Original Article

Assessment of body fat mass index and basal metabolism to body fat ratio as markers of cardiovascular risk in obese Indian population

Jagadeeswaran Indumathy, Gopal Krushna Pal, Pravati Pal, Subash Chandra Parija[1], Jayaraman Balachander[2]

Departments of Physiology, [1]Microbiology and [2]Cardiology, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry, India

Abstract

Background and Aim: Obesity is one among the prominent public health threats globally. Altered body composition and increased basal metabolism (BM) have been reported in obesity. However, the association of body composition and metabolic indices with cardiovascular (CV) risk in obese Indian population has not been studied. Therefore, the purpose of the present study was to determine the independent contribution of body composition and BM indices to CV risk in apparently healthy obese subjects.

Methods: Basal CV and body composition parameters were recorded in 100 subjects divided into controls (n = 48) and obese (n = 52) groups. Association and independent contribution of body mass index (BMI), BM to body fat (BM/BF) ratio and BF mass index (BFMI) with rate pressure product (RPP), an established CV risk was performed by Pearson's correlation and multiple regression analysis, respectively.

Results: Basal CV parameters were significantly increased in obese group compared to controls. Body composition parameters were also found to be significantly altered in obese group compared to controls. BMI, BM/BF, and BFMI had an independent contribution to RPP in the obese group, whereas no such association was observed in controls. Among these parameters, RPP had maximum association with BFMI (β =0.411, $P \leq 0.001$) and BM/BF (β =0.373, P = 0.005) in obese group.

Conclusion: Findings of the present study demonstrates increased RPP in obese subjects, predisposing them to future cardiac related morbidities. BFMI and BM/BF ratio appears to be better markers of CV risk in obese Indian population.

Key words: Basal metabolism, body fat mass index, cardiovascular risks, obesity, rate pressure product

Received: 16th August, 2015; ***Revised:*** 21th September, 2015; ***Accepted:*** 29th September, 2015

INTRODUCTION

Obesity and its associated co-morbidities such as dyslipidemia, hypertension, insulin resistance, diabetes mellitus, and other cardiovascular (CV) related dysfunctions have become a prominent threat to public health worldwide.[1] There are several obesity indices including body mass index (BMI), body fat (BF) mass, fat-free mass (FFM), waist-to-hip ratio, and waist-to-height ratio to estimate the CV risk in the obese population.[2-4] Though, BMI is a widely accepted and easy method for defining the level of obesity; evidence suggest body composition as the primary determinant of health and better predictor of mortality risk than BMI.[5] However, no

Access this article online	
Quick Response Code:	Website: www.ijcep.org
	DOI: 10.4103/2348-8093.169966

Address for correspondence: Dr. Gopal Krushna Pal, Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry - 605 006, India.
E-mail: drgkpal@gmail.com

How to cite this article: Indumathy J, Pal GK, Pal P, Parija SC, Balachander J. Assessment of body fat mass index and basal metabolism to body fat ratio as markers of cardiovascular risk in obese Indian population. Int J Clin Exp Physiol 2015;2:180-4.

study published so far has validated a specific component of body composition as a predictor of future CV risks in otherwise healthy young obese subjects. The basal metabolic rate represents the largest component of total energy expenditure[6] and has been reported to be a risk factor for mortality.[7,8] Though, studies have reported increased resting energy expenditure in obesity,[6,9] the contribution of basal metabolism (BM) to the altered CV profile in obese subjects have not been studied. Altered body composition and increased BM have been reported in obesity, but to the best of our knowledge, no study has assessed the association of body composition indices and BM with CV risk in obese Indian population. Increased rate pressure product (RPP), an index of myocardial work stress has been documented to be an indicator of CV risk.[10] Therefore, the present study aims to determine the independent contribution of body composition indices and BM to RPP in apparently healthy obese subjects.

MATERIALS AND METHODS

Subjects

This is a cross-sectional study, conducted in the Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry, India. After obtaining approval of the project plan from research and ethics committees of JIPMER, 100 healthy young adults aged between 18 and 40 years were recruited from the medicine out-patient department, JIPMER.

Grouping of the subjects

Height was measured to the nearest millimeter by a wall-mounted stadiometer and weight was measured with digital weigh balance to the nearest 0.1 kg. BMI was calculated using the formula weight in kilograms divided by square of height in meters. Based on the BMI classification of WHO for Asian population,[11] these subjects were divided into following two groups:

- Control group: Normal healthy subjects having BMI 18.50–22.99 ($n = 48$)
- Obese group: Healthy subjects having BMI 27.50 or above ($n = 52$).

Written informed consent was obtained from all the participants prior to initiation of the study. A brief medical and personal history was obtained from the subjects. Subjects on antihypertensive therapy or receiving any medication, with a history of smoking and/or alcoholism, with acute or chronic ailments and known cases of diabetes mellitus, hypertension, cardiac diseases, kidney disease or any endocrinal disorder were excluded from the present study. As the level of physical fitness is a major determinant of vagal tone, subjects performing regular athletic activities, body-building exercises, and yoga[12,13] were also excluded from the study.

Baseline cardiovascular parameters

After 10 min of supine rest, blood pressure (BP) was recorded by an oscillometric method using automated BP monitors Omron MX3 (Omron Healthcare Co., Ltd., Kyoto, Japan). For each subject, systolic BP (SBP), diastolic BP (DBP), and heart rate (HR) were recorded in left arm twice with an interval of 5 min between the recordings. For each of these parameters, the average of the two data was considered as the final recording. RPP, a determinant of myocardial oxygen consumption and workload, was calculated using the formula, RPP = (basal HR [BHR] × SBP) $\times 10^{-2}$.[10]

Assessment of body composition

Body composition was determined by bioelectrical impedance analysis (BIA), a method which involves the measurement of bioelectrical resistive impedance.[14] This method is regarded as safe and reliable and based upon the principle that the electrical conductivity of the fat-free tissue mass is far greater than that of fat. Measurements at 5/50/100/200 kHz were obtained using the multiple frequency BIA instrument Bodystat®, (Model Quad Scan 4000®, Isle of Man, United Kingdom). Subjects were instructed to avoid eating or drinking for 4 h prior to the test, and to avoid exercise and alcohol for 24 h prior to the test. Subjects were placed in the supine position with no parts of the body touching another for at least 10 min in standardized conditions (quiet environment and ambient temperature). The electrodes were placed on the dorsal surfaces of the hand and foot proximal to metacarpal-phalangeal and metatarsal-phalangeal joints, respectively. BIA included BF, lean body mass, body cell mass (BCM), total body water (TBW), intracellular water (ICW), and extracellular water (ECW). The other parameters obtained using the current range of 50–100 kHz includes BF%, BF mass index (BFMI), BM, BM to BF (BM/BF) ratio, BM to body weight (BM/BW) ratio and activity metabolism (AM).

Statistical analysis of data

SPSS version 13 (SPSS Software Inc., Chicago, IL, USA) was used for statistical analysis. All the data were presented as mean ± standard deviation. Normality of data was tested by Kolmogorov–Smironov test. The level of significance between the groups was tested by Student's *t*-test. The association between RPP and various parameters was assessed by Pearson's correlation analysis. The parameters that yielded significance in correlation analysis were considered in a single model for multiple regression analysis with RPP (dependent variable). The $P < 0.05$ was considered statistically significant.

RESULTS

There was no significant difference in age ($P = 0.757$) between the control and obese group subjects [Table 1]. BMI and basal CV parameters such as BHR, SBP, DBP, mean arterial pressure, and RPP were found to be significantly ($P < 0.0001$) high in obese group compared to controls [Table 1].

Body composition parameters such as BF, BCM, BM, AM, and BFMI were found to be significantly increased, and body lean, TBW, ECW, ICW, BM/BW ratio and BM/BF ratio were found to be significantly decreased in obese group compared to controls [Table 2]. Although there was no significant correlation of RPP with any of the parameter in controls, the correlation of BMI, BM/BF ratio and BFMI with RPP was significant in the obese group [Table 3]. Multiple regression analysis revealed the significant individual contribution of BMI, BM/BF ratio and BFMI to RPP in the obese group; whereas no such contribution was observed in control subjects [Table 4].

Table 1: Comparison of age, BMI and basal CV parameters between control and obese group

Parameters	Control group (*n*=48)	Obese group (*n*=52)	*P*
Age (years)	28.33±7.21	27.84±8.52	0.757
BW (kg)	53.16±6.97	76.75±10.86	<0.0001
BMI (kg/m^2)	19.88±1.12	31.09±2.11	<0.0001
BPV parameters			
BHR (per min)	70.02±9.79	80.84±10.51	<0.0001
SBP (mmHg)	107.73±8.92	120.00±7.67	<0.0001
DBP (mmHg)	66.95±6.74	79.88±7.81	<0.0001
MAP (mmHg)	80.54±6.89	88.53±6.98	<0.0001
RPP (mmHg/min)	75.36±11.92	97.12±14.98	<0.0001

The values are expressed as mean±SD; statistical analysis was done by Student's *t*-test. The $P<0.05$ was statistically considered significant. BW: Body weight, BMI: Body mass index, BHR: Basal heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, RPP: Rate pressure product, BPV: Blood pressure variability, SD: Standard deviation, CV: Cardiovascular

Table 2: Comparison of body composition parameters between control and obese group

Parameters	Control group (*n*=48)	Obese group (*n*=52)	*P*
Body fat (%)	19.50±6.62	24.53±10.01	0.004
Body lean (%)	80.71±6.21	73.92±13.82	0.002
BCM (kg)	24.53±4.82	30.16±6.03	<0.0001
TBW (%)	59.51±6.46	51.76±6.24	<0.0001
ECW (%)	26.24±1.79	24.22±1.77	<0.0001
ICW (%)	32.10±4.83	29.23±3.78	0.001
BM (kcal/day)	1416.97±156.65	1727.50±291.99	<0.0001
AM (kcal/day)	2098.87±370.62	2559.84±436.39	<0.0001
BM/BW (kcal/kg)	26.79±1.09	24.00±2.28	<0.0001
BM/BF (kcal/kg)	158.56±72.69	117.67±54.23	0.001
BFMI	3.77±1.36	6.66±3.19	<0.0001

The values are expressed as mean±SD; statistical analysis was done by Student's *t*-test. The $P<0.05$ was statistically considered significant. BCM: Body cell mass, TBW: Total body water, ECW: Extracellular water, ICW: Intracellular water, BM: Basal metabolism, AM: Activity metabolism; BM/BW: Ratio of basal metabolism to body weight, BM/BF: Ratio of basal metabolism to body fat, BFMI: Body fat mass index, SD: Standard deviation

Table 3: Correlation of RPP with various parameters in control and obese groups

Parameters	Control group (*n*=48)		Obese group (*n*=52)	
	r	*P*	*r*	*P*
BMI	0.109	0.462	0.278	0.046
BM	0.025	0.867	0.086	0.542
BM/BW	0.006	0.966	0.218	0.121
BM/BF	0.036	0.810	0.239	0.038
BFMI	0.029	0.842	0.324	0.019

The $P<0.05$ was statistically considered significant. RPP: Rate pressure product, BMI: Body mass index, BM/BW: Ratio of basal metabolism to body weight, BM/BF: Ratio of basal metabolism to body fat, BFMI: Body fat mass index

DISCUSSION

Increased RPP in obese subjects depicts a considerable increase in myocardial workload and oxygen consumption in these subjects.[10] Increased RPP has also been documented as an indicator of CV risk.[10] Therefore, increased RPP in obese subjects might predispose them to adverse CV events in future. Resting HR has been reported to be associated with increased CV morbidities.[15] Hence, the increased resting HR in obese subjects compared to controls [Table 1] indicates increased CV risk in obese subjects. The body composition parameters were significantly altered in obese subjects depicting an increase in BF proportion with the corresponding decrease in the body lean proportion [Table 1]. Studies have highlighted the importance of determining BF and FFM in the assessment of mortality risk and clinical outcome associated with obesity.[5] However, the absolute values of BF and FFM vary with height, weight, and age. BFMI adjusted for height reflects a precise assessment of adiposity status in obese subjects.[16] In the present study, BFMI had an independent association with RPP in obese group subjects [Table 4]. Thus, increased adiposity expressed in terms of BFMI could be used as a marker of CV risk in obesity.

BM is a major contributor to energy balance, as it plays a key role in the utilization of fat content of the body and in determining the energy imbalance associated with obesity.[17,18] Therefore, it could be assumed that the increased BM in obese subjects might contribute to their state of energy dyshomeostasis. This was further supported by increased BCM in obese subjects [Table 1], as BCM reflects the metabolically active cells in the body.[19] The high basal metabolic rate has been reported to be a risk factor for mortality. Therefore, the increased BM and BCM might aggravate the mortality risks associated with obesity.

Table 4: Multiple regression analysis of RPP (as dependable variable) with various parameters (as independent variables) in control and obese groups

Parameters	Control group (*n*=48)		Obese group (*n*=52)	
Independent variables	Standardized regression coefficient *B*	*P*	Standardized regression coefficient *B*	*P*
BMI	0.204	0.165	0.370	0.007
BM/BF	0.154	0.295	0.399	0.003
BFMI	0.074	0.619	0.394	0.004

The *P*<0.05 was statistically considered significant. BMI: Body mass index, BM/BF: Ratio of basal metabolism to body fat, BFMI: Body fat mass index, RPP: Rate pressure product

The ratios of both BM/BW and BM/BF were decreased in obese compared to control group. While the absolute resting metabolic rate is higher, the BM/BW ratio and BM/BF ratio is lower in obese subjects due to the lower metabolic rate of adipose tissue.[17] In the present study, BM/BF ratio had an independent association with RPP in obese group subjects [Table 4]. Thus, findings of the present study suggest that the increased metabolism in obese subjects might possibly contribute to CV abnormalities associated with obesity. Moreover, it has been reported that Asian population with an average BMI (within the normal range) is at increased risk for developing CV related morbidities compared to their counterparts in other ethnic groups.[11]

Recently, India has been listed third among the top global hazard countries accounting for about 30 million obese populations.[1] Therefore, early assessment and prevention of future CV risks in this high-risk population should be considered. In the present study, the BFMI and BM/BF ratio were observed to be better markers of CV risks in obesity and might contribute to the future CV morbidities associated with obesity. Though, BFMI had maximum contribution with RPP, the findings of the present study indicate that BM/BF ratio should also be considered as a potential marker for the assessment of CV risk in obese subjects. However, future studies should be conducted in larger sample size using multiple regression analysis to confirm the prediction and independent contribution of these indices in the presence of other co-variants.

Limitations of the study

From the findings of the present study, we could not clearly elucidate the possible physiological link of BFMI and BM/BF ratio with CV risks in the obese population. Therefore, future studies should assess the physiological link between these indices and CV profile in a larger population of obese subjects.

CONCLUSION

Increased resting HR, BP, and RPP in apparently healthy obese subjects might predispose them to adverse CV events in future. Increased resting metabolic activity in obese subjects might further increase their susceptibility to mortality risks. BFMI and BM/BF ratio appear to be better markers of CV risk in obese Indian population.

Acknowledgments

We would like to acknowledge the financial assistance from JIPMER in the form of intramural Ph. D research grant.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Ng M, Fleming T, Robinson M, Thomson B, graetz N, Margono C, *et al.* Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: A systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014;384:766-81.
2. Yan RT, Yan AT, Anderson TJ, Buithieu J, Charbonneau F, Title L, *et al*. The differential association between various anthropometric indices of obesity and subclinical atherosclerosis. Atherosclerosis 2009;207:232-8.
3. Bombelli M, Facchetti R, Fodri D, Brambilla G, Sega R, Grassi G, *et al.* Impact of body mass index and waist circumference on the cardiovascular risk and all-cause death in a general population: Data from the Pamela study. Nutr Metab Cardiovasc Dis 2013;23:650-6.
4. Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0·5 could be a suitable global boundary value. Nutr Res Rev 2010;23:247-69.
5. Segal KR, Dunaif A, Gutin B, Albu J, Nyman A, Pi-Sunyer FX. Body composition, not body weight, is related to cardiovascular disease risk factors and sex hormone levels in men. J Clin Invest 1987;80:1050-5.
6. Jéquier E. Energy expenditure in obesity. Clin Endocrinol Metab 1984;13:563-80.
7. Speakman JR. Body size, energy metabolism and lifespan. J Exp Biol 2005;208(Pt 9):1717-30.
8. Ruggiero C, Metter EJ, Melenovsky V, Cherubini A, Najjar SS, Ble A, *et al.* High basal metabolic rate is a risk factor for mortality: The baltimore longitudinal study of aging. J Gerontol A Biol Sci Med Sci 2008;63:698-706.
9. Hoffmans M, Pfeifer WA, Gundlach BL, Nijkrake HG, Oude Ophuis AJ, Hautvast JG. Resting metabolic rate in obese and normal weight women. Int J Obes 1979;3:111-8.
10. White WB. Heart rate and the rate-pressure product as determinants of cardiovascular risk in patients with hypertension. Am J Hypertens 1999;12(2 Pt 2):50S-5S.
11. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363:157-63.
12. Hepburn H, Fletcher J, Rosengarten TH, Coote JH. Cardiac vagal tone, exercise performance and the effect of respiratory training. Eur J Appl Physiol 2005;94:681-9.
13. Veerabhadrappa SG, Baljoshi VS, Khanapure S, Herur A, Patil S, Ankad RB, *et al.* Effect of yogic bellows on cardiovascular autonomic reactivity. J Cardiovasc Dis Res 2011;2:223-7.
14. Kyle UG, Bosaeus I, De Lorenzo AD, Deurenberg P,

Elia M, Manuel Gómez J, *et al*. Bioelectrical impedance analysis-part II: Utilization in clinical practice. Clin Nutr 2004;23:1430-53.
15. Jensen MT, Suadicani P, Hein HO, Gyntelberg F. Elevated resting heart rate, physical fitness and all-cause mortality: A 16-year follow-up in the Copenhagen Male Study. Heart 2013;99:882-7.
16. Deurenberg-Yap M, Chew SK, Deurenberg P. Elevated body fat percentage and cardiovascular risks at low body mass index levels among Singaporean Chinese, Malays and Indians. Obes Rev 2002;3:209-15.
17. Lazzer S, Bedogni G, Lafortuna CL, Marazzi N, Busti C, Galli R, *et al.* Relationship between basal metabolic rate, gender, age, and body composition in 8,780 white obese subjects. Obesity (Silver Spring) 2010;18:71-8.
18. Weststrate JA, Dekker J, Stoel M, Begheijn L, Deurenberg P, Hautvast JG. Resting energy expenditure in women: Impact of obesity and body-fat distribution. Metabolism 1990;39:11-7.
19. Wang Z, St-Onge MP, Lecumberri B, Pi-Sunyer FX, Heshka S, Wang J, *et al*. Body cell mass: Model development and validation at the cellular level of body composition. Am J Physiol Endocrinol Metab 2004;286:E123-8.