

# Visceral Adiposity Index: An Effective Tool for Predicting Metabolic Syndrome in Bangladeshi Adult Population

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### ABSTRACT

**Background:** Obesity induces adipocyte dysfunction with secretion of adipokines, which results in a cascade of chemical reaction which triggers the atherogenic process and insulin resistance leading to a set of metabolic abnormalities i.e., metabolic syndrome. The Visceral Adiposity Index (VAI) is a simple, gender-based obesity index and has been proposed to be a predictor of metabolic syndrome.

**Objective:** Our study aims to evaluate the effectiveness of the Visceral Adiposity Index (VAI) in prediction metabolic syndrome in Bangladeshi adult population.

**Methods:** This cross-sectional study was carried out in Department of Biochemistry and Molecular Biology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh, from January to June of 2017. A total of 200 apparently healthy subjects (108 men and 92 women) were selected for the study, who attended the out-patient-departments of the same institution. Anthropometric measurements were recorded, e.g., height, weight, waist circumference (WC). Body mass index (BMI) was calculated. Overnight fasting blood samples were collected to estimate plasma glucose and serum lipid profile. Then VAI was calculated for men and women separately and evaluated as a tool in diagnosis of metabolic syndrome among the participants. Receiver operating characteristic (ROC) curves were plotted to assess the performance of VAI in metabolic syndrome prediction by gender. The power of metabolic syndrome prediction was quantified by the area under the curve (AUC) with 95% confidence intervals.

**Results:** The mean age of the study participants was 42.4±5.2 years. Among 108 men, 63 had metabolic syndrome, while among 92 women, 31 had metabolic syndrome. Sensitivity and specificity of VAI in predicting metabolic syndrome in male study subjects were 83.2% and 70.3%, respectively, while in female study subjects 80.1% and 70.5% respectively. Receiver operating characteristic (ROC) curve analysis showed that the optimal cutoff value of VAI in male study subjects was 2.16 and area under the curve (AUC) value was 0.907, while in female study subjects, the values were 2.25 and 0.918 respectively (P<0.001).

**Conclusion:** The Visceral Adiposity Index (VAI) was found simple, accessible, and effective obesity index to predict metabolic syndrome in apparently healthy adults.

**Keywords:** Visceral Adiposity Index, Metabolic Obesity, Metabolic Syndrome, Bangladesh

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## INTRODUCTION

Excess accumulation of intra-abdominal adipose tissue, which is often termed as 'visceral obesity', is part of a phenotype including dysfunctional subcutaneous adipose tissue expansion and lipid storage closely related to clustering cardiometabolic risk factors that results in some negative impacts on health.<sup>1</sup> Obesity induces adipocyte dysfunction with secretion of adipokines. This results in a cascade of chemical reaction which triggers the atherogenic process and insulin resistance leading to a set of metabolic abnormalities.<sup>2</sup>

Body Mass Index (BMI) is the most commonly used tool to classify obesity. However, BMI-based classification is no longer reliable because it does not take visceral fat distribution and adipocyte dysfunction into account. Some normal-weight adults are also found to have increased insulin resistance, atherogenic lipid profiles and hence are prone to suffer from Type 2 diabetes mellitus, cardiovascular and cerebrovascular disease.<sup>3-5</sup> Therefore, a newer term "metabolic obesity" has been coined to address this issue. Metabolic obesity can be defined as the presence of metabolic syndrome in an individual, irrespective of his/her BMI. This implies that a person could be metabolically obese, in spite of having a normal BMI or being normal-weight.<sup>6-9</sup>

In clinical practice, such metabolically obese but normal-weight people seem to be the most challenging one to deal with. People who are metabolically obese but have normal weights stay out of the focus of clinicians and researchers. They are often thought to remain free from obesity-related complications due to their normal BMIs. In contrast, being metabolically unhealthy, they are definitely prone to an increased risk of Type 2 diabetes mellitus, cardiovascular diseases and stroke.<sup>6-9</sup> Therefore, early and accurate detection of patients with this phenotype has immense medical, social and economic significance.

Very recently, a number of studies have validated the Visceral Adiposity Index (VAI) to be a reliable and valuable indicator of visceral fat distribution and function. It also correlates well with the degree of insulin resistance.<sup>10</sup> The Visceral Adiposity Index (VAI) is a simple, gender-based mathematical formula comprising both anthropometric (body mass index, i.e., BMI and waist circumference) and biochemical parameters (serum triglycerides and HDL cholesterol levels). It does not require any complex investigation.

There are several studies done in different regions of the globe; however, to date, there is no published report on VAI in our population. Hence, we proposed this study to evaluate the effectiveness of the Visceral Adiposity Index (VAI) in prediction metabolic syndrome in Bangladeshi adult population.

## METHODS

This cross-sectional study was carried out in Department of Biochemistry and Molecular Biology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh, from January to June of 2017. A total of 200 apparently healthy subjects (108 men and 92 women) were selected for the study, who attended the out-patient-departments of the same institution. The study subjects were selected aged between 18 and 60 years through purposive and convenient sampling method (after exclusion of subjects who were pregnant, diabetic, or having history of kidney, liver, endocrine or malignant disease or any type of infection). The purpose and procedures were explained to them in details and written informed consent was taken. They were evaluated by history, clinical examination, and laboratory investigations as per data collection sheet. Anthropometric measurements were recorded, e.g., height, weight, waist circumference (WC). Then body mass index (BMI) was calculated i.e., weight in kilograms divided by the square of height in meters ( $\text{Kg}/\text{m}^2$ ), for each of them. In sitting position, systolic and diastolic blood pressure were recorded. Overnight fasting blood samples were collected to estimate plasma glucose and serum lipid profile. Fasting plasma glucose was estimated by using hexokinase method (in AU680 Clinical Chemistry Analyzer – Beckman Coulter, Inc., made in USA). Serum total cholesterol (TC), triglycerides (TG) and High-Density Lipoprotein cholesterol (HDL-C) were estimated by using enzymatic method (in ARCHITECT c4000 Clinical Chemistry Analyzer – Abbott Diagnostics Inc., made in USA). Low-Density Lipoprotein cholesterol (LDL-C) was calculated using the 'Friedewald formula'. Individuals were considered to have metabolic syndrome having at least three or more of the criteria (as determined by the American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement)<sup>11</sup>, and were categorized.

Visceral Adiposity Index (VAI) was calculated by the following formula:<sup>10</sup>

For males:

$$VAI = [WC/39.68 + (1.88 \times BMI) \times (TG/1.03) \times (1.31/HDL-C)]$$

For females:

$$VAI = [WC/36.58 + (1.89 \times BMI) \times (TG/0.81) \times (1.52/HDL-C)]$$

Here, WC or waist circumference is expressed in cm, BMI in kg/m<sup>2</sup>, serum TG and HDL-C in mg/dl.

Then VAI was evaluated as a tool to predict metabolic syndrome for each study subject. Receiver operating characteristic (ROC) curves were plotted to assess the performance of (VAI) in prediction of metabolic syndrome by gender. The power of metabolic syndrome prediction was quantified by the area under the curve (AUC) with 95% confidence intervals, i.e., a larger AUC reflecting better predictive accuracy.

All statistical analyses were conducted using SPSS version 22.0. for Windows (SPSS, Chicago, IL, USA). The difference was considered statistically significant at P value <0.05 based on a 2-sided probability. This study was approved by the Institutional Review Board (IRB) of Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh.

**RESULTS**

The mean age of the study participants was 42.4±5.2 years. Among 108 men, 63 had metabolic syndrome,

while among 92 women, 31 had metabolic syndrome (Table-I), as determined by the anthropometric and biochemical parameters, based on the criteria of the American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement.<sup>11</sup> Then study subjects were further evaluated by VAI. Sensitivity and specificity of VAI in detection of metabolic syndrome in male study subjects were 83.2% and 70.3%, respectively, while in female study subjects 80.1% and 70.5% respectively (Table-II). Receiver operating characteristic (ROC) curve analysis showed that the optimal cutoff value of VAI in male study subjects was 2.16, and area under the curve (AUC) value was 0.907; those indicated that VAI is a good predictor of metabolic syndrome in adult males. (Table-II, Fig. 1). Similarly, in female study subjects, the optimal cutoff value was 2.25, and area under the curve (AUC) value was 0.918; those also indicated that VAI is a good tool for prediction of metabolic syndrome in adult females (Table-II, Fig. 2).

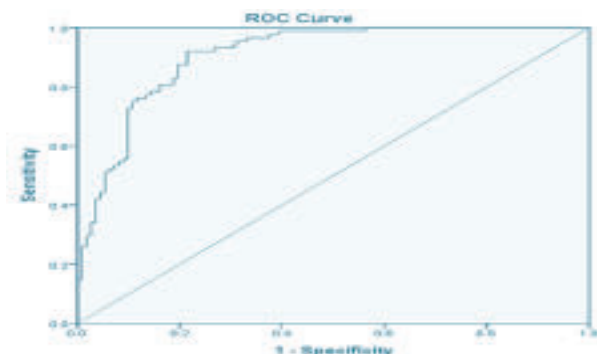
**Table-I:** Presence of metabolic syndrome among the study subjects (n=200)

Sex	Metabolic Syndrome		Total
	Yes (%)	No (%)	
Male	63 (31.5%)	45 (22.5%)	108
Female	31 (15.5%)	61 (30.5%)	92
Total	94 (47%)	106 (53%)	200

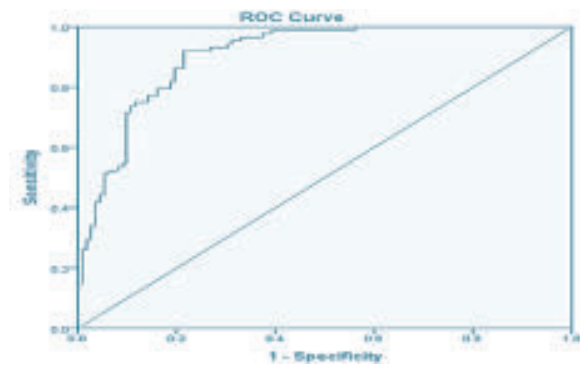
**Table-II:** Performance of Visceral Adiposity Index (VAI) to predict metabolic syndrome

Cut-off Points		Sensitivity (%)		Specificity (%)		AUC (95% CI)		P value	
Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
2.16	2.25	83.2	80.1	70.3	70.5	0.907	0.912	<0.001 <sup>S</sup>	<0.001 <sup>S</sup>

S=significant



**Fig. 1:** Receiver Operating Characteristic (ROC) Curve for Visceral Adiposity Index (VAI) in men.



**Fig. 2:** Receiver Operating Characteristic (ROC) Curve for Visceral Adiposity Index (VAI) in women.

## DISCUSSION

The present study demonstrated the utility of VAI as a simple but effective marker in detection of metabolically obese but normal-weight phenotype among Bangladeshi adults. To our knowledge, this is the first report on VAI that it has a high rate of accuracy for prediction of metabolic syndrome in Bangladeshi healthy men and women.

Amato et al. studied on 1,764 Italian patients and reported optimal VAI cut-off points ranging from 1.92 to 2.52 based on different age group,<sup>12</sup> while Baveicy et al. found the optimal cut-off points for VAI 4.11 (AUC: 0.82; 95% CI: 0.81–0.84) in men and 4.28 (AUC: 0.86; 95% CI: 0.85–0.87) in women to prediction of metabolic syndrome in 10,000 Iranian people.<sup>13</sup> Pekgor et al. reported a cut-off value of VAI in predicting metabolic syndrome 2.2 as they studied on 92 overweight and obese Turkish individuals.<sup>14</sup> Roriz et al. studied on 191 adults and elderly Brazilians and found the cut-off value 1.24 to 1.45 (sensitivity e"76.9%, specificity e"61.1) in men and 1.46 to 1.84 (sensitivity and specificity e"66.7) in women as well as a higher AUC i.e., 0.83 (CI: 0.705–0.955) and 0.71 (CI: 0.566–0.856) in men and women respectively.<sup>15</sup> Joshi et al. investigated 3,329 asymptomatic and healthy Gujarati Indian adults and the results reported that VAI had the best AUC (0.856) for metabolic syndrome.<sup>16</sup> According to Li et al., VAI showed the best diagnostic value for metabolic syndrome in men (ATPIII criterion: AUC 0.849, 95% CI 0.812–0.886; IDF criterion: AUC 0.792, 95% CI 0.739–0.844) in a Chinese population.<sup>17</sup> Štípanek et al. reported a cut-off value of 2.37, with a sensitivity of 0.86 and a specificity of 0.78, as they studied on 783 Czech individuals and concluded that VAI may provide a better estimation of subclinical atherosclerosis.<sup>18</sup>

The result of our study was compared and found more or less in agreement with that of above-mentioned studies. However, we found only few studies to support our results as because very limited number of studies have been conducted across the globe. Since no previous studies were found in our country to compare with our findings, it is still convincible with our results that the study was an appropriate one because of its simple mathematical calculations for clinical use, cost-effectiveness, and accessibility (with minimum laboratory facilities of a resource-poor country like Bangladesh). The result of the present

study is expected to help clinicians diagnose metabolic obesity even in normal-weight individuals quickly and conveniently.

It may be mentioned that similar studies were done in the same hospital setting to predict metabolic syndrome using 'lipid accumulation product' and 'triglycerides and glucose index', which showed that people having normal weights could be metabolically obese and are at risk of diabetes mellitus or cardiovascular diseases or other related complications.<sup>19,20</sup> Our present study reinforces that individuals should be assessed early and periodically and by using VAI, clinicians can detect metabolic syndrome in a simple way, counsel their patients to consider lifestyle interventions, and thereby prevent a significant amount of morbidity and mortality.

One of the limitations of the present study was its small sample size, due to time constraint and limited budget; another one was being a single-centre study in an urban area. Besides, selection of the study subjects was purposive following convenient sampling technique. Therefore, drawing conclusion for a general population from the study results would be challenging. Moreover, the study design (cross-sectional) limits observation on the mechanism of visceral adiposity in metabolic syndrome or assessment of the outcomes, which could be obtained from a prospective cohort study.

## CONCLUSION

Our data suggest that there is a significant prevalence of metabolic syndrome in apparently healthy Bangladeshi people and the Visceral Adiposity Index (VAI) is a simple, accessible, and effective tool to predict metabolic syndrome in those apparently healthy adults. However, a large-scale study involving multicentre both in rural and urban settings is recommended to reproduce the findings of this study and make it generalizable to the reference population.

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