Research article

Association of visceral adiposity index with cardiovascular risk factors among young adults

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ABSTRACT

Introduction and Aim: The frequent cause of mortality today is cardiovascular disease. Though dyslipidemia predicts cardiovascular risk, the possibility of risk cannot be excluded in normal lipid profile. Therefore, the study was conducted to associate visceral adiposity index (VAI) with cardiovascular risk factors among young adults.

Materials and Methods: It is a cross-sectional study in which 150 men and 150 women between the ages of 20 and 40 participated. A detailed clinical history, anthropometric measurements, fasting plasma glucose and fasting lipid profile were estimated. VAI was calculated.

Results: Mean VAI was 2.13±0.5 in men and 2.65±0.8 in women. Based on visceral adiposity index, 53% men and 61% women have a high risk of cardiovascular disease. VAI correlated positively with waist circumference, BMI, waist hip ratio, blood pressure, fasting plasma glucose, serum triglyceride, lipid ratios. VAI showed significant negative correlation with HDL cholesterol.

Conclusion: We explored the increase in cardiovascular risk among young adults. Though mean values of lipid profile and lipid ratios were within the desired range in our study, around 50% of the young adults had high risk for cardiovascular disease. Hence, VAI index can be used along with the existing lipid profile to identify those at increased cardiovascular risk.

Keywords: Cardiovascular risk; dyslipidemia; visceral adiposity index.

INTRODUCTION

Cardiovascular disease has now turned into the main source of mortality worldwide (1,2). Previously, cardiovascular disease was a disease of developed countries, but now developing countries are most affected by cardiovascular disease (3). This increase in cardiovascular disease is basically a direct result of expansion in the predominance of cardiovascular risk factors that include dyslipidemia, obesity, absence of active work, elevated blood pressure and smoking (4,5). Dyslipidemia is the significant factor for the occurrence of cardiovascular incidents (6).

Dyslipidemia assessed by traditional lipid parameters is not adequate to predict cardiovascular risk, especially in individuals with moderate risk (6). Hence there is a need to identify a predictor of cardiovascular risk, even in patients with normal lipid profile. Visceral adiposity is another significant factor for the progress of cardiovascular disease. Visceral adiposity can be measured by using computerized tomography, densitometry and magnetic resonance imaging but they are too complex, require more time and costly (7). Body mass index (BMI) that defines obesity, does not measure visceral adiposity. Though waist circumference (WC) can identify visceral adiposity, it does not differentiate subcutaneous fat from visceral fat (8).

Visceral adiposity index (VAI) is a newly introduced mathematical representation, which is specific to gender. It includes biochemical as well as anthropometric parameters like triglyceride, BMI, High density lipoprotein and WC. VAI is found to be a measure of dysfunction of adipose tissue and hence predicts cardiovascular risk indirectly (8). There are very few studies associating VAI with cardiovascular risk factors in residents of India. Therefore, our study was conducted to associate VAI with cardiovascular risk factors among young adults.

MATERIALS AND METHODS

Study population

The current study was done in the Clinical Biochemistry Laboratory at Aarupadai Veedu Medical College, Pondicherry. It was a cross sectional study approved by the Institutional Ethical Committee. The study involved one hundred and fifty men and one hundred and fifty women between 20 and 40 years old recruited from out-patient departments by random sampling method. Those with a history of liver disease, cardiovascular disease, renal disease, cancer, autoimmune disease, thyroid disorder, acute illness, and pregnant women were excluded.

Data collection

The history about the study subjects including diabetes, smoking, tobacco use, alcoholism, family

history and drug history was collected after getting written informed consent from them. We measured their height and weight and calculated BMI as weight (kilogram)/height (metre square). We measured waist circumference (WC) midway between the last rib and iliac crests. We measured hip circumference at points of greater trochanters. Their waist hip ratio (WHR) was also calculated as waist circumference divided by hip circumference. We measured their blood pressure in their right arm by mercury sphygmomanometer while sitting position.

Three millilitres of blood were collected from the median cubital vein in fasting state. Their plasma glucose levels and fasting lipid profile levels were assayed in the Mindray BS-380 Biochemistry autoanalyzer. The glucose oxidase method was used to estimate glucose levels and the cholesterol oxidase method was used to estimate total cholesterol levels. These diagnostic reagent kits were supplied by Jeev Diagnostics, Chennai, India. High density lipoprotein was estimated by direct method and glycerokinase method was used to measure serum triglyceride. These diagnostic reagent kits were supplied by Shenzhen Mindray bio-medical electronics, China.

VAI was calculated as given below (7)

$$\text{VAI (Men)} = [WC \text{ (cm)}/39.68 + (1.88 \times BMI \text{ (kg/m}^2))] \times [TG \text{ (mmoL/L)}/1.03] \times [1.31/HDL\text{-}C \text{ (mmol/L)}]$$

$$\text{VAI (Women)} = [WC \text{ (cm)}/36.58 + (1.89 \times BMI \text{ (kg/m}^2))] \times [TG \text{(mmoL/L)}/0.81] \times [1.52/HDL\text{-}C \text{ (mmol/L)}]$$

VAI was interpreted using age stratified cut off points used in Caucasian population to predict cardiovascular risk, as no cut off values are available in Indian population. VAI > 2.52 in < 30 years old and VAI > 2.23 in 30-40 years old were taken as elevated VAI levels to predict cardiovascular risk (9).

Risk factors for cardiovascular disease

- Diabetes Mellitus is characterized by fasting plasma glucose levels of more than or equal to 126mg/dL according to American Diabetes Association (10).
- Systemic Hypertension is characterized by blood pressure more than or equal to140/90 mm Hg according to Joint National Committee seven criteria (11).
- Dyslipidemia according to National Cholesterol Education Programme (12).
- Hypercholesterolemia is defined as total cholesterol levels more than or equal to 200 mg/dL.
- Hypertriglyceridemia is defined as triglyceride levels more than or equal to 150 mg/dL.
- Low density lipoprotein levels more than130 mg/dL.
- High density lipoprotein levels less than 40 mg/dL in males and less than 50 mg/dL in females.

- BMI more than or equal to 25 kg/m^2 is obesity and more than or equal to 23 kg/m^{2}is overweight (12).
- WC more than or equal to 80 cm in women, more than or equal to 90 cm in men (12).
- Physical Activity was graded as per World Health Organization devised Global Physical Activity Questionnaire (13).
- An activity is graded as high or vigorous physical activity if it needs a strenuous physical effort and largely increases the pulse rate or respiratory rate.
- An activity is graded as moderate physical activity if it needs a moderate physical effort and results in small increase in the pulse rate or respiratory rate.
- An activity is graded as sedentary physical activity if it does not meet the criteria of vigorous or moderate activity.
- Family history– The subjects were considered to have positive family history if they had a parent or grandparent with a coronary heart disease before the age of sixty.

Statistical analysis

Statistical analysis was done in SPSS V.28.0. Qualitative data were represented in proportions and continuous data were represented in mean ± SD. Independent t test and chi square test was done to compare continuous and qualitative variables respectively. Chi square test compared gender specific distribution of cardiovascular risk factors. Pearson correlation was performed to correlate VAI with cardiovascular risk factors. P value less than 0.05 was taken as statistically significant.

RESULTS

Characteristics of study participants

The study involved one hundred and fifty men and one hundred and fifty women between 20 and 40 years old. Men were significantly taller and had significantly higher weight, WC and WHR Compared to women. The difference in age, hip circumference, body mass index and blood pressure between males and females were not significant. (Table 1).

Men had significantly higher serum low density lipoprotein, non-high-density lipoprotein, low density lipoprotein/high density lipoprotein, total cholesterol/ high density lipoprotein, and triglyceride/ high density lipoprotein than women. High density lipoprotein was significantly low in men compared to women. The difference in plasma glucose, triglyceride and total cholesterol between men and women was not significant.

The mean VAI was 2.13±0.5 in men and 2.65±0.8 in women. Women had significantly higher VAI values than men (Table 2). 53% of men and 61% of women had elevated VAI (Fig. 1).

**Table 1**: Gender wise comparison of anthropometric variables

Variables	Males (n=150)	Females (n=150)	p value
Age (years)	32.5±3.7	32.1±4.9	0.366
Height (cm)	167.3±6.5	156.3±5.9	**<0.0001***
Weight (kg)	71.9±10.9	62.6±9.7	**<0.0001***
Body mass index (kg/m2)	25.6±3.3	25.4±3.9	0.601
Waist circumference (cm)	95.3±6.4	87.3±10.4	**<0.0001***
Hip circumference (cm)	98.2±5.2	99.5±8.6	0.142
Waist hip ratio	0.97±0.03	0.88±0.07	**<0.0001***
Systolic blood pressure (mm Hg)	120±14.4	117.3±15.2	0.149
Diastolic blood pressure (mmHg)	77.5±9.7	77.5±9.4	0.870

Data represented as mean ±SD; *Statistically significant p value

Table 2: Comparison of fasting plasma glucose, lipid profile, lipid ratios and visceral adiposity index between males and females.

Variables	Males (n=150)	Females (n=150)	p value
Fasting plasma glucose (mg/dL)	84.8±21.6	80.2±15.5	0.07
Total cholesterol (mg/dL)	180.8±34.6	177.5±37.1	0.457
Triglyceride (mg/dL)	142.7±57.3	142.1±44.7	0.930
Low density lipoprotein (mg/dL)	112.2±34.3	102.3±41.9	**0.039***
High density lipoprotein(mg/dL)	40.2±7.3	48.8±8.8	**<0.0001***
Total cholesterol/High density lipoprotein	4.68±1.1	4.0±1.2	**<0.0001***
Low density lipoprotein/High density lipoprotein	2.97±1.1	2.37±1.2	**<0.0001***
Triglyceride/High density lipoprotein	3.52±0.8	3.14±0.9	**0.001***
Non-High-density lipoprotein (mg/dL)	140.8±33.2	130.7±40.3	**0.030***
Visceral adiposity index	2.13± 0.5	2.65±0.8	**<0.0001***

Data represented as mean ±SD; *Statistically significant p value
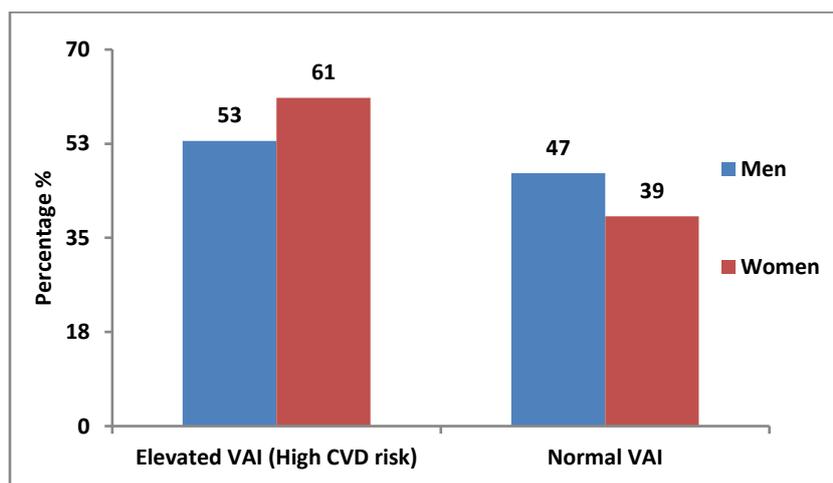
VAI – Visceral adiposity index, CVD- cardiovascular disease
Fig. 1: Cardiovascular risk based on VAI levels in young adults.

Among men, 83% had elevated waist circumference, 79% were overweight, 62% were obese, 57% had sedentary physical activity, 56% had low HDL cholesterol, 43% had high serum triglyceride, 31% had high total cholesterol, 30% had high LDL cholesterol, 21% were hypertensive and 5% were hyperglycemic. Among women, 74% had elevated waist circumference, 72% were overweight, 72% had sedentary physical activity, 69% had low HDL cholesterol, 58% were obese, 36% had high serum triglyceride, 23% had high LDL cholesterol, 22% had high total cholesterol, 17% were hypertensive and 3% were hyperglycemic (Fig. 2).

VAI correlated positively with WC, BMI, WHR, blood pressure, fasting plasma glucose, triglyceride, lipid ratios and non-high-density lipoprotein. VAI was negatively correlated with high density lipoprotein cholesterol (Table 3).
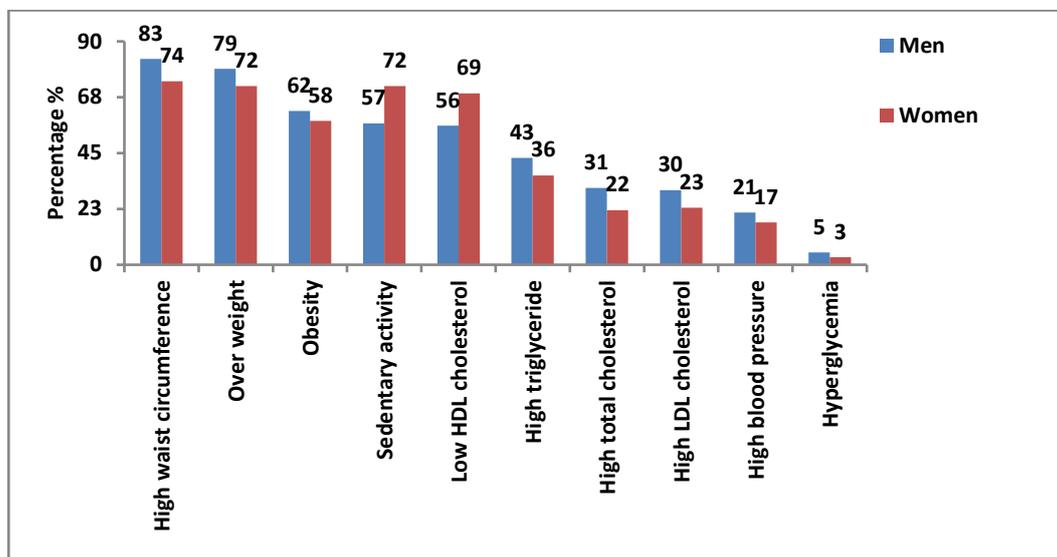
Fig. 2: Gender wise distribution of cardiovascular risk factors in young adults

Table 3: Correlation of Visceral adiposity index (VAI) with cardiovascular risk factors in young adults

Variables	VAI	
	r value	p value
Body mass index	0.128	**0.040***
Waist circumference	0.166	**0.008***
Waist hip ratio	0.282	**<0.0001***
Systolic blood pressure	0.141	**0.024***
Diastolic blood pressure	0.155	**0.013***
Fasting plasma glucose	0.195	**0.002***
Total cholesterol	0.024	0.697
Triglyceride	0.611	**<0.0001***
Low density lipoprotein	0.030	0.634
High density lipoprotein	-0.457	**<0.0001***
Total cholesterol/High density lipoprotein	0.451	**<0.0001***
Low density lipoprotein/High density lipoprotein	0.145	**0.021***
Triglyceride/High density lipoprotein	0.789	**<0.0001***
Non-High-density lipoprotein	0.136	**0.030***

*p value< 0.05, statistically significant

DISCUSSION

We estimated visceral adiposity index (VAI) in young adults and mean VAI was 2.13±0.5 in men and 2.65±0.8 in women in our study. The values obtained in our study are low compared to the study conducted in Jordanian adults (8), in which the study subjects were older, compared to our study. Women had significantly higher VAI levels compared to men, similar to the studies conducted in Peruvian adults (3) and Jordanian adults (8). As per the cut offs used in Caucasian population (10), 53% of men and 61% of women had elevated VAI. This also suggests high risk of cardiovascular disease in our study population.

Visceral adipose tissue estimated by bioimpedance method strongly associates with VAI in a study conducted in obese individuals. Hence VAI can be employed as a measure of adipocyte dysfunction (7). Visceral adiposity has more endocrine-like activity and hence, it is more pathogenic compared to subcutaneous adiposity. Several studies have found VAI as a more reliable measure of accumulation of visceral fat, as estimated by imaging techniques (14). VAI may provide insight into non classical cardiovascular risk factors like increased adipokine synthesis and pro-inflammatory activities as studies have shown that inflammation is a link that connects adipose tissue with cardiovascular risk (15).

Elevated waist circumference (WC) was the most common risk factor in both male and female participants. Elevated WC indirectly reflects the increased accumulation of visceral fat in the study subjects (16). Next to waist circumference, the second most prevalent risk factor was overweight and obesity. In our study, 79% men and 74% women were overweight, 62% men and 58% women were obese. This gives a very alarming picture of obesity in our study population. This is similar to findings observed

in the Malaysian population where 79.9% were obese and overweight (17).

Then, sedentary physical activity was prevalent with 72% in women and 57% in men. Women were less physically active than men as obtained in the studies of Akil *et al.,* (18) in New Delhi and Mckenzie *et al.,* (18) in the USA. Hence the increased prevalence of elevated waist circumference and obesity can be because of rapid urbanization and sedentary lifestyle in the study population (17). Therefore, young adults must be active to reduce blood pressure and blood cholesterol levels (20, 21).

Next prevalent cardiovascular risk factor was dyslipidemia. The most prevalent risk factor among the lipid parameters was low levels of high-density lipoprotein, in men as well as in women. The similar finding was obtained by Mohammed *et al.,* (22). Low high-density lipoprotein was more predominant in women than men in our study, as observed in the study conducted in the Northern part of India too (23).

Hypertension was the next prevalent cardiovascular risk factor in our study with a prevalence of 21% in males and 17% in females, as seen in the Malaysian population which was 20.1%. And the least prevalent cardiovascular risk factor was hyperglycemia which was 5% in males and 3% in females in our study, which is very less compared to that seen in the Malaysian population (17).

Then we correlated VAI with cardiovascular risk factors among young adults. VAI correlated positively with WC, BMI, WHR, blood pressure, fasting plasma glucose, triglyceride, lipid ratios and non-HDL cholesterol. VAI showed significant negative correlation with high density lipoprotein. However, the correlation of VAI with low density lipoprotein was not significant.

A study conducted in Jordanian adults (8) also showed positive correlation of VAI with SBP, DBP, fasting plasma glucose, serum TG and negative correlation with HDL-C. Correlation of VAI with cardiovascular risk factors can be explained by the statement that portal veins drain visceral adipose tissue into liver, where it causes insulin resistance, resulting in hyperglycemia (17).

Moreover, mobilization of free fatty acids is faster in visceral adipose tissue than subcutaneous adipose tissue, resulting in increased free fatty acid levels in the circulation. This leads to dyslipidemia, elevated blood pressure, impaired glucose tolerance and ultimately leads to atherosclerosis. And visceral fat produces vasoactive adipocytokines such as angiotensin which raises blood pressure, resulting in hypertension (17). As VAI correlates with all the cardiovascular risk factors in our study population, VAI can predict the cardiovascular risk among young adults.

Limitations

Our study could not explain causality because of its cross-sectional design. Hence longitudinal studies must be conducted further to strengthen association between VAI levels and cardiovascular risk.

CONCLUSION

We explored the increase in cardiovascular risk among young adults. Although mean values of lipid profile and lipid ratios were within the desired range in our study, around 50% of the young adults had high risk for cardiovascular disease. Hence, VAI index can be used along with the existing lipid profile to identify those at increased cardiovascular risk. These individuals must be advised to follow a healthy lifestyle such as consuming a healthy diet and doing regular aerobic exercises.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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