10.44	97.1 $\pm$ 9.06	0.83 $\pm$ 0.05
Male	169.9 $\pm$ 7.03	68.9 $\pm$ 12.4	23.9 $\pm$ 4.04	22.0 $\pm$ 5.84	83.7 $\pm$ 9.87	94.6 $\pm$ 8.58	0.88 $\pm$ 0.04
Residence							
Rural	164.5 $\pm$ 9.31	64.8 $\pm$ 13.5	23.8 $\pm$ 4.12	25.6 $\pm$ 7.20	82.7 $\pm$ 10.30	95.3 $\pm$ 8.67	0.86 $\pm$ 0.05
Urban	163.4 $\pm$ 9.6	63.8 $\pm$ 13.07	23.9 $\pm$ 4.35	27.1 $\pm$ 7.42	82.2 $\pm$ 10.18	95.9 $\pm$ 9.02	0.85 $\pm$ 0.05

concept i.e. even within the so called 'normal' range of BMI the persons on the higher side of the range are at higher risk of NCDs than those lower than them. Furthermore, it is also a well-accepted scientific fact that Asians are at a higher risk of NCDs compared to their western counterparts even at lower levels of obesity, thus necessitating the separate criteria for Asian Indians with lower limits.

Thus in the present study using the Asian criteria was considered prudent as it helped in identifying the higher burden of risk among the students.

The sub-group analysis of the BMI data (Table 2) shows that the distribution of overweight and obesity among the students from rural background (21.9% and 34.3%) is comparable to those from urban background (16.7% and 36.7%), which dispels the myth that obesity is an urban problem as students from both backgrounds are at equal risk. The burden of overweight and obesity seen from the sex perspective also mirrors a similar picture with 17.1% and 36.9% of the females while 20.2% and 34.8% of the males being overweight and obese respectively. The male students as well as female students are at similar risk (Table 2).

The year wise distribution of the students shows that the pattern of the burden of overweight and obese is seen in all the four years of students with minor differences in the absolute proportions, which clearly reflects the pervasive nature of the malady across the entire student population.

The research study also attempted to explore the utility of other clinical markers of obesity like body fat percentage (BF%) in assessing obesity compared to the oft used parameter of BMI. The students were assessed for body composition using a BIA (Bioelectric Impedance Analysis) machine which gave out a cluster of measurements related to body composition for each study subject. Since our objective was to study the relationship and utility of body fat percentage, only that parameter was recorded and the rest of the output was conveniently ignored for the purpose of this study.

While there are no universally acceptable norms for body fat percentage like BMI, one set of criteria recommended by the ACSM (American College of Sports Medicine) in its ACSM Health Related Physical Fitness Assessment Manual 2008 is widely used and referred to [11]. The standards are different for men and women and again vary for different age groups within each gender. The categories in each group have a scaling approach starting from the best end of the spectrum labeled as 'Essential fat' followed by 'Excellent', 'Good', 'Average', 'Below average', and the worst being 'Poor'.

For our analysis the value of 22.4 was used as the upper limit for BF% in males and 27.7% for females as they correspond to the upper limit for the age group 20—29 years which includes most of our study subjects. For subjects below 20 years no separate standards were available in the ACSM guidelines, hence the 20—29 year was used as default. It is worthwhile to note that many research studies take an average of both 22.4% and 27.7% instead and use BF% >25% as an universal cutoff to define obesity for both males and females.

The analysis of the BF% (Table 03) of the students shows that 266 (63.3%) students have BF% higher than the cutoff value for their respective sex and age (i.e obese) whereas the remaining 154 (36.7%) have BF% within limits. Further analysis reveals that the agreement between BF% and BMI in identifying the 'high risk' is the highest in the 'obesity' category (93.3%) followed by 'overweight' category (67.1%). The startling finding is that students who were labeled as 'Normal' using the BMI criterion were found to be obese by BF% assessment (43%) and even 'Underweight' students were found to have more than normal levels of BF% (15.2%). Thus the BF% was found to be a more sensitive indicator of obesity compared to BMI (Table 3).

The study of the linear relationship between BF% and BMI reveals (Table 04) that there is a statistically significant ($p < 0.00$) strong positive correlation (0.57) between BF% and BMI. But sub-group analysis shows weak correlation in the underweight, normal and overweight categories and a modestly positive correlation in the obese category. This also underscores the fact that the linear relationship of BF% is independent of BMI especially in the lower BMI ranges of 'underweight' and 'normal' where the person is considered as having a low risk. Thus a person could well be at high risk because of higher than normal body fat percentage and yet remain in the false realm of normalcy if only BMI is used as the clinical criterion to define or screen obesity (Table 4).

The measurement of the waist circumference (WC) is an important marker of cardiovascular risk since it overtly measures abdominal girth which is the principal site for extra fat deposition. The government of India's National Program for Prevention and Control of NCDs has a set limit for WC as a screening tool where more than 90 cm in males and more than 80 cm in females is considered as risk for NCDs. The analysis of the anthropometric data in (Table 5), shows that 146 (34.8%) of the students had WC higher than normal which puts them at risk of NCDs. The breakup of the data shows that 55.3% of the female students had a higher than normal WC compared to only 22.3% of the male students, which was statistically significant. Likewise, the distribution of the WHR across the different BMI categories is summarized in (Table 06) which was also statistically significant (Tables 5 and 6).

Table 2: BMI data of Subjects.

BMI Category	Underweight	Normal	Overweight	Obese
Range	< 18.5	18.5—22.9	23—24.9	>=25
Overall (n=420)	33 (7.9%)	158 (37.6%)	79 (18.8 %)	150 (35.7%)
Year wise				
1 st year MBBS	27 (6.5%)	43 (39.8%)	19 (17.6%)	39 (36.1%)
2 nd year MBBS	10 (8.4%)	40 (33.6%)	23 (19.3%)	46 (38.7%)
3 rd year MBBS	14 (12.1%)	43 (37.1%)	17 (14.7%)	42 (36.2%)
4 th year MBBS	2 (2.6%)	32 (41.6%)	20 (26.0%)	23 (29.9%)
Sex wise				
Female	19 (10.2%)	67 (35.8%)	32 (17.1%)	69 (36.9%)
Male	14 (6.0%)	91 (39.1%)	47 (20.2%)	81 (34.8%)
Residence				
Rural	13 (7.7%)	61 (36.1%)	37 (21.9%)	58 (34.3%)
Urban	20 (8.0%)	97 (38.6%)	42 (16.7%)	92 (36.7%)

Table 3: The analysis of the BF% of the students.

BMI Category	Underweight	Normal	Overweight	Obese	Overall
Range	< 18.5	18.5—22.9	23—24.9	>=25	(n=420)
Body Fat Percent (Bf%)					
Normal	28 (84.8%)	90 (57.0%)	26 (32.9%)	10 (6.7%)	154 (36.7%)
Obese (At risk)	5 (15.2%)	68 (43.0%)	53 (67.1%)	140 (93.3%)	266 (63.3%)

Table 4: The study of the linear relationship between BF% and BMI reveals of the subjects.

BMI Category	Underweight	Normal	Overweight	Obese	Overall
Range	< 18.5	18.5—22.9	23—24.9	>=25	
r ²	-0.24	0.24	0.14	0.42	0.57
P value	0.16	0.00	0.20	0.00	0.00

Table 5: The analysis of the anthropometric data of the subjectcs.

BMI Category	Underweight	Normal	Overweight	Obese	Overall
Range	< 18.5	18.5—22.9	23—24.9	>=25	(n=420)
Waist circumference					
Normal (<=90 cm in males and <= 80 cm in females)	31 (93.9%)	152 (96.2%)	53 (67.1%)	38 (25.3%)	274(65.2%)
At risk (High)	2 (6.1%)	6 (3.8%)	26 (32.9%)	112 (74.7%)	146 (34.8%)

Table 6: BMI categories of the subjects.

WAIST CIRCUMFERENCE (WC)			
Sex	Female	Male	Total
Normal (<=90 cm in males and <= 80 cm in females)	93 (49.7%)	181 (77.7%)	274 (65.2%)
At risk (High)	94 (50.3%)	52 (22.3%)	146 (34.8%)

Table 7: The analysis of the anthropometric data fluctuations of the students.

BMI Category	Underweight	Normal	Overweight	Obese	Overall
Range	< 18.5	18.5—22.9	23—24.9	>=25	(n=420)
Waist circumference					
Normal (<=90 cm in males and <= 80 cm in females)	31 (93.9%)	129 (81.6%)	51 (64.6%)	64 (42.7%)	275(65.5%)
At risk (High)	2 (6.1%)	29 (8.4%)	28 (35.4%)	86 (57.3%)	145 (34.5%)

Table 8: The distribution of the WHR across the different BMI categories and their statistical significant.

WAIST CIRCUMFERENCE (WC)			
Sex	Female	Male	Total
Normal (<=90 cm in males and <= 80 cm in females)	120 (64.2%)	155 (66.5%)	275 (65.5%)
At risk (High)	67 (35.8%)	78 (33.5%)	145 (34.5%)

The waist circumference to hip circumference ratio (W/H ratio) is also an important predictor of cardiovascular risk vis-a-vis its ability to measure abdominal obesity. The WHO criterion upper limit for the W/H ratio is 0.9 for males and 0.85 for females [12]. Any value above these two is considered as a high risk category. The analysis of the anthropometric data in (Table 7), shows that 145 (34.5%) of the students had WHR higher than normal which puts them at risk of NCDs. The breakup of the data shows that 35.8% of the female students had a higher than normal WHR compared to 33.5% of the male students. However, the distribution of the WHR across the different BMI categories is summarized in (Table 8), which was statistically significant (Tables 7 and 8).

Discussion

Medical undergraduate students are more prone to obesity due to their extended hours spent on the study table as well as very little time for physical activity within their packed course schedule. In several studies done across India, it has been reported that the burden of overweight and obesity is high in medical students [13-15]. In one study done in

Gwalior by Tiwari et al has showed a prevalence of overweight as 9.93% and that of obesity as 1.53%. Deotale et al in Gran medical college, Mumbai have reported a prevalence of 14.33% and 3.34% respectively for overweight and obesity. Likewise, Fernandez from Pune reported a combined proportion of 13.2% among medical students for overweight and obesity together. Khan et al in a study in our neighboring country Pakistan reported that 30.5% of males and 16% of females had a BMI exceeding 25 kg/ m² [16]. However most of the studies have used the WHO global BMI criterion which has 25 kg/m² as a cut off. In one of the few studies which used the modified WHO criteria (for Asians and Indians) by KK Manojan et al done in a medical college in Kerala, the prevalence of obesity was 25.7% and overweight was 24.5% [17]. Our study which also uses the modified WHO criterion affirms the findings with burden of overweight as 18.8% and obesity as 35.7% among the students of our college.

One of the research objectives of the present study was to explore the validity of measurement of body fat percentage (BF%) as a marker of obesity compared to the often-used BMI. The relationship between BMI and BF% has been studied across various ethnic groups particularly

in western countries [18-21]. Body composition of Indians is different from other ethnic groups around the world. From the very few studies that have been published in India, it has been reported that for the same degree of obesity measured by BMI, the BF% among South Asians particularly Indians may be much more than other ethnic populations [22-25]. This was also established in our analysis where students who were labeled as 'Normal' using the BMI criterion were found to be obese by BF% assessment (43%) and even 'Underweight' students were found to have more than normal levels of BF% (15.2%). Thus the use of BMI alone as a screening tool in clinical practice to detect or rule out obesity can be fallacious and in fact dangerous as people who are indeed 'at risk' may be given the false impression of 'normalcy'.

Earlier research has indicated a positive correlation between BMI and BF% in various populations [18,19,22]. Although our study shows a strong positive correlation in the overall population ($r^2=0.57$) between BF% and BMI which was also statistically significant, the linear relationship was not uniform across all categories of BMI. It was minimal and negative in the underweight category ($r^2=-0.24$) and gradually increased to a positive correlation as one moved up the BMI categories from 'Normal' to 'Obese' through 'overweight'. In the 'Normal' and 'Obese' categories the correlation was positive and statistically significant as well. Similar findings have also been reported from a study in British adults [11].

Conclusion

The present research work was designed as a simple observational descriptive study to give a picture of the burden of overweight/ obesity among UG medical students of our college. The study findings of a high burden of overweight and obesity in medical students will hopefully convince research institutions like ICMR to establish a demographic health surveillance system for medicos. Indian medical students can be subjected to annual or semi-annual health assessment and their clinical and other parameters can be logged and they can be followed up (in a longitudinal format) to study the burden of risk factors and outcomes for various health conditions especially NCDs among them. [similar to the famous British Doctors study of Doll and Hill]. The country's medical regulator-the National Medical Commission (NMC) can be also motivated upon to include mandatory physical activity in the curriculum for all medicos and also endorse the prescription of annual health assessment of all the medicos.

That BMI of 23 kg/m² is not an effective predictor of obesity particularly in Indians is strikingly borne out in this study. The analysis of the body fat percentage even in this sample of relatively young study subjects reveals the so called "Indian paradox", that Indians are more prone to obesity (due to their smaller body frame) even at much lower BMI cut-offs compared to their western or Caucasian counterparts. Thus using BF% as a clinical marker of adiposity is more desirable than using BMI only to screen obesity.

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