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Relationship of visceral adiposity index (VAI) and visceral body fat among metabolically obese normal weight individuals from Pakistan

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ABSTRACT

Background: An increasing number of people throughout the world are suffering with visceral obesity. Accumulation of visceral fat is a pathogenic manifestation of global fat dysfunction, that leads to inflammation, atherosclerosis, abnormal lipid levels, and high blood pressure.
Methods: This association study was conducted at Department of Medicine, Mayo Hospital Lahore, Pakistan. 30 participants who meet the selection criteria were recruited after taking written consent. Then patients were evaluated for their height, weight and waist circumference body mass index. Visceral fat was calculated by using machine for bio-impendence analysis. Visceral adiposity index was calculated. 5 cc venous blood sample was' collected under aseptic measures and all samples were sent to the hospital's laboratory for assessment of lipid profile and blood sugar levels.
Results: We have studied 30 patients (43.8 % female and 56.3 % male), mean age of study population calculated was 40.6 ± 11.80 years. The mean Visceral Body Fat was found to be 13.53 ± 1.41, High-Density Lipoprotein cholesterol mean calculated was 36.91 ± 9.18 mg/dL, and mean Visceral Adiposity Index calculated was 16.75 ± 7.55. Pearson Correlation was used, to find correlation between Visceral Adiposity Index and Visceral Body fat. The value turned out to be 00.899** shows positive correlation, p-value was 0. 001 significant.
Conclusion: In this study we found positive correlation of visceral adiposity index and visceral body fat by use of Bio impedance analysis machine among metabolically obese normal weight individuals. Visceral adiposity index requires many blood tests while Bio impedance analysis machine can be used in simple outdoor settings hence, we can isolate high risk patient in outdoor settings without any invasive procedures or laboratory investigations.

1. Introduction

Obesity, defined as having BMI of 30 kg/m^2 or higher, is complex disease influenced by various factors. However, BMI criteria for obesity varies, especially among those of Asian ancestry [1]. In UK, 27 % of adults were found to be obese. The prevalence of individuals who were either overweight or obese rose from 53 % to 93 % in 2017 [2]. This trend increased consistently with age, peaking in the 55 to 64 age group. Globally, approximately, 650 million adults were considered obese, in 2020 [3].

Several metabolic conditions have previously been linked to obesity, including cardiovascular disease, diabetes type 2, hypertension, as well as cancer [4,5]. Obesity-related metabolic disorders, on either hand, vary widely among patients with increased adiposity. Patient with obesity mostly suffering from metabolic obesity. Metabolically non-obese persons are described as having a more healthy metabolic profile, which includes lack of insulin sensitivity resistance and absence of high blood pressure, as well as an overall healthy cholesterol and inflammation profile [6]. Metabolically obese normal weight is sub-population of normal-weight people with aberrant metabolic characteristics [7]. The prevalence of metabolically obese individuals with normal weight can vary significantly based on how aggressively these metabolic issues are diagnosed and specific criteria used for assessment [8]. Visceral fat cells are linked to number of metabolic and

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cardiovascular disorders; function of all adipose tissue depots, especially subcutaneous adipose tissue (SAT), affects development of visceral adiposity. When SAT is unable to adequately store energy due to dysfunction, excess energy can overflow into visceral fat, leading to its accumulation [9]. Visceral adipose tissue mass, as well as total body fat percentage, are linked to and potentially linked to disease trajectories, although BMI evaluation does not fully account for them [10]. Normal weight individuals can be metabolically obese. Visceral fat does not always correlate with body weight. In people of normal weight, estimating visceral fat may provide important information for actions to improve metabolic risk factors [11].

When it comes to quantifying visceral fat, DXA are the gold standard, but their use in clinical practice as well as epidemiological data is confined due to its greater cost, need for specialized technology and skilled manpower [12,13].

There is much risk for cardiovascular disease due to visceral adiposity dysfunction [14]. With non-invasive method of bioimpedance analysis (BIA), visceral fat can be estimated on an outpatient basis, potentially removing the requirement for fasting lipid levels and physical measurements such as waist circumference. BIA's specificity and accuracy for predicting visceral fat at the individual level, however, may differ, even though it can fairly estimate overall visceral fat among groups of individuals. Additional research is required to confirm that BIA is a reliable method for precisely determining visceral fat in each patient [15]. This may be useful in normal weight individuals who are traditionally considered to be at lower risk for cardiovascular and cerebrovascular disease. Bio impedance analysis (BIA) has grown in popularity over the past two decades as method of estimating body composition, and it is now widely used [16]. The present study is aimed to find correlation between visceral adiposity index (VAI) (specific metric used to estimate visceral fat accumulation and assess associated metabolic risks, calculated using waist circumference, BMI, triglyceride levels, high-density lipoprotein cholesterol) and bio impedance analysis in metabolically obese normal weight individuals.

2. Methodology

After IRB approval i.e. 24/RC/KEMU dated 12-01-2021, 30 participants who met the selection criteria were included Sample size of 30 cases was estimated using 95 % confidence level, 95% power of test with expected correlation value LDL/HDL i.e. r = 0.601, using formula; **$n = [(Z_\alpha + Z_\beta)/C]$** [2] **+3** Patients of age 18–75 years, both male and female, having normal weight BMI (between 18.5 22.9 kg/m^2) and Metabolically obese were recruited in the study. Metabolic obesity was defined on the basis of adult treatment panel III with individual fulfilling 3 out of 5 criteria being categorized as metabolically obese i.e. Hypertension, Diabetes mellitus, Waist circumference, High Density Lipoprotein, Triglycerides. Pregnant/lactating females, patients on antiobesity drugs/lipid lowering drugs with in last 3 months, patients with history of bariatric surgery/liposuction/other abdominal surgeries, malignancy, patients with history of MI/CVA with in last 14 days, known epileptics and patients with cardiac arrhythmias with implantable cardiac devices were excluded. written informed consent was taken from all patients. Name, age, sex and BMI was noted. Then patients were assessed for their height, weight and waist circumference BMI and Visceral fat. Weight and height were measured using medically certified scale and medically certified stadiometer according to international criteria. The BMI was calculated: **BMI=weight/height (m) 2**.

5cc venous blood sample was collected under aseptic measures in the morning, blood samples were taken at 8:30 and 9:00 a.m. after overnight fast to measure HDL-C, TG and Blood sugar level and categorized accordingly. At halfway between costal border and iliac crest, anthropometric tape was placed parallel to floor at conclusion of calm exhalation to measure waist circumference. Bioelectric impedance analysis system (Omron BF08) was used to determine fat weight, FM percentage, fat-free weight and fat-free weight percentage. Blood pressure was measured using oscillometer equipment.

Fat distribution and metabolism are reflected in VAI's calculation as follows:

VAI (males)=WC /39.68 + (1.88 × BMI) × TG /1.03 × 1.31/HDL

VAI (females)=WC / 39.58 + (1.89 × BMI) × TG / 0.81 × 1.52/ HDL

A person's weight and height are measured in centimeters, their BMI in kilograms per square meter, and their TG and HDL-C in mg/dl. The data was examined using SPSS 26.0. Age, triglycerides, HDL-C, and visceral adiposity index were reported as mean SD. Visceral adiposity index and visceral body fat were linked using Pearson's correlation coefficient. Data analysis was done using SPSS. Mean and standard deviation was computed for quantitative variables. Data was stratified for gender, and results mean were compared using independent sample *t*-test. Pearson correlation was calculated and p values < 0.05 was taken as significant.

3. Results

We studied 30 participants for the purpose of this study. All of them were metabolically obese normal weight individuals, included 56.3 % (n = 17) males and 43.8 % (n = 13) females, mean age of study population was 40.6 ± 11.80 years. Systolic and diastolic BP mean noted was 145.83 ± 4.871 mmHg and 87.3 ± 2.806 mmHg, respectively.

Anthropometry revealed that mean BMI 20.55 ± 1.38kg/m2 and waist circumference was 77.83 ± 6.17 cm. Mean Visceral Body Fat on bioimpedance analysis was found to be 13.53 ± 1.41 %.

Mean HbA1c of our study participants was 7.04 ± 0.53 %. HDL-C level was 36.91 ± 9.18 mg/dL and triglycerides levels were 158.75 ± 10.01 mg/dl. Visceral Adiposity Index was calculated by the above mention formulae in methodology; and mean was found to be 2.64 ± 1.34.

Table 1 summarizes and compares these parameters among male and female participants. WC, VBF, VAI and TG levels found higher in male participants, and these differences were statistically significant $p < 0.05$.

Pearson Correlation was used to find correlation between VBF and VAI of the whole group as well as that of male and female individuals. Correlations have also been determined between VBF & HDL, VBF & HDL, VAI & HDL and VAI and VBF. These are summarized in Table 2. VAI with VBF, VAI with TG and VBF with TG found to have positive association for entire population, however strong association was found for female participants as compared to males. Among VBF with HDL-C, and VAI with HDL-C no significant association was found.

4. Discussion

BIA is widely available, secure, economical technique for estimating body composition in clinical populations.

We have studied 30 patients (43.8 % female and 56.3 % male), mean age calculated was 40.6 ± 11.80 years. The mean Visceral Body Fat was

Table 1
Comparison of Study population characteristics according to gender.

Characteristics	Male (n = 17) Mean (SD)	Female (n = 13) Mean (SD)	p-value
Age (years)	35.18 (10.87)	47.69 (9.15)	0.002[a]
Systolic BP (mmHg)	145.18 (5.27)	146.69 (4.34)	0.408
Diastolic BP (mmHg)	87.18 (2.83)	87.46 (2.87)	0.708
BMI (kg/m^2)	20.34 (1.38)	20.83 (1.39)	0.344
Waist circumference (cm)	80.76 (6.17)	74.00 (3.65)	0.002[a]
Visceral body fat (%)	14.43 (0.88)	12.34 (1.05)	0.00[a]
HbA1c (%)	7.037 (0.18)	7.001 (0.14)	0.578
HDL-C (mg/dL)	36.13 (8.72)	37.91 (10.01)	0.408
Triglycerides, (mg/dL)	221.28 (76.57)	76.98 (60.46)	0.00[a]
Visceral Adiposity Index (VAI)	3.49 (0.85)	1.53 (1.01)	0.00[a]

[a] Statistically Significant.

Table 2
Correlation between study parameters.

Correlation b/w:	Correlation Coefficient r (p-value)		
	Entire Study Group (n = 30)	Males (n = 17)	Females (n = 13)
VBF & VAI	0.899 (0.00)	0.661 (0.004)	0.886 (0.000)
VBF & HDL-C	−0.064 (0.736)	0.031 (0.905)	−0.005 (0.986)
VBF & TG	0.839 (0.000)	0.561 (0.019)	0.808 (0.001)
VAI & HDL-C	0.096 (0.612)	0.204 (0.433)	0.294(0.329)
VAI & TG	0.993 (0.000)	0.803 (0.000)	0.974 (0.000)

VAI: Visceral adiposity index, HDL-C: High density lipoprotein cholesterol, TG: triglycerides, VBF: Visceral body fat.

13.53 ± 1.41 %, the mean HDL-C was 36.91 ± 9.18 mg/dL, and mean Visceral Adiposity Index was 2.64 ± 1.34. WC, VBF, VAI and TG levels found higher in male participants, and these differences were statistically significant $p < 0.05$. Pearson Correlation was used, to find correlation between Visceral Adiposity Index and Visceral Body fat, turned out to be 00.899** shows positive correlation, p-value was 0. 000 significant. However, among VBF with HDL-C, and VAI with HDL-C no significant association was found.

Similarly, in one study majority of participants were males, 73 % men and 27 % women. Nearly half had visceral fat area exceeding cut-off value of 100 square cm. Additionally, 42 % of males had waist-to-hip ratio greater than 0.9, while 56 % of females had greater than 0.8. Very strong correlation was observed between visceral fat area and waist-to-hip ratio among both males (correlation coefficient = 0.936, $p < 0.05$) and females (correlation coefficient = 0.920, $p < 0.05$). The correlation between waist circumference and BMI with visceral fat area was modest, with values of correlation coefficient = 0.739 and correlation coefficient = 0.758 for males, and correlation coefficient = 0.774 and correlation coefficient = 0.605 for females, respectively [17].

The waist-to-height ratio demonstrated highest ROC value [AUC = 0.745, $p < 0.001$] for finding diabetics with elevated visceral fat, outperforming BMI, waist and hip circumference, and waist-to-hip ratio. Similarly, regression analysis revealed that waist-to-height ratio had strongest association with visceral fat levels [unadjusted OR = 21.49, $p < 0.001$], findings indicate that waist-to-height ratio is more effective than BMI, hip and waist circumference, and waist-to-hip ratio in identifying diabetic patients with high visceral fat levels [18].

5. Limitations

Our study has certain limitation, small sample size and single centred study, further more we have not comparison group. Further studies will be needed to cover this aspect. Because BIA determines fat-free mass by measuring resistance to electrical current as it travels through body's lean and fat tissues, BIA, although widely used, lacks specificity and precision [19]. Prediction equations are used to estimate fat-free mass in order to make up for this. Although BIA can estimate total body fat, attempts to assess visceral and subcutaneous abdominal fat with BIA have demonstrated strong associations with more precise imaging methods such as CT scans [20]. Because total fat mass is determined by deducting fat-free mass from body weight, and because BIA's measurements are based on fat-free tissue, caution should be exercised when interpreting these results. The person's level of hydration may have an impact on this approach; dehydration is a common concern in clinical settings, especially in cancer patients. Errors in fat estimations may result from BIA's imprecise measurement of lean tissue. These restrictions most likely account for the differences in total body fat measured by DEXA and BIA [21,22]. Accuracy of BIA and anthropometric approaches in measuring visceral fat deposition in a clinical setting is restricted, despite their potential utility in defining adipose tissue distribution in initial diagnosis of abdominal obesity and for general application in epidemiological investigations [23].

6. Conclusions

In this study, we discovered that among metabolically obese healthy adults, there was positive association between the Visceral Adiposity Index (VAI) and visceral body fat as determined by BIA. While BIA can be used efficiently in outpatient clinical settings to identify high-risk patients without invasive procedures or laboratory investigations, VAI requires multiple blood tests.

The following key points emerge from our findings:

- There is positive correlation between VAI and visceral body fat as measured by BIA, however females found to have strong correlation as compared to males.
- BIA offers practical alternative to VAI for identifying individuals at risk for metabolic disorders.
- Utilizing BIA can streamline the assessment process, reducing the need for invasive blood tests and laboratory investigations.

Authorship

All authors contributed significantly to the conception, design, execution, and interpretation of the study. There are no other individuals who meet the criteria for authorship and should be acknowledged.

Data integrity

The authors assert that the data reported in this study are accurate and that no manipulation or fabrication of data has occurred. All findings are reported honestly and transparently.

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Declaration of competing interest

The authors declare that there are no conflicts of interest related to this study. No financial interests, personal relationships, or affiliations that could influence the study or its findings have been disclosed.

Acknowledgment of Responsibilities

The authors take full responsibility for the content of the paper and its findings. They ensure that the work meets the necessary academic and ethical standards.

AI: Chat GPT 4 and quilbolt tools were is used for paraphrasing. However, no data was taken for article writing from AI tools.

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