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Original Research Article

ASSESSMENT OF VISCERAL ADIPOSITY INDEX IN POST-MENOPAUSAL WOMEN: A NOVEL TOOL TO PREDICT CARDIOVASCULAR RISK

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ABSTRACT

Background: Obesity in menopausal women represent an important public health concern as it is closely associated with cardiovascular risk. During the transition to post-menopausal phase, Adipose tissue distribution shifts to visceral compartments due to loss of estrogen. Visceral Adiposity Index (VAI), a mathematical formula, serves as a strong predictor of Visceral Adiposity Dysfunction and cardiovascular risk. This study was aimed to assess the VAI in post-menopausal women and to correlate with Body mass index (BMI), waist circumference (WC), lipid profile parameters and blood pressure. **Materials and Methods:** A total of 60 post-menopausal women with no comorbidities were recruited for the study. Anthropometric parameters such as height, weight and circumference were measured. Lipid profile was done by collecting blood samples. VAI was calculated using the formula (VAI = {WC/[36.58 + (1.89 × BMI)] } × (TG/0.81) × (1.52/HDL). **Result:** BMI (27.04 ±3.91) and waist circumference (92.98 ± 8.16) was observed to be increased in post-menopausal women. The VAI of the study group is 3.08 ±1.76 which indicates moderate adipose tissue dysfunction and found to have dyslipidemia. In our study we observed a positive correlation between VAI and BMI, WC, systolic blood pressure, diastolic blood pressure, TG and a significant negative correlation between VAI and HDL. **Conclusion:** This study concludes that VAI was a practical and reliable tool for assessing the cardiometabolic risk in post-menopausal women.

INTRODUCTION

Cardiovascular disease is one of the major causes of mortality in India, including rural areas. Multiple studies are conducted in males as they are considered an intrinsic risk factor for cardiovascular diseases (CVD).[1]

In women, due to the beneficial role of estrogen in their reproductive age there is a delay in the emergence of CVD. Normally, women tend to have more adipose tissue than men; however, they pileup preferably in the subcutaneous depot that leads to reduced obesity related complications.[2] This gynoid pattern of fat distribution is due to 17 β estradiol, the predominant form of estrogen found in women during their reproductive age.[3]

As a result of increased life expectancy in developing countries, women spend their post-menopausal life in a state of estrogen deficiency that contributes to visceral adiposity. This shift in fat distribution and change in body mass composition during menopausal transition are associated with increased cardio metabolic risk factors including elevated blood pressure, increased LDL and obesity.

Visceral adipose tissue (VAT), a metabolically active tissue releases different bioactive molecules and hormones, such as adiponectin, leptin, tumour necrosis factor (TNF), resistin and interleukin-6.[4] Visceral adipose dysfunction (VAD) involves increased adipocytokine secretion and enhanced proinflammatory activity which is also a marker of cardiometabolic risk. Visceral adiposity along with dyslipidemia leads to a decline in insulin sensitivity and an increased risk of diabetes mellitus, hypertension, and atherosclerosis.[5]

BMI, a standard measure of obesity is not considered a reliable marker for estimating visceral fat & visceral adipose tissue dysfunction, as it does not include factors like gender, race etc. Waist circumference (WC), a better indicator of visceral fat,

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but its limitation is that it cannot differentiate between subcutaneous and visceral fat. The accurate method to measure visceral fat is Magnetic resonance imaging (MRI), Computed tomography (CT) scan, ultrasonography, and VAD was assessed by measurement of adipocytokines in plasma but expensive.[6]

Visceral adiposity index (VAI) a mathematical equation serve as a predictor of VAD, when compared to individual parameters, such as waist circumference (WC), body mass index (BMI), and lipid profile.[4] Hence, this study was chosen to assess the visceral adiposity index in post-menopausal women to predict the cardiovascular risk and to correlate the BMI, waist circumference, Lipid profile and Atherogenic index with VAI in post-menopausal women.

MATERIALS AND METHODS

This cross-sectional study was conducted after obtaining institutional ethical clearance. Totally 60 postmenopausal women aged >40 years were recruited for the study based on the sample size calculation. Postmenopausal women were selected based on the criteria who lack menstruation for at least previous 12 months.

Post menopausal women receiving hormone replacement therapy or those who were on medications (antihypertensive, antihyperlipidemic, antiepileptic, chemotherapeutic, anticoagulant, or corticosteroid) or those who were in surgical menopause (hysterectomized / ovariectomized) were excluded. Post menopausal women with H/o of smoking, alcohol consumption and with history of chronic disease (CVD, hypertension, diabetes etc.) were also excluded.

Informed written consent was obtained from the study participants. Detailed history and clinical examination were done. They were instructed to sit quietly for 10 minutes, and the blood pressure was recorded in the arm using OMRON Automatic BP Monitor. To calculate VAI, the following anthropometric parameters such as height, weight and waist circumference were measured.

The height (in meters) was measured using a stadiometer with the subject standing barefoot, feet together, arms together and back leaning on the wall. The subject was asked to look directly forward. The back of their feet, calves, bottom, upper back and the back of their head would be in contact with the wall.

The weight (in Kg) of the subject was recorded using an electronic weighing scale which has been standardized. The subject was asked to remove any heavy items from their pockets (wallets, key's etc.) and remove any heavy items of clothing or apparel. BMI was calculated using the formula.

$$BMI = \frac{Weight\,(kg)}{[Height(m)]^2}$$

The waist circumference (in centimetres) of the subject was measured at the midpoint between the lowest rib and the iliac crest using a standard measuring tape after the subject exhales.

Lipid profile: Venous blood samples were collected from all patients after 12-h fasting. Lipid profiles, including total cholesterol, low density lipoprotein (LDL), high density lipoprotein (HDL), and triglyceride (TG) levels, were obtained using the colorimetric enzyme method.

From these parameters, visceral adiposity index was calculated using the formula given below: VAI = {WC/[36.58 + (1.89 × BMI)] } × (TG/0.81) × (1.52/HDL). (for women),[3] where WC expressed in cm, BMI in Kg/m2, TG in mmol/L, and HDL in mmol/L.

Atherogenic index (AI) which is a surrogate marker of atherogenesis, and CVD is calculated as Log of TG/HDL.

Postmenopausal women were categorized according to their VAI scores into mild (VAI score > 1.93 or ≤ 2.17), moderate (VAI score > 2.18 or ≤ 3.24), and severe (VAI score > 3.25) VAI groups.[7]. The collected data such as Demographic, anthropometric, and biochemical test values were tabulated and analyzed using SPSS 20.

RESULTS

Totally 60 post-menopausal women participated in the study. Based on the VAI score they were categorized into following groups.

Group 1. VAI score <1.93 - No Adipose tissue dysfunction (ATD)

Group 2: VAI score 1.93- 2.16 : mild Adipose tissue dysfunction (ATD)

Group 3: VAI score 2.16- 3.25 : moderate Adipose tissue dysfunction (ATD)

Group 4: VAI > 3.25 : severe Adipose tissue dysfunction (ATD)

The anthropometric measurements, blood pressure recordings and biochemical parameters were analyzed by arithmetic mean and standard deviation. The association between VAI and blood pressure readings, biochemical parameters were analyzed using Pearson Correlation Test. P value less than 0.05 was statistically significant. To analyze the differences between the means of groups was done using ANOVA.

Table 1: Demographic, Biochemical and Metabolic Characteristics in the Study Group

	MEAN ± SD
AGE (yrs)	51.86 ±4.67
WEIGHT (kg)	60.17 ±9.30
HEIGHT (cm)	149.11 ±8.15
BMI	27.04 ±3.91

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WC (cm)	92.98 ±8.16
SBP (mm Hg)	124.29 ± 19
DBP (mmHg)	75.43 ±8.08
TG (mg/dl)	147.18 ±43.58
HDL (mg/dl)	44.08 ±10.25
LDL (mg/dl)	86.20 ±37.20
VLDL(mg/dl)	28.88 ±12.68
Visceral adiposity index(VAI)	3.08 ±1.76
Atherogenic index(AI)	0.49 ±0.23

This table shows the mean (±SD) of the baseline characteristics of the study group.

Table 2: Anthropometric measurements, and biochemical test results of the patients with mild, moderate or severe VAI.

	NO ATD (n=12)	MILD ATD (n =10)	Moderate ATD (n=22)	Severe ATD (n=16)	F value	P value
AGE (yrs)	51.75 ±5.32	50.60 ± 4.67	51.45 ± 4.16	52.44 ±5.07	0.302	0.824
BMI	25.6 ± 3.22	27.79± 2.03	27.59 ± 4.80	27.21± 3.34	0.815	0.491
WC (cm)	92.90 ± 8.04	90.06 ± 7.69	92.42 ± 8.44	94.91± 7.40	0.731	0.538
SBP (mmHg)	106.75 ± 9.58	122.40± 11.84	122.59 ± 11.61	139.69 ± 20.98	11.31	<0.001*
DBP(mmHg)	69.17 ± 4.10	73.50± 5.22	74.86 ±7.29	80.19± 8.23	5.900	<0.001*
TG(mg/dl)	80.76 ±20.84	119.77± 18.60	140.82 ± 26.59	209.25± 76.75	19.252	<0.001*
HDL(mg/dl)	52.47 ± 12.5	45.28± 7.58	43.58 ± 8.46	39.45± 5.66	4.914	<0.004*
VAI	1.42 ± 0.35	2.19 ± 0.16	2.77± 0.28	4.74± 1.75	30.452	<0.001*
AI	0.18 ± 0.14	0.42 ± 0.05	0.51±0.05	0.70± 0.15	52.648	<0.001*

(* P value less than 0.05 was considered to be statistically significant)

Based on VAI, the study group was divided into 4 subgroups. The optimum cutoff points for VAI score <1.92. In this table out of 60 post-menopausal women only 12 belong to nil adipose tissue dysfunction. Remaining subjects have mild to severe adipose tissue dysfunction.

There is a significant difference in Blood pressure, triglycerides, and HDL between the groups. Cardiovascular risk predictor indices VAI and AI showed a significant difference between the groups. As the VAI score increases, the blood pressure increases and it is found to be statistically significant. Similarly higher the VAI score, which determines adipose tissue dysfunction triglycerides increase and HDL decreases and found to be statistically significant.

Table 3: Correlation of VAI with Cardiovascular Risk Parameters

	r value	P value
BMI	0.28	0.83
WC	0.111	0.39
SBP	0.76	< 0.001*
DBP	0.60	<0.001*
TG	0.95	<0.001*
HDL	-0.39	<0.001*
AI	0.89	<0.001*

(* P value less than 0.05 was statistically significant)

Table 4: Correlation of Atherogenic Index with cardiovascular risk parameters

	r value	P value
BMI	0.174	0.18
WC	-0.036	0.78
SBP	0.732	<0.001*
DBP	0.591	<0.001*
TG	0.859	<0.001*
HDL	-0.579	<0.001*
VAI	0.89	<0.001*

(*P value less than 0.05 was considered to be statistically significant)

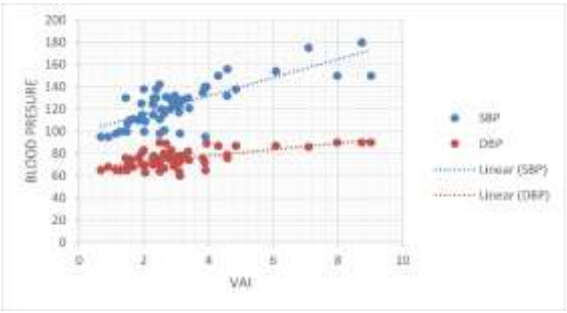

Figure 1- Correlation of VAI with systolic and diastolic blood pressure

This graph shows a significant positive correlation between VAI and blood pressure.

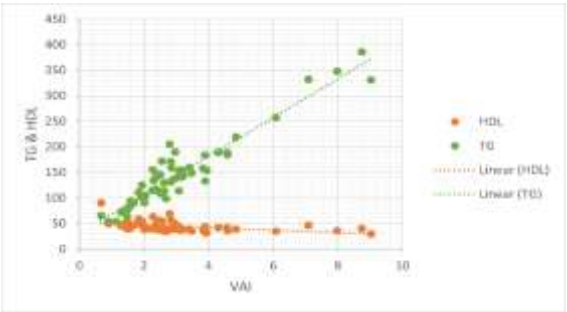

Figure 2- Correlation of VAI with Triglycerides and HDL

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This graph shows a significant positive correlation of visceral adiposity index with triglycerides and significant negative correlation with HDL.

DISCUSSION

Post menopausal women included in this study were without any comorbidities and their mean BMI and Waist circumference was found to be increased. Chaudhri et al stated that women gain 12 pounds within 8 years of the onset of menopause.[8] Lovejoy et al suggested that during menopausal transition weight gain occurs not only due to reduced physical activity and energy expenditure but also due to alteration of adipose tissue metabolism, and fat oxidation.[9] Raikkonen et al observed that waist circumference was superior to other anthropometric measures, in identifying women with abdominal obesity, but doesn't differentiate the visceral fat from subcutaneous fat.[10] The reason for redistribution of fat in the abdominal region in postmenopausal women due to dysregulation of energy metabolism. In the present study, both the BMI and WC were higher, and had intergroup variation but not statistically significant. This indicates that these anthropometric indices cannot predict adipose tissue dysfunction.[11]

In our study, Blood pressure was found to be within normal range, since hypertensive post-menopausal women were excluded. However, higher the VAI score found to have significantly high blood pressure. This indicates that VAI is the better tool to predict the cardiovascular risk. Myat Su Bo et al states that visceral fat produces vasoactive adipocytokines (e.g., angiotensinogen, a tumour necrosis factor-α (TNF-α) that plays an important role in elevation of blood pressure.[12]

Dyslipidaemia, an important marker of CVDs is characterized by an increase in levels of TG and a decrease in level of HDL-C in the blood. In our study the mean TG was 147.18 ± 43.58 & HDL was 44.08 ± 10.25. However higher the VAI found to have significantly higher TG (209.25±76.75) and lower HDL (39.45 ± 5.66). Shabestari et al stated that elevated plasma triglycerides (TG) levels were associated with a higher risk of CVD.[13] In the present study, we observed that post-menopausal women had high-triglyceride / low-HDL cholesterol levels, a probable cause for atherosclerosis, hypertension, and higher mortality rate.[14]

The atherogenic index (AI), a strong predictor of atherosclerosis and CVDs is calculated as logarithmic conversion of TG into HDL ratio. Based on AI values. one can predict the risk for CVD: −0.3 to 0.1 for low risk, 0.1 to 0.24 for medium, and more than 0.24 for high risk. In our study the mean AI was found to be 0.49 ± 0.23, predicts that the post-menopausal women for prone for atherosclerosis and thereby to cardiovascular disease.[6] AI was more positively correlated with TG and was more negatively correlated with HDL-C; thus, AI was the strongest marker in predicting risk of CVDs among the other indices.

Correlation between VAI and cardiovascular risk factors shows linear positive correlation. Among the cardiovascular risk factors anthropometric variables such as BMI & WC correlated positively but not statistically significant. The systolic and diastolic pressure showed a significant positive correlation with VAI. Thus, higher the VAI the blood pressure was also higher. Similarly, the TG showed a significant positive correlation, whereas the HDL showed significant negative correlation with VAI. Higher the VAI the TG is also higher whereas the HDL is lower.

In females during reproductive period, estrogen maintains energy homeostasis via ERα, and ERβ receptors by suppressing energy intake and lipolysis, enhancing energy expenditure and ameliorating insulin secretion and sensitivity".[3] Post menopausal women have estrogen deficiency which leads to accumulation of visceral fat, releases excess free fatty acids which are drained by portal venous system and drained into liver, that enhances lipid synthesis and gluconeogenesis, as well as insulin resistance, resulting in hyperlipidaemia, glucose intolerance, hypertension, and finally atherosclerosis. Thus, Visceral adipose tissue dysfunction results in a shift from an anti-inflammatory to a proinflammatory profile and has greater chance to get CVD complications.[14]

These findings suggests that VAI incorporates both anthropometric and metabolic parameters, thereby indirectly reflecting other nonclassical cardiovascular risk factors. Hence VAI can be considered as a valuable index to predict cardiovascular risk.

CONCLUSION

In our study, healthy post-menopausal women were included, but their BMI and WC are higher and had dyslipidaemia. They were also found to have elevated Blood pressure. We also observed a positive association between VAI and BMI, WC, systolic blood pressure, diastolic blood pressure, TG and a significant negative association between VAI and HDL.

This study concludes that VAI is a simple and effective tool for assessing the cardiometabolic risk in post-menopausal women. The detection of postmenopausal women with a high cardiometabolic risk may aid in the implementation of early lifestyle changes and treatment strategies which are essential in alleviating visceral fat accumulation and conserving metabolic health to prevent future CVD.

REFERENCES

1. Prabhakaran D, Jeemon P, Roy A. Cardiovascular Diseases in India. Circulation. 2016 Apr 19;133(16):1605-20.
2. Lee MJ, Wu Y, Fried SK. Adipose tissue heterogeneity: Implication of depot differences in adipose tissue for obesity

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complications. Molecular Aspects of Medicine. 2013 Feb;34(1):1–11.
3. Mauvais-Jarvis F. Estrogen and androgen receptors: regulators of fuel homeostasis and emerging targets for diabetes and obesity. Trends in Endocrinology & Metabolism. 2011 Jan;22(1):24–33
4. Gulbahar A, Caglar GS, Arslanca T. Evaluation of visceral adiposity index with cardiovascular risk factors, biomarkers in postmenopausal women to predict cardiovascular disease: A 10 year study. Experimental Gerontology. 2022 Dec;170:111986.
5. Amato MC, Giordano C, Galia M, Criscimanna A, Vitabile S, Midiri M, et al. Visceral Adiposity Index. Diabetes Care. 2010 Apr 1;33(4):920–2.
6. Hamzeh B, Pasdar Y, Mirzaei N, Faramani RS, Najafi F, Shakiba E, et al. Visceral adiposity index and atherogenic index of plasma as useful predictors of risk of cardiovascular diseases: evidence from a cohort study in Iran. Lipids Health Dis. 2021 Dec;20(1):82.
7. MC Amato, Glordano M, Pitrone and Galluzzn. Cut of points of the visceral adiposity index (VAI) identifying a visceral adipose dysfunction associated with cardiometobolic risk in a Causian Scilian population. Lipids in health nad Disease 2011; vol10: article 153
8. Chaudhary M, Sharma P. Abdominal obesity in India: analysis of the National Family Health Survey-5 (2019–2021) data. The Lancet Regional Health - Southeast Asia. 2023 Jul;14:100208
9. Lovejoy JC, Champagne CM, De Jonge L, et al. Increased visceral fat and decreased energy expenditure during the menopausal transition. Int J Obes (Lond). 2008;32(6):949–58
10. Lee HJ, Jo HN, Kim YH, Kim SC, Joo JK, Lee KS. Predictive Value of Lipid Accumulation Product, Fatty Liver Index, Visceral Adiposity Index for Metabolic Syndrome According to Menopausal Status. Metabolic Syndrome and Related Disorders. 2018 Nov;16(9):477–82.
11. Räikkönen K, Matthews K, Kuller L. Anthropometric and psychosocial determinants of visceral obesity in healthy postmenopausal women. Int J Obes. 1999 Aug;23(8):775–82.
12. Bo MS, Cheah WL, Lwin S, Moe Nwe T, Win TT, Aung M. Understanding the Relationship between Atherogenic Index of Plasma and Cardiovascular Disease Risk Factors among Staff of an University in Malaysia. Journal of Nutrition and Metabolism. 2018 Jul 4;2018:1–6.
13. Shabestari AN, Asadi M, Jouyandeh Z, Qorbani M, Kelishadi R. Association of Lipid Accumulation Product with Cardio-Metabolic Risk Factors in Postmenopausal Women.
14. Amtul Rahman, Ayesha Jubeen and Tagore Ravirala. A cross sectional study to asses lipid profile and atherogenic index of plasma in premenopausal and postmenopasal women in rural Telangana. International Journal of Clinica Biochemistry and Research 2021; 8(1): 29-32.

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