**Original Article :**

**Assessment of visceral and subcutaneous fat using computed tomography and correlating with lipid profiles and body mass index among asymptomatic individuals attending a tertiary care hospital**

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**Abstract**

**Backround:** This study was conducted to quantify the visceral and subcutaneous fat using Computed Tomography(CT) at the umbilicus level and to correlate between visceral/subcutaneous fat distribution and plasma lipids levels among asymptomatic individuals.

**Aims:** Correlation of visceral & subcutaneous fat with lipid profile and Body Mass Index among asymptomatic individuals attending a tertiary health care facility.

**Settings and Design:** cross sectional study

**Material and method:**  200 asymptomatic individuals attending the Radiology OPD of Government Medical College & Hospital, Aurangabad were selected as study participants. Single section abdomen CT scan was performed in these individuals at the level of umbilicus using 128 slices MDCT (“SOAMTOM AS+ ) to quantify visceral and sub cutaneous fat .The Data obtained were processed using syngo.via workstation and statistical analysis was done using SPSS software version 21.

**Results:** BMI and subcutaneous fat levels increased with age (*p*=0.028) and this pattern was found predominantly in females however increased visceral fat levels were observed in male participants which did not correlate with age (*p*=0.712). Participants who were generally obese and with increased levels of visceral/subcutaneous fat exhibited increased levels of total cholesterol and triglycerides on lipid profile examination. High density lipoproteins levels significantly reduced in obese and subjects with visceral fat (*p*=0.001) & (*p*=0.002) and were not significant among subcutaneous obese subjects(*p*=0.49) furthermore, levels of low-density lipoproteins significantly increased in visceral obese subjects (*p*=0.001), and were not significant among subcutaneous and general obese subjects (*p* =0.066) & (*p*=0.20) respectively.

**Conclusions:**  Our study throws light on the fact that visceral obese subjects had an indirect risk of coronary artery disease than subcutaneous and general obese subjects and also proposes computed tomography (CT) as an eminent diagnostic tool for quantitative measurement of visceral fat.

**Keywords**: visceral fat, subcutaneous fat, Body Mass Index, Computed Tomography, coronary artery disease.

**INTRODUCTION**

Plethora of literature have highlighted the emergence of lifestyle-related diseases like obesity and cardiovascular diseases that is regarded as the 5th leading cause of mortality,globally.[1],[2] Especially, in developing countries like India, the incidence of obesity-related non-communicable diseases (OR-NCDs) including dyslipidaemia, coronary heart disease (CHD), type 2 diabetes mellitus (T2DM) and hypertension are frequently reported even at younger age group.[2] Previous studies have noted that the amount of visceral fat is specifically associated with derangements of lipid and glucose metabolism specifically among obese population without any correlation to their degree of obesity.[3] Therefore it is imperative to evaluate the relative distribution of fat between visceral and subcutaneous sites using non invasive and accurate diagnostic tools like computed tomography (CT).Fig:1(a&b) rather than measuring general obesity by using conventional anthropometric measures like body mass index(BMI) and waist circumference(WC) as these anthropometric parameters does not quantify subcutaneous fat (SF) and visceral fat (VF) separately. [4] [5] & [6]

**MATERIAL & METHODS**

**Study design and Selection of Subjects:**

A cross-sectional study was planned among 200 subjects aged between 20–60 years, who were referred to the Department of Radio-diagnosis, Government Medical College & Hospital, Aurangabad for diagnostic evaluation of various abdominal indications using computerized tomography between january 2018 to june 2019 were selected**.** During subjects recruitment, asymptomatic subjects with otherwise normal abdominal findings were included and patients with obvious abdominal pathology,surgically treated scars ,prior history of any abdominal intervention and on anti hyperlipidemic drugs were excluded from the study. Moreover, terminally ill patients, pregnant females and highly irritable patients were excluded.

**Anthropometric measurements**

Each subject’s body weight and height were measured from which BMI was calculated using the formula of weight (in kg) divided by the height in meter square (m2).

**Biochemical measurements**

Lipid profile - Venous blood samples of all the study participants were collected after overnight fasting and analysis of plasma levels of Triglycerides(TGs) and total cholesterol(TC) were measured using enzymatic methods. High-density lipoprotein (HDL) and low-density lipoprotein (LDL) levels were measured using direct methods and Friedewald formula respectively.

**Equipment and analysis Procedure**

Estimation of abdominal adipose tissue cross-sectional areas were done by single-slice CT scan on **“SOAMTOM AS+ 128 slices.** Single slice 5 mm thickness scan was performed at the umbilical level (between L4 and L5 vertebrae) using an abdominal scout radiograph to standardize the position of the scan to the nearest millimetre. Scan parameters were: 120kV, 250 mA, slice thickness 5mm, the field of view :500mm, window width: 500, window centre: 40. The umbilical region was selected due to ease of localization and this anatomical level has the maximum ratio of fat to the total tissue area which represents total fat content throughout the abdomen.[7] & [8] Axial section image was selected in the workstation (syngo.via) and with the use of inbuilt analysis software the segmentation of subcutaneous and visceral compartments were performed. Then each compartment comprising of adipose tissue area was calculated with selected attenuation range between –200 to - 40 Hounsﬁeld units.

 For defining visceral and subcutaneous obesity , the cut off values for Indian population were considered as prescribed by Anoop Misra et al[9] which is >135 cm2 and >110 cm2 for males and > 75 cm2  and >134 cm2 for females respectively.

**RESULTS**

The present study included 200 asymptomatic subjects including 112 males and 88 females in the age group of 20 to 60 years and mean age of 43.9 ± 15.2 years(Table-1). General obesity based on BMI was significantly higher in females 48/79(61%) than males 31/79(39%). Among obese females, 22/31(70%) of them were in the post-menopausal age group (51- 60 yrs). Similarly, subcutaneous fat was also higher in females 38/62(61%) than males 24/62(39%), especially in the post-menopausal age group (51- 60 yrs). Both BMI and subcutaneous fat correlated significantly with age(*p*=0.028) & (*p*=0.033) and sex(*p*=0.001)& (*p*=0.001). Visceral fat was high among males 41/75(54%) and was more common in the age group between 41- 50 years than in females 34/75(46%). Presence of visceral fat was also high among post-menopausal age group 23/34(69%) however presence of visceral fat correlated only with sex (*p* =0.001), and not with age (*p* =0.712). (Table-2)

**Table -1 Anthropometric, lipid Profiles and Abdominal fat distribution by CT (males versus females)**

|  |  |
| --- | --- |
| Variables |   Mean (SD)  |
| Male(n=95) |  Female(n-105)  | P values |
|  Age |  42.2 ± 9.1 | 45.5 ± 9.3 |  0.64 |
|  BMI |  25.5 ± 3.2 | 26.3 ± 4.1 | < 0.022 |
|  Visceral Fat |  282 ± 78.3 | 250 ± .91.6 | < 0.001 |
|  Subcutaneous Fat |  248 ± 90.2 | 288 ± 122.9 | < 0.001 |
|  Total Cholesterol |  152 ± 54.8 | 155 ± 61.2 | < 0.031 |
|  Triglycerides |  168 ± 41.6 | 172 ± 57.5 | < 0.001 |
|  HDL |  41 ± 5.4. | 48 ± 6.3 | < 0.002 |
|  LDL |  137 ± 39.0 | 126 ± 33.3. |  0.20 |

**Table:2 Correlation of visceral fat, subcutaneous fat, BMI with clinical & biochemical parameters**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Visceral Fat | Subcutaneous Fat | BMI |
| Age |  0.72 |  0.028 |  0.033 |
| Sex |  0.001 |  0.001 |  0.001 |
| Menstrual status |  0.41 |  0.036 |  0.001 |
| BMI |  0.033 |  0.001 |  \_ |
| Total Cholesterol |  0.001 |  0.024 |  0.001 |
| Triglycerides |  0.041 |  0.002 |  0.049 |
| HDL |  0.001 |  0.49 |  0.002 |
| LDL |  0.001 |  0.66 |  0.20 |

|  |  |  |
| --- | --- | --- |
|  |  **BMI** |  **Total Number**  **(n-200)** |
|  **Normal** | **Abnormal** |  **Total** |
| **Normal(SF+ VF)** |  **92** |  **11** |  **103** |
| **Abnormal(SF + VF)** |  **9** |  **31** |  **40** |
| **Only Subcutaneous Obesity** |  **3** |  **19** |  **22** |
| **Only Visceral obesity** |  **17** |  **18** |  **35** |
|  |  **121** |  **79** |  **= 200** |

**Table 3- Correlation between adipose tissue distribution and BMI**

Visceral fat, subcutaneous fat and BMI all showed a significant positive correlation with total cholesterol (TC) (*p* =0.001), (*p*=0.024) & (*p* =0.001) and triglyceride(TG) levels (*p* =0.041) (*p* =0.002) & (*p* =0.049). Visceral fat and BMI showed a significant negative correlation with HDL levels (*p* =0.001)& (*p* =0.002), but subcutaneous fat did not show any significant correlation with HDL(*p* =0.49). Visceral fat showed a significant positive correlation with LDL levels (*p*=0.001) however, subcutaneous fat and BMI did not show significant correlation with LDL levels respectively(*p* =0.066) & (*p* =0.20). (Table-2)

**DISCUSSION**

Computed tomography (CT) is a perfect diagnostic choice for quantitative measurement of visceral fat due to its value being reliable, reproducible and easily accessible.In the current study single section technique was followed as area-based measurements of visceral fat at the level of umbilicus were relevant rather than volumetric measurements of visceral fat from the entire abdomen (diaphragm to pelvis).The justifications of the techniques employed were in concordance with studies done by P Maurovich-Horvat[7], T Irlbeck[10] and Masato Mizui[1] who observed that there were no significant differences between the two methods, yet the radiation exposure to subjects significantly decreased from 2.7 mSv (volumetric method) to approximately 0.5 mSv (area-based single-slice technique) which is less than annual general population radiation exposure limits(1mSv).[1], [6], [7], [10], [11] & [12] Magnetic resonance imaging( MRI) is another cross-sectional diagnostic tool used for VF measurements. Although the modality does not use ionizing radiation, its long acquisition time, inaccessibility and cost were the disadvantages. And also it is difficult to derive a direct relationship between tissue property and pixel value using this modality. Considering all these facts mentioned above,the CT scan was preferred.[5] &[7].

Visceral obesity was more common in males, and subcutaneous & general obesity were mostly found in females, especially in the postmenopausal age groups (50-60yrs), which is in concordance to studies conducted by Steven R. Smith et al [13], Anne E Sumner et al[14] and Hideki Asakawa et al. [15] This post-menopausal prevalence of obesity was likely due to loss of protective role of oestrogen and increased amount of lipoprotein lipase levels & its activity in the gluteal and femoral subcutaneous regions.[16]

On lipid profile correlation, deranged total cholesterol, TGs, HDL, LDL levels were more common in subjects with abnormal abdominal fat content (VF & SF) than normal abdominal fat content (VF & SF). The positive correlation of total cholesterol & triglyceride levels with visceral & subcutaneousfat along with BMI were similar to the study conducted by Neha Jain[17]. Low level of HDL were found in both visceral and general obesity subjects, however the visceral obesity subjects had 2.5 times less HDL level when compared to general obesity subjects.These results were congruent to the study conducted by Jean-Pierre Despres.[18] Subcutaneous obesity subjects did not show any variations in HDL levels(Table-2), which was similar to the study conducted by Hideki Asakawa.[15]

Precisely increased LDL levels were found among visceral obesity subjects and were not associated with subcutaneous & general obesity subjects (p value=0.061) & (*p* value=0.121) (Table-2), which was similar to studies conducted by Shahram Mazaheri[19], Yuqi Luo et al[20], Simone Lemieux[21] and Jean-Pierre Despre´s.[22] It is well established that both HDL and LDL are proatherogenic lipoproteins as decreased plasma level of HDL-C leads to impaired clearance of excess fat from the bloodstream and increased LDL- C levels, accelerates the development of atherosclerosis and plaque formation in coronary vessels.

There is a type of obesity which is prevalent in India called “thin fat obesity” which is excessive accumulation of fat in relation to the individual’s BMI. This pattern seems different and is rarely seen in other countries. Due to these reasons, the standard global cut off for BMI by WHO is reduced for the Indian population from 25 to 23 for overweight category and from 30 to 25 for obese category. There is a surge in these type of cases in the last two decades owing to sedentary lifestyles including lack of physical activity, excessive intake of high fat and high carbohydrate food products.[2]& [23]

We report 17/ 79(21%) subjects with high visceral fat with normal BMI & subcutaneous fat levels. These subjects are called as Metabolic obese with normal weight (MONW) or simply called as thin fat obese.[24]& [25] **Fig:2 (a&b).** Out of 15/17 (87%) of these MONW subjects had deranged lipid profile levels particularly,proatherogenic lipoproteins (HDL &LDL) (Table-3).

Likewise, 22/62 (35%) of the study subjects had high subcutaneous fat and high BMI with normal visceral fat levels which were more distributed among postmenopausal females which amounted to 17 (77%) cases. **Fig:3(a&b)**. Among the participants falling under this category,16/22 (72%) had normal lipid profile and the remaining 6/22(27%) had deranged lipid profile(Table-3). Derangement was evident only with TG levels,however proatherogenic lipoproteins (HDL & LDL) levels remained normal which explains the direct role of visceral fat in producing derangement of lipid levels especially proatherogenic lipoproteins.

In our study, significant rise in levels of proatherogenic lipoproteins were observed among subjects who had viscerally obesity. Similar pattern was reported by Delma J. Nieves.[26].

It is thus concluded from this study results that visceral obese subjects were indirectly at risk of developing coronary artery disease when compared with individuals who had subcutaneous obesity & general obesity.

Further research can throw light on the role of visceral obesity as a prominent risk factor in development of myocardial infarction / CAD in people who present with metabolic syndrome and other comorbidities.

**CONCLUSIONS**

It was noted that every study participant with increased visceral fat exhibited abnormal proatherogenic lipid profile, irrespective of body mass index and subcutaneous fat status. This elucidates that visceral obesity was an indirect risk factor for developing coronary artery disease. Individuals with subcutaneous obesity and normal visceral fat showed normal lipid levels and presented low risk for coronary artery disease.Computerized tomography remains an indispensable diagnostic tool for assessing visceral fat which is an indirect indicator of coronary artery disease. By using single section examination, the risk of radiation(0.5mSv) is very minimal than annual general population exposure limits(1mSv).

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**Conflicts of interest:** None

**Ethics committee approval:** This study was duly approved by the ethics committee of Government Medical College & Hospital, Aurangabad, Maharashtra

**BIBLIOGRAPHY:**

 1. Mizui M, Mizoguchi Y, Senda Y, Yokoi M, Tashiro T. Visceral Fat Area Evaluation by Computed Tomography Correlates with Visceral Fat Volume. Glob J Health Sci. 2017;9(10):78.

2. Misra A, Khurana L. Obesity-related non-communicable diseases: South Asians vs White Caucasians. Int J Obes [Internet]. 2011;35(2):167–87.

3. Busetto L, Carraro R, Universitario H, Princesa D La, Digito M. Assessment of abdominal fat distribution in obese patients : Anthropometry versus computerized tomography. 1992;(May 2014).

4. Shuster A, Patlas M, Pinthus JH, Mourtzakis M. The clinical importance of visceral adiposity: A critical review of methods for visceral adipose tissue analysis. Br J Radiol. 2012;85(1009):1–10.

5. Sottier D, Petit JM, Guiu S, Hamza S, Benhamiche H, Hillon P, et al. Quantification of the visceral and subcutaneous fat by computed tomography: Interobserver correlation of a single slice technique.. 2013;94(9):879–84.

6. Ryo M. Clinical significance of visceral adiposity assessed by computed tomography: A Japanese perspective. World J Radiol. 2014;6(7):409.

7. Maurovich-Horvat P, Massaro J, Fox CS, Moselewski F, O’Donnell CJ, Hoffmann U. Comparison of anthropometric, area- and volume-based assessment of abdominal subcutaneous and visceral adipose tissue volumes using multi-detector computed tomography. Int J Obes. 2007;31(3):500–6.

8. Ryckman EM, Summers RM, Liu J, del Rio AM, Pickhardt PJ. Visceral fat quantification in asymptomatic adults using abdominal CT: is it predictive of future cardiac events? Abdom Imaging. 2015;40(1):222–6.

9. Misra A, Wasir JS, Vikram NK, Pandey RM, Kumar P. Cutoffs of abdominal adipose tissue compartments as measured by magnetic resonance imaging for detection of cardiovascular risk factors in apparently healthy adult Asian Indians in north India. Metab Syndr Relat Disord. 2010;8(3):243–7.

10. Irlbeck T, Massaro JM, Bamberg F, O’Donnell CJ, Hoffmann U, Fox CS. Association between single-slice measurements of visceral and abdominal subcutaneous adipose tissue with volumetric measurements: The framingham heart study. Int J Obes. 2010;34(4):781–7.

11. Lee YH, Hsiao HF, Yang HT, Huang SY, Chan WP. Reproducibility and Repeatability of Computer Tomography-based Measurement of Abdominal Subcutaneous and Visceral Adipose Tissues. 2017;7(July 2016):1–7.

 12. Günalp M, Gülünay B, Polat O, Demirkan A, Gürler S, Akkaş M, et al. Ionising radiation awareness among resident doctors, interns, and radiographers in a university hospital emergency department. Radiol Medica. 2014;119(6):440–7.

13. Smith SR, Lovejoy JC, Greenway F, Ryan D, De Jonge L, De La Bretonne J, et al. Contributions of total body fat, abdominal subcutaneous adipose tissue compartments, and visceral adipose tissue to the metabolic complications of obesity. Metabolism. 2001;50(4):425–35.

14. Sumner AE, Farmer NM, Tulloch-Reid MK, Sebring NG, Yanovski JA, Reynolds JC, et al. Sex differences in visceral adipose tissue volume among African Americans. Am J Clin Nutr. 2002;76(5):975–9.

15. Asakawa H, Tokunaga K, Kawakami F. Relationship of abdominal fat with metabolic disorders in diabetes mellitus patients. Diabetes Res Clin Pract. 2002;55(2):139–49.

16. WARREN MD. Social and preventive medicine. Br J Clin Pract. 1961;15:217–27.

17. Jain N, Koley S, Sandhu JS. A study of correlation between intra-abdominal fat and lipid profiles and some anthropometric parameters in vegetarian and non-vegetarian middle aged women of Jabalpur, Madhya Pradesh. Anthropologist. 2009;11(2):77–81.

18. Despres JP, Moorjani S, Ferland M, Tremblay A, Lupien PJ, Nadeau A, et al. Adipose tissue distribution and plasma lipoprotein levels in obese women. Importance of intra-abdominal fat. Arteriosclerosis. 1989;9(2):203–10.

19. Mazaheri S, Sadeghi M, Sarrafzadegan N, Sanei H, Hekmatnia A, Tavakoli B. Correlation between body fat distribution, plasma lipids and apolipoproteins with the severity of coronary involvement in patients with stable angina. ARYA Atheroscler. 2011;6(4):140–3.

20. Luo Y, Ma X, Shen Y, Hao Y, Hu Y, Xiao Y, et al. Positive relationship between serum low-density lipoprotein cholesterol levels and visceral fat in a Chinese nondiabetic population. PLoS One. 2014;9(11):1–7.

21. Lemieux S, Prud’homme D, Moorjani S, Tremblay A, Bouchard C, Lupien PJ, et al. Do elevated levels of abdominal visceral adipose tissue contribute to age-related differences in plasma lipoprotein concentrations in men? Atherosclerosis. 1995;118(1):155–64.

22. Després JP, Couillard C, Gagnon J, Bergeron J, Leon AS, Rao DC, et al. Race, visceral adipose tissue, plasma lipids, and lipoprotein lipase activity in men and women: The health, risk factors, exercise training, and genetics (HERITAGE) family study. Arterioscler Thromb Vasc Biol. 2000;20(8):1932–8.

23. Mehta, Nihar; Vanani V. Obesity in India : Prevalence, Implications and management. API Med Updat. 2016;(January 2016):610–5.

24. Katsuki A, Sumida Y, Urakawa H, Gabazza EC, Murashima S, Maruyama N, et al. Increased visceral fat and serum levels of triglyceride are associated with insulin resistance in Japanese metabolically obese, normal weight subjects with normal glucose tolerance. Diabetes Care. 2003;26(8):2341–4.

25. Kurpad A V., Varadharajan KS, Aeberli I. The thin-fat phenotype and global metabolic disease risk. Curr Opin Clin Nutr Metab Care. 2011;14(6):542–7.

26. Nieves DJ, Cnop M, Retzlaff B, Walden CE, Brunzell JD, Knopp RH, et al. to Intra-Abdominal Fat. 2003;52(January).

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