Research Article

Body adiposity index in metabolic syndrome

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Abstract

Background: Obesity is a chronic and complex disease defined as an excess of body fat. Adipose tissue accumulation increases the incidence and risk of adverse metabolic events and diseases. Many techniques have been developed for assessing and/or determining body fat or adiposity. A new index of adiposity, namely the body adiposity index (BAI) has been developed. Metabolic syndrome is a group of abnormalities that confers an increased risk of developing atherosclerotic cardiovascular diseases and type 2 diabetes mellitus. **Aim:** To determine BAI levels in metabolic syndrome, to analyse correlation of BAI with metabolic risk factors and to determine what appropriate cut-off value of BAI would be most closely predictive of the metabolic syndrome. **Materials and Methods**: A cross-sectional study was undertaken in M S Ramaiah Medical College and Hospitals, Bangalore. A detailed personal and clinical history, blood pressure, anthropometric measurements were recorded and a fasting blood sample was drawn from each of the 90 subjects selected. The serum samples were analyzed for Fasting Blood Sugar and lipid profile. **Results:** BAI levels in subjects with metabolic syndrome was 30.29% ±4.36 and 27.97 %±3.72 in controls without the presence of a single risk factor for metabolic syndrome. BAI showed a significant positive correlation with Serum triglycerides, Systolic and diastolic blood pressure in both the cases and controls and a significant negative correlation with Serum High Density Lipoprotein (HDL). A cut-off of 26.76% for BAI had an optimal sensitivity and specificity to be most closely predictive of the metabolic syndrome. **Conclusion:** BAI can be used as an additional marker in screening populations for metabolic syndrome in field studies; however its validity needs to be demonstrated in field studies with larger populations, before accepting it as a new marker to predict cardiovascular and other health risks.
Keywords: Metabolic Syndrome, Body Adiposity Index, cardiovascular risk, HDL and triglycerides.

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INTRODUCTION

Obesity is a chronic and complex disease defined as an excess of body fat that has become one of the most important public health problems. The increase in prevalence of obesity has led to an increase in the prevalence of several related comorbidities[1,2]. Adiposity is the physiological characteristic of obese and overweight people, which puts them at-risk for cardiovascular disease[3,4]. Adipose tissue accumulation also increases the incidence and risk of adverse metabolic events and diseases[5]. Body fat content, fat distribution or adiposity, therefore, could be considered as important indicators of metabolic risk. Many techniques have been developed for assessing and/or determining body fat or adiposity. These include the body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), skinfold thickness, dual-energy X-ray absorption (DXA) and hydrostatic densitometry[6,7]. Recently, a new index of adiposity, namely the body adiposity index (BAI) has been developed, to overcome the shortcomings of BMI. BAI can be calculated solely from the hip circumference and height {(hip circumference in cms)/[(height in meters)$^{1.5}$ - 18]}, and it can be used to reflect body fat percentage (BF%) in adults[8]. It has been suggested that the BAI can be used to mirror %body fat for adult men and women of differing ethnicities without numerical correction. The BAI can be measured without weighing, which renders it

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useful in settings where measuring accurate body weight is problematic. It can be used in the clinical setting even in remote rural locations with very limited access to reliable scales. The BAI estimates % adiposity directly[8]. The Metabolic syndrome (MS) refers to a group of abnormalities like abdominal obesity, atherogenic dyslipidemia, raised blood pressure, insulin resistance and/or glucose intolerance, that confer an increased risk for developing type 2 diabetes mellitus (T2DM) and cardiovascular diseases[9]. This syndrome is seen in about 20-30% of the adult population worldwide[10]. The syndrome is common and has a rising prevalence worldwide, relating largely to a complex interplay of rapid nutritional alterations, sedentary lifestyle and socioeconomic evolution, increasing affluence, rural-to-urban migration, leading to obesity[10]. A number of associations/organizations have proposed criteria for the definition of metabolic syndrome[11-15]. The most recent definition is from the Joint Interim Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; the National Heart, Lung, and Blood Institute (AHA/NHLBI); the American Heart Association; the World Heart Federation; the International Atherosclerosis Society; and the International Association for the Study of Obesity[16] and also a Consensus Statement for Diagnosis of Obesity, Abdominal Obesity and the Metabolic Syndrome for Asian Indians[17]. As per these consensus statements, the presence of three or more of the following five parameters could be considered as presence of MS.

1. Elevated waist circumference: ≥90 cm in men and ≥80 cm in women
2. Elevated triglycerides: ≥150 mg/dL or on drug treatment (example-fibrates, nicotinic acid) for elevated triglycerides
3. Reduced HDL-C: <40 mg/dL in men and <50 mg/dL in women, or on drug treatment for reduced HDL-C (example-fibrates, nicotinic acid),
4. Elevated blood pressure: ≥130 mm Hg systolic blood pressure and/or ≥85 mm Hg diastolic blood pressure or on antihypertensive drug treatment in a patient with a history of hypertension,
5. Elevated fasting glucose: ≥100 mg/dL or on drug treatment for elevated glucose.

Many studies in India have reported a continuing high prevalence of metabolic syndrome in both rural and urban India[1822]. The objective of this study was a) to determine BAI levels in metabolic syndrome, b) to analyse correlation of BAI with metabolic risk factors and c) to determine what appropriate cut-off value of BAI would be most closely predictive of the metabolic syndrome.

MATERIALS AND METHODS

This study is part of a cross sectional study entitled "Serum Osteocalcin levels in Metabolic Syndrome" that was conducted for a period of one and a half years from December 2012 to May 2014 at M S Ramaiah Medical College and Hospitals, Bangalore, after obtaining ethical clearance from the institutional Ethics committee. Study subjects were selected from those attending the routine health check up clinic at M S Ramaiah Hospitals. 45 people (males and pre-menopausal females) in the age group 20-50 years having 3 or more of the 5 criteria mentioned above[16,17] were included as cases. Age and gender matched healthy individuals, who did not have even a single criterion of the metabolic syndrome were taken as controls for the study. Subjects with hepatic disease, renal disease, acute illnesses, infections, thyroid and other endocrine dysfunctions, heart diseases, inpatients admitted for surgery, female subjects who were pregnant or lactating were excluded from the study. A written and informed consent was obtained from each study subject. A detailed history with physical examination and anthropometric measurements was recorded using standardized protocol and instruments[23]. About 3mL of blood was collected, with due aseptic precautions after an overnight fast (no calorific intake) of 8-12 hours, from each study subject, in the phlebotomy section of the diagnostic laboratory of M S Ramaiah Hospitals, Bangalore. The blood samples were allowed to clot and were centrifuged at 4000 rpm for 8-10 minutes. After separation of serum, the following lab investigations were done on the samples on Cobas 6000c501 RXL MAX TM, fully automated analyzer at the diagnostic laboratory of M S Ramaiah Hospitals, Bangalore- Fasting blood sugar(FBS) by Hexokinase method[24], Serum total cholesterol- enzymatic colorimetric method using cholesterol oxidase[25], Serum triglyceride enzymatic colorimetric method using glycerol phosphate oxidase[26], Serum high density lipoprotein- enzymatic colorimetric method using cholesterol oxidase and esterase[27], Low density lipoprotein using Friedwalds equation[28]. The following methods of statistical analysis have been used in this study. Data was entered in Microsoft excel and analysed using SPSS (Statistical Package for Social Science, Ver.10.0.5) package. The results were averaged (mean + standard deviation) for continuous data and number and percentage for dichotomous data. The student't' test was used to determine whether there was a statistical difference between groups in the parameters measured if the data is normal. "p" value of less than 0.001 was accepted as indicating statistical significance.

RESULTS

The present study was a cross sectional case controlled study, with 90 study subjects- 45 subjects of metabolic syndrome having the presence of 3 or more criteria/parameters according to the AHA/NHLBI[16,17] as cases and 45 healthy subjects not having the presence of even a single parameter of metabolic syndrome[16,17], as controls. The mean ± SD of age in years in cases was 43.36±5.77 and 36.22±7.65 in controls. Amongst the cases, 21(46.7%) subjects were females and 24(53.3%) were males and amongst the controls there were 22(48.9%) female subjects and 23(51.1%) male subjects. Table-1 shows a comparison of the baseline variables and biochemical parameters between the two groups. Statistically significant differences were found between the two groups in terms of FBS, Serum Triglycerides, Serum HDL, Systolic BP, Diastolic BP, Waist circumference, Hip circumference and BAI. Table 2 shows the coefficients of bivariate correlations between BAI and cardiovascular risk factors.

Table 1: The baseline variables and biochemical parameters between the two groups

	Cases n=45 Mean± SD	Controls n=45 Mean± SD	'p' value
Fasting Blood Sugar (mg/dl)	161.8 ±38.65	87.53±8.10	<0.001*
S.Total Cholesterol (mg/dl)	195.93±51.91	169.93±28.7	0.004
S.Triglyceride (mg/dl)	177.93±41.99	92.18±28.39	<0.001*
S. High Density Lipoprotein (mg/dl)	31.56±10.4	50.49±8.39	<0.001*
Systolic Blood Pressure (mm/Hg)	134.4±9.07	120.13±6.33	<0.001*
Diastolic Blood Pressure (mm/Hg)	87.82±5.14	78.98±4.48	<0.001*
Waist Circumference(cms)	90.73±4.82	77.33±3.275	<0.001*
Height (metre)	1.65±0.081	1.67±0.088	0.200
Hip Circumference(cms)	101.73±4.223	98.93±3.810	0.001*
Body Adiposity Index	30.29±4.36	27.97±3.72	0.008*

Table 2: Correlations between BAI vs parameter in study subjects

	BAI in Cases r	BAI in Controls r
Fasting Blood Sugar in mg/dl	0.23	0.13
Triglyceride in mg/dl	**0.39***	**0.45***
High Density Lipoprotein in mg/dl	**-0.39***	**-0.40***
Waist Circumference in cms	0.11	0.03
Systolic Blood Pressure in mm/Hg	**0.37***	**0.32***
Diastolic Blood Pressure in mm/Hg	**0.30***	**0.29***

r=Correlation Coefficient, The level of significance was *p<0.01

Using a cut-off for BAI as 26.76, proposed by a previous study[29], a sensitivity of 86.67% (95% CI: 73.20 % to 94.91 %) and specificity of 33.33% (95% CI: 20.01 % to 48.95 %) was obtained as shown in Table 3. Figure 1 shows the ROC curve for BAI with respect to the presence of MS and Area Under the Curve (AUC) was 0.78.

Table 3: ROC curve analysis to determine the diagnostic value of BAI to predict the Metabolic Syndrome

	Cut-off	Sensitivity	Specificity	LR+	LR-	AUC	P value
BAI	>26.76	86.67	33.33	1.30	0.40	0.7752	0.001**

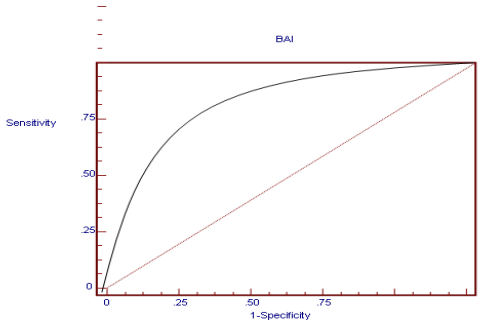

Figure 1: ROC Curve to determine the diagnostic value of BAI to predict the Metabolic Syndrome

DISCUSSION

The objective of this cross sectional study was a) to determine BAI levels in metabolic syndrome, b) to analyse correlation of BAI with metabolic risk factors and c) to determine what appropriate cut-off value of BAI would be most closely predictive of the metabolic syndrome. In the present study, BAI levels in subjects with metabolic syndrome was 30.29% ±4.36 and 27.97 %±3.72 in controls without the presence of a single risk factor for metabolic syndrome. Bergman *et al*. suggested the body adiposity index (BAI) based on the measurements of hip circumference and height, as an alternative to BMI to assess obesity. This index showed a high correlation with body fat measured using DXA (r = 0.85, P,0.001). In their study, conducted only in two U.S. ethnic populations, African Americans and Mexican Americans, Bergman *et al*. concluded that the BAI is a useful predictor of obesity that involves more simple measurements because weight is not needed[8]. In the present study, BAI showed a significant positive correlation with Serum triglycerides, Systolic and diastolic blood pressure in both the cases and controls (Serum Triglycerides r=0.39 in cases and r=0.45 in controls, Systolic Blood Pressure r=0.37 in cases and r=0.32 in controls, Diastolic Blood Pressure r=0.30 in cases and r= 0.29 in controls). BAI showed a significant negative correlation with Serum High Density Lipoprotein (HDL) (r= 0.39 in cases and r= 0.40 in controls). A study done by Yeon-Ah Sung *et al*.,[11] showed BAI was significantly correlating to other anthropometric measurements and metabolic indices like fasting blood sugar, serum fasting insulin, serum triglycerides and serum HDL. In order to determine the appropriate cut-off value of BAI that would be most closely predictive of the metabolic syndrome, an ROC curve was plotted, using a cut-off for BAI of 26.76% (proposed by a previous study by Bennasar-Veny M *et al*.,[29]). The Area Under the Curve (AUC) was found to be 0.78, with a sensitivity of 86.67% and specificity of 33.33%. A study by Veny *et al*., (Veny 2013) used the cutoff point of 26.76% for BAI to get a sensitivity of 78% (95% CI: 76%–78%) and a specificity was 51% (95% CI: 51%–52%). The body mass index (BMI) is an accepted and useful index to characterize obesity in individuals. However, despite its widespread use, it does not provide an accurate measurement of body composition, and may be influenced by age, sex, and ethnicity[30,31]. BAI has been suggested to have several advantages over BMI. BAI gives similar associations with BF% for men and women and may be more practical to assess in field studies because it does not require a weight measurement.BAI was developed and validated in studies of Mexican-American and African-American adults. Several recent studies of BAI values for predicting fat content or metabolic disorders in European-American, Mexican-American, Caucasian and Asian subjects have reported controversial results[11,32,33,34]. In Caucasians, BAI is a better estimate of adiposity than BMI in non-obese subjects, but less effectively than BMI in obese men and women[33,35]. Another study reported that BMI more strongly correlated with BF% than BAI, and more highly associated with diabetes risk in Caucasian[36]. In Mexican Americans, BAI was correlated more strongly than BMI with BF% in sex-pooled analyses, but not in sex-stratified analyses. Also, BAI is inferior to the widely used BMI as a correlate of the cardiometabolic risk factors[37]. Only few studies have determined the relationship between both BMI and BAI and BF% in Asian subjects[11,38]. A recent study done in north India concluded that the correlation of BMI to percentage of body fat was better than that of BAI to percentage of body fat, the sensitivity and specificity of BAI were similar to, if not better than, BMI[39]. There were a relatively small number of subjects included in the present study, therefore, the findings may not be generalized to larger populations, and our analyses may have been underpowered. In conclusion, BAI is higher in subjects of metabolic syndrome, BAI correlated significantly to metabolic risk factors like Serum Triglycerides, Hypertension and Serum HDL and a cut-off of 26.76% for BAI had an optimal sensitivity and specificity to be most closely predictive of the metabolic syndrome. BAI can be used as an additional marker in screening populations for metabolic syndrome in field studies; however its validity needs to be demonstrated in field studies with larger populations, before accepting it as a new marker to predict cardiovascular and other health risks.

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