Original Article

Correlation Of Body Mass Index With Body Fat Percentage & Validation Of BMI Cut – Off Value For Overweight In Male Adults

*Syed Adnan Ahmed ** Mohammad Saleh Soomro *** Abdul Qadir

* Lecturer, Department of Physiology, Baqai Medical University, ** Prof. & Chairman Department of Physiology, Baqai Medical University, *** Assist. Prof., Department of Physiology, Karachi Institute of Medical Sciences (KIMS), Karachi

ABSTRACT

Background: Several studies have raised the suspicion that the Body Mass Index (BMI) cut – off for overweight as defined by the WHO may not adequately reflect the actual overweight status of the population belonging to different geographical back grounds. Health risk, particularly of Hypertension (HTN) & Diabetes Mellitus Type – 2 (DM – II), are directly related to the increase in Body Fat Percentage (BF%) which results in obesity. **Objectives**: The present study was conducted to evaluate the validity of BMI Cut – off points for overweight in local population by determining their BMI, BF% and establishing the relationship between BMI & BF% with the health risk outcome particularly of HTN & the DM – II. **Methodology**: This study was conducted on 200 male participants from 18 to 42 years of ages, during January 2017 & June 2017, at Department of Physiology, Baqai Medical University, Karachi. Based on age all participants were divided into four groups of 50 individuals each. BMI & BF% were evaluated together with the anthropometric parameters. Comparison was made to evaluate the BMI cut – off value with reference to BF% of the individuals. Data was analyzed using SPPS version 22.0. **Results:** On analysis of the obtained data, significant correlation ($p < 0.05$) were found between BMI and BF%, 20% of the subjects in BMI range of 24 – 24.99 kg/m^2 showed higher BF%, i.e. > 25% (Normal 18 – 24.9%). An increase in BF% together with the risk for HTN and the DM – II were also observed with advancement of age. The BMI cut – off value in our study subjects came out to be 24.5 kg/m^2 **Conclusion:** Our study suggests, 24.5 kg/m^2 as a BMI cut – off value in the population studied. Study also emphasizing the need for establishing the BF% criteria for assessing the risk particularly of HTN & DM – II.

KEYWORDS: BMI, BF%, PBF, New Cut-Off, Overweight.

Med. Channel 2018; 24 (1) 38-43

Correspondence:
SYED ADNAN AHMED
(M.B.B.S)
Lecturer,
Department of Physiology,
Baqai Medical University,
Gadap Town, Main Super Highway,
Karachi, Pakistan
Email: saa.adnan@live.com
Mobile: +92300-2403618

Received on: 10-10-2017
Accepted on: 01-01-2018

INTRODUCTION

Body-mass index (BMI), an important indicator of obesity in large

populations, generally reflects degree of fatness among individuals. Body-mass index can however over- or underestimate the adiposity, depending upon certain circumstances. Clinically, obesity is defined as the accumulation of excess body fat to the extent that it may have adverse effects on health. It is crucial to determine a threshold of body fat that is associated with potential harm to an individual's health [1]. In the absence of body fat measurement, the ratio of weight over height squared or body mass index (BMI), also referred to as Quetelet index, is a common and useful indicator for defining obesity in adult individuals [2]. However, it is increasingly recognized that fat mass, rather than the BMI, is a better indicator of true fat mass and hence the obesity. Weight is primarily made up of fat mass and the muscle mass. BMI, with weight in the numerator, cannot distinguish between the two components. Thus, an individual with high muscle mass can be classified as obese, even though the individual does not carry excess body fat. By clinical definition, a better measure of obesity should be based on an individual's percent body fat (PBF), which can now be measured by a variety of instruments, including bioelectrical impedance analysis, magnetic resonance imaging, computed tomography, and dual energy X-ray absorptiometry (DXA).

While the WHO recommended BMI thresholds for defining obesity and overweight are well established, but it is not clear, what is the appropriate threshold of PBF for classifying an individual as obese. It is widely claimed that a PBF greater than 25% for men and 35% for women are the criteria for diagnosing obesity [2,3]. The claim is attributed to a WHO report, but we have pointed out that this claim is a misquotation of the WHO Technical Report [4], which makes no recommendation for any PBF threshold. As a matter of fact, until now there exist no body fat thresholds for defining obesity. The population is ideal for studying the burden of obesity in transitional economies. However, no studies in the past have examined the burden of obesity using PBF as an indicator. Thus, in this study, we sought to analyze the association between PBF and BMI, and define the prevalence of overweight and obesity using both BMI and PBF criteria [5].

MATERIALS & METHODS

A cross sectional study was carried out in the Department of Physiology, Baqai Medical University, after the approval from the Basic Advance Studies & Research, Baqai Medical University and permission from Baqai ethical committee. This study was conducted on 200 subjects between 18 to 42 years of ages.

SAMPLE TECHNIQUE**:** The sample technique was convenient sampling.

BODY FAT % MEASUREMENT:

By using Bioelectric Impedance Analyzer (BF – 508, Omron Health Care Co., Kyoto, Japan). Small electric current (500 μA), allowed to pass through the body, since the resistance to electricity varies between adipose, muscle and skeletal tissue, the resistance between the two pair of electrodes provided a measure of body fat. The fat – free mass is a good conductor as it contains large amount of water (approximately 73%) and the electrolytes, while fat is anhydrous and a poor conductor of electric current. During measurement, the instrument record that impedance from hands to the feet, which corresponds to the whole-body impedance. Consequently, BF% was calculated from the impedance value and the pre – entered personal data of the subject. Fat-free mass and fat mass are estimated with a regression equation based on data obtained through comparison with bio-impedance estimates with hydro densitometry (Biodynamics, Inc., Seattle, WA).

$$FFM = (a \times Ht^2) + (b \times Wt.) + (c \times A) + (d \times R) + e$$

The equation used in the present study was also utilized in earlier studies [6], where FFM is fat-free mass, Ht. is height (cm), Wt. is weight (kg), A is age (years), and R is impedance (©). The constants, "a" through "e", are proprietary information of Biodynamics, Inc. We utilized the model for estimation of FFM on our entire study population. We constructed categories of BMI according to the WHO International Criteria for all populations (<18.5 kg/m^2; 18.5–24.9 kg/m^2; 25–29.9 kg/m^2 and >30 kg/m^2) [7], and according to the WHO criteria for Asian populations with suggested public health action (< 23 kg/m^2; 24 – 27.5 kg/m^2; 27.6 – 32.49 kg/m^2 and e" 32.5 kg/m^2).[8] Since there are no accepted cut points for percentage body fat [9], we utilized the PBF cut points defined in Okorodudu et al., 2010, a diagnostic performance meta-analysis of BMI in relationship with

Table III.
Comparison of Body Fat % Ranges with the Ranges and Mean Levels of BMI in Males.

	Frequency	BMI Range	Mean ± SD	p-Value
Essential Fat 2 - 5%	0	Nil	0	
Athletes 6 - 13.9%	11	16.2 – 24	20.25±2.26	<0.05
Fitness 14 - 17.9%	45	19.7 - 27.2	23.18±1.79	
Average 18 - 24.9%	104	20.7 - 30.3	24.55±1.81	
Obese 25% & Higher	40	23.9 - 36.4	27.88±2.85	

TABLE I.
Body Fat Percentage in Different Categories of Age in Male Subjects

Age (Years)	N	BF%	p-Value
18-23	50	21.5±5.5	<0.05
24-29	50	20.7 ± 5.01	
30-35	50	19.2 ± 4.6	<0.05
36-41	50	21.53 ± 4.65	

TABLE II.
Body Fat Percentage in Different Categories of BMI in Male Subjects.

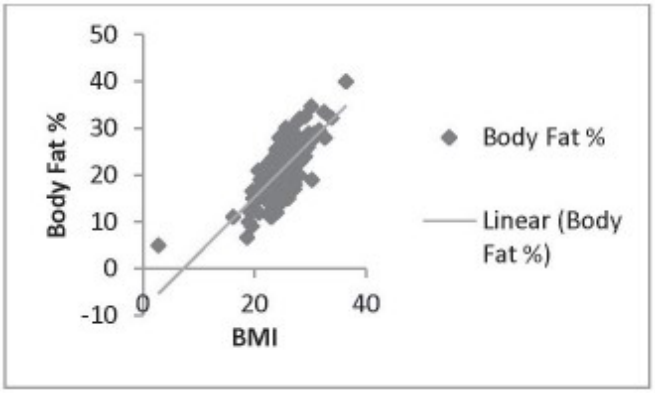
BMI (kg/m2)	N=(200)	BF%		p-value
		Prevalence (%)	Mean ±SD	
<20	9	4.5	11.74±2.99	<0.05
20-21.99	15	7.5	17.12±2.22	
22-23.99	58	29	18.29±2.7	
24-24.99	34	17	20.68±3.42	
25-25.99	34	17	22.33±3.58	
26-27.99	28	14	23.15±4.17	
28-29.99	13	6.5	26.2±3.42	
>30	9	4.5	30.4±5.8	

percentage of body fat [10].

RESULTS

Table I shows the ages were categorized in different groups, each group contained equal number of participants (n=50). The mean body fat percentage (BF %) in age group 18 – 23 years was found 21.5 ± 5.5%, in 24 – 29 years it was 20.7 ± 5.01%, in

GRAPH 1:
Correlation of Body Fat% & BMI in Male Participants.



30 – 35 years it was 19.2 ± 4.6%, and in age group 36 – 42 years the BF% was found 21.53 ± 4.65%. The body fat percentage was statistically significant in each group (p-value <0.05).

Table II shows the body fat % was observed in different categories of BMI. Body fat % was found statistically significant in each category of BMI (p-value <0.05).

Table III shows BMI ranges were compared against body fat %. In different categories of body fat %, BMI cut off values were checked as well as Mean BMI levels were compared. No participants were observed in the category of Essential Fat (2 – 5%). Category of Athletes (6 – 13.9%) 11 participants were observed with mean value of BMI 20.25 ± 2.26. Category of Fitness (14 – 27.9%) 45 participants were observed with mean value of BMI 23.18 ± 1.79. Category of Average (18 – 24.9%) 104 participants were observed with mean value of BMI 24.55 ± 1.81. Category of Obese (25% & Higher) 40 participants were observed with mean value of BMI 27.88 ± 2.85. BMI was statistically significant (p-value <0.05) in each Body fat % ranges.

Figure I, represent the correlations that were analyzed between body fat % and the BMI in participating subjects. The graph showed that the regression line was well approximated the data and the R^2 value was came out to be 0.556, which confirms strong correlation between body fat % and BMI.

DISCUSSION

The information needed to directly associate percentage body fat with morbidity and mortality is, unfortunately, presently unavailable even though there is increasing interest in ranges of body fat associated with optimum health. Some research suggests that other measures of body fat, such as skinfold thicknesses, bioelectrical impedance, underwater weighing, and dual energy x-ray absorption, may be more accurate than BMI.[11]In the present study, within normal limits of BMI, higher body fat % and presence of risk factor(s) (type 2 diabetes/hypertension) were observed. The 1993 WHO Expert Committee reported that weight gain in adult life was associated with increased morbidity and mortality at higher BMI range.[12]Therefore, BMI cut-off for overweight should be interpreted based on risk factors of morbidity and mortality. Type 2 diabetes mellitus, cardiovascular disease and increased mortality are the most important sequelae of obesity and abdominal fatness, but other associations like musculoskeletal disorders, limitations of respiratory function and reduced physical functioning and quality of life were also observed[13]. Three specific factors led WHO to convene another expert consultation on BMI classifications. First, there was increasing evidence of the emerging high prevalence of type 2 diabetes and increased cardiovascular risk factors in parts of Asia at BMI below the cut-off point of 25 kg/m^2 that defines overweight in the current WHO classification.[14] Second, there was increasing evidence that the association between BMI, percentage of body fat, and body fat distribution differ across population. [15]

Third, there had been two previous attempts to interpret the WHO BMI cut-offs in Asian and Pacific population which contributed to the growing debate on whether there is a need for developing different BMI cut-off points for different ethnic groups. The existing assumptions and definitions of cut-offs of each parameter are based on the data from Caucasian.

populations. Asian Indians have a characteristic obesity phenotype, consisting of relatively lower BMI, excess body fat %, abdominal and truncal adiposity and less lean tissue.[16] WHO Expert Consultation proposed a new BMI cut-off of 23.0 kg/m^2 for public health action in Asia. The use of this cut-off, however, was not directly supported by data on mortality, since

deaths from any cause were lowest among men with BMI of 24.0 to 24.9 and women with a BMI of 25.0 to 26.9 kg/m^2 in a representative group of Chinese subjects.[17] In our study we followed the earlier reports for cut off points for BF% (25%). In Asian Indians, abdominal fat increased with increasing age, while the total BF showed little change. In the other ethnic groups, both abdominal and total BF increased with age.[18] Ethnic differences in fat distribution, muscularity, bone mass and leg length may contribute to ethnic-specific relationships between body fatness and BMI. Thus, the use of universal BMI cut-off points may not be appropriate for the comparison of obesity prevalence between ethnic groups.[19] Since the body fat % cut-off is a debatable issue, further studies to validate the cut-off for Pakistani population are required. [20]

CONCLUSION

Subjects showed higher prevalence of body fat percentage & BMI along with the risk for hypertension & type – 2 diabetes mellitus with the advancement of age of the individuals. Based on the available categorization for body fat percentage, [10] the results of this study validate the WHO recommendations of BMI ranges for healthy adult male & for the obese. Though unavailability of appropriate ranges of body fat percentage suggesting the need for evaluation & development of proper categorization of body fat percentage.

REFERENECES

1. Jackson AS, Stanforth PR, Gagnon J, Rankinen T, Leon AS, Rao DC, et al. The effect of sex, age and race on estimating percentage body fat from body mass index: The Heritage Family Study. Int J ObesRelatMetabDisord. 2002; 26: 789-796.
2. World Health Organization: Obesity and overweight: fact sheet N0 311; 2012.
3. Ko GT, Tang J, Chan JC, Sung R, Wu MM, Wai HP, et al. Lower BMI cut-off value to define obesity in Hong Kong Chinese: an analysis based on body fat assessment by bioelectrical impedance. Br J Nutr 2001;85(2):239–42. pmid:11242492.
4. Chang CJ, Wu CH, Chang CS, Yao WJ, Yang YC, Wu JS, et al. Low body mass index but high percent body fat in Taiwanese subjects: implications of obesity cutoffs. Int J ObesRelatMetabDisord 2003;27(2):253–9.
5. Deurenberg P. Universal cut-off BMI points for obesity are not appropriate. Br J Nutr 2001;85(2):135–6.
6. Pappas G, Akhtar T, Gergen PJ, Hadden WC, Khan AQ. Health status of the Pakistani population: a health profile and comparison with the United States. Am J Public Health. 2001;91(1):93.
7. D. Heber, S. Ingles, J. M. Ashley, M. H. Maxwell, R. F. Lyons, and R. M. Elashoff, "Clinical detection of sarcopenic obesity by bioelectrical impedance analysis," American Journal of Clinical Nutrition, vol. 64, supplement 3, pp. 472s–477s, 1996.
8. WHO Expert Committee on Physical Status, "Physical status: the use and interpretation of anthropometry," WHO Technical Report Series, vol. 854, pp. 1–416, 1995.
9. WHO Expert Consultation, "Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies," The Lancet, vol. 363, pp. 157–163, 2004.
10. K. M. Flegal, J. A. Shepherd, A. C. Looker et al., "Comparisons of percentage body fat, body mass index, waist circumference, and waist-stature ratio in adults," American Journal of Clinical Nutrition, 2009. 89(2): pp. 500–508.
11. Gu D, He J, Duan X. Body weight and mortality among men and women in China. JAMA 2006; 295: 776-83.
12. Stevans J. Ethnic specific revisions of body mass index cut offs to define overweight and obesity in Asians are not warranted. Int J RelatMetab Disorder 2003; 27: 1297-9.
13. Swinburn BA, Ley SJ, Carmichael HE, Plank LD. Body size and composition in Polynesians. Int J Obes1999; 23: 1178-83.
14. Mei Z, Grummer-Strawn LM, Pietrobelli A, Goul-ding A, Goran MI, Dietz WH. Validity of body mass index compared with other body-composition screening indexes for the assessment of body fatness in children and adolescents. Am J ClinNutr 2002; 75:978-85.
15. Guricci S, Hartriyanti Y, Hautvast JGAJ, Duerenberg P. Relationship between body fat and body mass index: differences between Indonesians and dutch Caucasians. Eur J ClinNutr. 1998; 52:779–83.
16. Villareal DT, Apovian CM, Kushner RF, Klein S. Obesity in older adults: technical review and position statement of the American Society for Nutrition and NAASO, The obesity Society. Am J ClinNutr2005; 82: 923-34.
17. World Health Organization Western Pacific Region, International Association for the Study of Obesity, International Obesity Task Force. Asia Pacific perspective: Redefining obesity and its treatment. Australia: Health Communications Australia; 2000.
18. D. G. Altman and J. M. Bland, "Diagnostic tests 1: sensitivity and specificity," British Medical Journal, 1994. 308(6943): p. 1552.
19. Kushner RF, Kunigk A, Alspaugh M, Andronis PT, Leitch CA, Schoeller DA. Validation of bioelectrical- impedance analysis as a measurement of change in body composition in obesity. Am J ClinNutr1990; 52 :219-23.
20. K. M. Flegal, J. A. Shepherd, A. C. Looker et al., "Comparisons of percentage body fat, body mass index, waist circumference, and waist-stature ratio in adults," American Journal of Clinical Nutrition, 2009. 89(2): 500–508.

Acknowledgements: We would like to pay regards to the Baqai Medical University for granting us permission to conduct this study.

Authors Contribution: **Main Author** Supervisor *** Co-supervisor*

Conflict of interest statement: Non