1. Introduction

Cardiovascular diseases are one of the very important causes of death all over the world. There are several factors known to be strongly associated with coronary heart disease. Body fat is one such factor. Among the components of body fat, visceral adiposity has been proposed to correlate more with coronary heart disease risk. Visceral fat and WHR are linked to the development of glucose intolerance in many populations, including Asian Indians. But whether body fat can identify future coronary heart disease by itself is not known. There are well studied and proven scoring systems to identify future risk of coronary heart disease events in an individual like Framingham score, PROCAM score and Vascular age. Our study is an effort to find out if quantity of body fat, the anthropometric parameters indicating body fat and its components—visceral and tissue fat can be considered as a predictor of future coronary heart disease events similar to Framingham risk score, PROCAM score and Vascular age.
2. Material and Methods

Study was conducted after getting clearance from our college- Karnataka Institute of Medical Sciences ethics committee. After taking written and informed consent, study subjects were evaluated by clinical examination first and by fat measurement, blood tests later. Our study included 103 patients who were willing to be part of study.

2.1 Inclusion criteria: Adult patients willing for clinical evaluation, to undergo tests for body fat measurement and blood test for lipid profile estimation.

2.2 Anthropometric measurements: Using a measuring tape, with the subject standing, the waist circumference was measured as the narrowest circumference between the lower costal margin and the iliac crest. The hip circumference was the maximum circumference at the level of the greater trochanter of femur. Waist Hip Ratio (WHR) was then calculated.

2.3 Body fat measurement: Body fat was measured by bio-impedence method by Omron karada scan HBF 361. The study subjects were asked to hold the body fat measuring instrument in standing position with arms extended. Total body fat, subcutaneous fat, visceral fat as measured by the instrument were noted. This method has been proven to correlate well with body fat analyzed by DEXA.

2.4 Lipid profile test: Serum lipid profile of the study subjects was tested in the morning after overnight fast for 12 hours at least.

2.5 Calculation of coronary heart disease risk scores: Framingham score, PROCAM score and Vascular age were calculated using software after entering relevant data of history, anthropometric data, blood sugar levels and serum lipid profile values.

2.6 Statistical analysis: The data were analyzed using the software SPSS. Mean and standard deviation for each continuous variable was calculated separately for males and females. The correlation between the Framingham risk scores, PROCAM scores, Vascular age with anthropometric data and components of serum lipid was tested by Carl Pearson’s correlation coefficient method. The influence of anthropometric data and components of serum lipid on Framingham risk scores, PROCAM scores, Vascular age was tested by the multivariate regression analysis.

3. Results and Data Analysis

Our study included 103 patients. The distribution of the cardiac risk factors, results of laboratory investigations and the anthropometric data are summarized in table1.

| AGE          | MALES (n=71) | FEMALES (n=32) | TOTAL (n=103) |
|--------------|-------------|----------------|---------------|
| 54.09±10.64  | 52.53±12.59 | 53.61±11.24    |
| DIABETES     | 37.5%       | 47.9%          | 44.7%         |
| Smoking      | 35.2%       | 0%             | 24.3%         |
| SBP          | 141.23±21.72| 142.75±22.14   | 141.70±21.75  |
| DBP          | 82.67±11.67 | 85.87±11.89    | 83.66±11.77   |
| Weight       | 72.40±9.66  | 65.06±10.35    | 70.12±10.40   |
| Height       | 165.12±5.60 | 155.71±7.01    | 162.20±7.46   |
| T.Chol       | 179.43±43.20| 176.09±46.13   | 178.39±43.93  |
| LDL          | 114.29±32.72| 113.71±36.93   | 114.11±33.90  |
| HDL          | 39.09±6.62  | 51.21±43.09    | 42.86±25.02   |
| TGL          | 162.52±68.25| 147.62±71.80   | 157.89±69.36  |
| BMI          | 26.49±3.63  | 27.21±5.05     | 26.71±4.12    |
| WHR          | 0.963±0.05  | 0.86±0.09      | 0.93±0.08     |

SBP-Systolic blood pressure, DBP-Diastolic blood pressure, Tchol-total cholesterol, TGL-Triglycerides, BMI-body mass index, WHR-waist hip ratio
A high percentage of patients in our study were suffering from Diabetes mellitus (44.7% overall). 35% of the male patients were smokers. Mean systolic blood pressure was in hypertensive range (141.70 mmHg ± SD 21.75) among the whole study group as well as males and females. But diastolic blood pressure (83.66±11.77mmHg) in our whole study group as well as separately in males and females was within normal limits. Mean BMI of our whole study group was 26.71± 4.12 suggestive of slight overweight. The same was observed in males and females separately also. Mean values of Total cholesterol (178.39±43.93), HDL (42.86±25.02), LDL (114.11±33.90) were within normal limits, but triglyceride levels were slightly higher (157.89±69.36). There was no significant gender difference in Vascular age (p value 0.13) and PROCAM scores (p value 0.97), but Framingham Risk score was significantly higher in males (p value 0.0000) [table 2].

Table 2: Comparison of male and female with different variables

| Variable          | Sex    | n   | Mean  | SD    | t-value | P-value |
|-------------------|--------|-----|-------|-------|---------|---------|
| Vascular age      | Male   | 71  | 73.66 | 10.15 | 1.5138  | 0.1332  |
|                   | Female | 32  | 69.81 | 15.24 |         |         |
| PROCAM score      | Male   | 71  | 9.11  | 7.46  | -0.0252 | 0.9799  |
|                   | Female | 32  | 9.16  | 9.45  |         |         |
| Framingham score  | Male   | 71  | 15.01 | 11.55 | 5.9501  | 0.0000* |
|                   | Female | 32  | 2.66  | 2.97  |         |         |

*p<0.05

In order to negate the influence of anti-hypertensive and hypo-lipidemic medications on results, the results were re-analyzed by dividing the patients into two groups, one receiving anti-hypertensive and hypo-lipidemic treatment and the other not receiving treatment. But the Vascular age, PROCAM score and Framingham Risk score were not significantly different between these two groups [table 3].

Table 3: Comparison of with and without treatment with different variables

| Variable          | Treatment | n   | Mean  | SD    | t-value | P-value |
|-------------------|-----------|-----|-------|-------|---------|---------|
| Vascular age      | Without Rx| 75  | 74.09 | 10.31 | 1.1264  | 0.2633  |
|                   | With Rx   | 28  | 70.10 | 12.17 |         |         |
| PROCAM            | Without Rx| 75  | 8.68  | 7.82  | -0.3413 | 0.7338  |
|                   | With Rx   | 28  | 9.60  | 9.44  |         |         |
| Framingham score  | Without Rx| 75  | 10.19 | 10.30 | -1.0675 | 0.2888  |
|                   | With Rx   | 28  | 14.00 | 12.87 |         |         |

Rx- treatment

Body mass index (BMI), Total body fat percentage, tissue fat and visceral fat levels were not found to correlate with Vascular age [table 4], PROCAM score [table 5] and Framingham Risk scores [table 6]. But Waist Hip Ratio (WHR) was found to significantly correlate with Framingham Risk scores [table 6].

Table 4: Correlation coefficient between waist-hip ratio, visceral fat, tissue fat, total fat% and BMI with vascular age by Karl Pearson’s correlation coefficient method

| Variables          | Vascular age with | r-value | t-value | p-value |
|--------------------|-------------------|---------|---------|---------|
| Waist-hip ratio    |                   | 0.0534  | 0.5371  | 0.5924  |
| Visceral fat       |                   | 0.1522  | 1.5479  | 0.1248  |
| Tissue fat         |                   | 0.0007  | 0.0067  | 0.9946  |
| Total Fat%         |                   | -0.0785 | -0.7911 | 0.4308  |
| BMI                |                   | -0.0010 | -0.0101 | 0.9919  |
Table 5: Correlation coefficient between waist-hip ratio, visceral fat, tissue fat, total fat% and BMI with PROCAM by Karl Pearson’s correlation coefficient method

| Variables     | PROCAM with |        |        |        |
|---------------|-------------|--------|--------|--------|
|               | r-value     | t-value| p-value|
| Waist-hip ratio | -0.0520     | -0.5232| 0.6020 |
| Visceral fat  | 0.1073      | 1.0842 | 0.2808 |
| Tissue fat    | -0.0150     | -0.1505| 0.8807 |
| Total Fat%    | -0.0387     | -0.3891| 0.6980 |
| BMI           | -0.0355     | -0.3573| 0.7216 |

*p<0.05

Table 6: Correlation coefficient between waist-hip ratio, visceral fat, tissue fat, total fat% and BMI with Framingham score by Karl Pearson’s correlation coefficient method

| Variables     | Framingham score |        |        |        |
|---------------|-----------------|--------|--------|--------|
|               | r-value | t-value | p-value|
| Waist-hip ratio | 0.2579 | 2.6828 | 0.0085*|
| Visceral fat  | 0.0041 | 0.0412 | 0.9673 |
| Tissue fat    | -0.1021 | -1.0318| 0.3046 |
| Total Fat%    | -0.1323 | -1.3418| 0.1827 |
| Body Mass Index | -0.0262 | -0.2629| 0.7931 |

*p<0.05

The set of independent predictors for each of the dependent variables was determined through stepwise regression analyses. In these multivariate models, visceral fat remained the strongest correlate of each of the coronary heart disease risk scores, and WHR was the next most significant independent predictor of these outcomes.

Table 7: Multiple linear regression analysis of Vascular age by BMI, total body fat, tissue fat, Visceral fat and WHR.

| Variable       | Coefficient | Std Error | F-test | P-Value |
|----------------|-------------|-----------|--------|---------|
| Body Mass Index| -0.151      | 0.763     | 0.0392 | 0.843396|
| Total Fat      | -0.096      | 0.295     | 0.1069 | 0.744460|
| Subcut. tissue fat | -0.463 | 0.559     | 0.6876 | 0.409022|
| Visceral Fat   | 1.159       | 0.574     | 4.0824 | 0.046119|
| Waist Hip Ratio| 7.592       | 21.582    | 0.1237 | 0.725789|
| CONSTANT       | 72.216      | 14.847    | 23.6602| 0.000004|

Correlation Coefficient: $r^2=0.05$
Table 8: Multiple linear regression analysis of PROCAM score by BMI, total body fat, tissue fat, Visceral fat and WHR.

| Variable                | Coefficient | Std Error | F-test | P-Value  |
|-------------------------|-------------|-----------|--------|----------|
| Body Mass Index         | -0.127      | 0.518     | 0.0604 | 0.806395 |
| Total Fat               | 0.038       | 0.200     | 0.0370 | 0.847873 |
| Subcut. tissue fat      | -0.274      | 0.379     | 0.5214 | 0.472020 |
| Visceral Fat            | 0.716       | 0.389     | 3.3884 | 0.048744 |
| Waist Hip Ratio         | -7.080      | 14.640    | 0.2339 | 0.629753 |
| CONSTANT                | 17.340      | 10.071    | 2.9645 | 0.088329 |

Correlation Coefficient: $r^2=0.04$

Table 9: Multiple linear regression analysis of Framingham Risk Score by Body Mass Index, total body fat, tissue fat, Visceral fat and Waist Hip Ratio.

| Variable                | Coefficient | Std Error | F-test | P-Value  |
|-------------------------|-------------|-----------|--------|----------|
| Body Mass Index         | -0.621      | 0.676     | 0.8434 | 0.360727 |
| Total Fat               | -0.019      | 0.261     | 0.0055 | 0.940866 |
| Subcut. tissue fat      | -0.550      | 0.495     | 1.2361 | 0.269003 |
| Visceral Fat            | 0.321       | 0.508     | 0.4002 | 0.528478 |
| Waist Hip Ratio         | 67.700      | 19.118    | 12.5400| 0.000617 |
| CONSTANT                | -23.415     | 13.152    | 3.1697 | 0.078179 |

Correlation Coefficient: $r^2=0.16$

4. Discussion

Body fat is one of the very well proven risk factors for coronary heart disease. Body mass index (BMI), waist circumference (WC) are the anthropometric measures commonly employed to quantify overall adiposity. However, as more and more research has been carried out in this field, it is becoming obvious that regional fat depots may be playing a greater role than overall adiposity with regards to coronary heart disease etiology.\(^7\)\(^-\)\(^9\) This has been stressed by several studies which have highlighted pericardial fat and abdominal visceral adipose tissue (VAT) as unique, pathogenic fat depots.\(^10\)\(^-\)\(^16\) However, the results have not been consistent and in study by Amir A. Mahabadi et al.\(^17\) none of these fat depots are independently associated with CVD after further adjustment for traditional risk factors. Our study is an effort to understand the concept of varying influence of different fat tissues on coronary heart diseases. We tested this by quantifying total body fat, visceral fat, tissue fat and correlating them with known scoring systems of identifying future risk of coronary heart disease events- Framingham Risk Score, PROCAM score and Vascular age. Our study, as per our knowledge, is the first to test correlation between components of body fat and coronary heart disease risk scores.

Framingham risk score is used to predict the 10 year risk of developing coronary heart disease in people without history of cardiovascular disease.\(^18\) It has been developed based on data from a sample of the Framingham Heart and Offspring studies. This scoring system considers sex, age, total cholesterol, HDL cholesterol, systolic blood pressure, and smoking.

PROCAM score is also a risk score to predict risk of coronary heart events in individuals with no coronary heart disease and is derived from the European PROCAM study, performed in Germany.

"Heart Age" or "Vascular Age" is a newer concept to convey expression of age-appropriate cardiovascular risk based on the output of Framingham Risk Scores and shown to promote more accurate risk perception in users.\(^19\) It is a
simple method for communicating risk to general population.

Earlier, fat, in general, was considered to be always associated with increased coronary heart disease risk. But as more and more research has been carried out, this concept has been proven to be only partly correct. The location of fat is an important determinant of its coronary heart disease risk potential. In the abdomen, visceral fat appears to confer greater disease risk than adipose tissue in the subcutaneous location. Coronal heart disease risk is also influenced by the location of fat within the thigh. Fat in other fat depots (i.e., stored within muscle, around muscle fibers) is related to insulin resistance in obese persons, but there appears to be no such correlation with subcutaneous thigh fat. Although the mechanisms responsible for the differing effects of central and peripheral adiposity on coronary heart disease risk remain to be determined, the total adiposity probably does not adequately indicate the extent of coronary heart disease risk in individuals. Hence, usefulness of BMI, which is only an indicator of total adiposity only, in assessing coronary heart disease risk is therefore questionable. The same factor has been reflected in our study also and we did not find BMI and total body fat to be significantly correlating with coronary heart disease risk prediction scores. But, Waist Hip Ratio, which is a marker of visceral adiposity, and visceral fat itself were found to correlate significantly with coronary heart disease risk prediction scores. On the other hand, tissue fat was not found to correlate with coronary heart disease risk scores. The scientific reason why truncal adiposity increases risk for coronary heart diseases and lower-extremity adiposity decreases risk for coronary heart diseases has been based on heterogeneity of adipose tissue metabolism in different locations. It is clear from the data available from in vitro studies that adipocytes located in visceral abdominal regions are more sensitive to lipolytic stimuli and resistant to suppression of lipolysis by insulin than fat cells from gluteal-femoral subcutaneous regions; Daily systemic flux of free fatty acids, per unit of fat mass, has been shown to be higher in subjects with a predominant abdominal adiposity than in those with fat predominant in lower body, due both to a higher sensitivity to the activation of lipolysis and to an reduced suppression of lipolysis in abdominal fat cells. And also, abdominal fat may impact hepatic free fatty acid flux directly due to its location close to the portal circulation and, hence, increase TG synthesis and decrease hepatic insulin clearance.

Thus from our study, we recommend considering WHR and visceral fat to be equivalent to coronary heart disease risk prediction scores. In clinical practice, apart from stressing only on measures aimed at weight reduction, measures to reduce abdominal adiposity may be more fruitful in coronary heart disease risk reduction. Instead of calculating coronary heart disease risk scores, which are not very easy to calculate in clinical practice, WHR and visceral fat can be used as easy to use, scientifically sound tools to convey future coronary heart disease risk events to the general population.

5. Conclusion
-WHR, visceral fat are best correlates of coronary heart disease risk scores.
-BMI, total body fat, tissue fat do not correlate with coronary heart disease risk scores.
-WHR, visceral fat can be considered as surrogates of coronary heart disease risk prediction scores in clinical practice.

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