Body Adiposity Index versus Body Mass Index and Other Anthropometric Traits as Correlates of Cardiovascular Disease

M Regi[1], N Sharma[2]

[1]*Ph.D Scholar, Research and Development Centre, Bharathiar University, Coimbatore, India*

[2]*Department of Nutrition and Dietetics, Mount Carmel College, No.58, Palace ground, Bengaluru, India*

Abstract:-

Objective: **The worldwide prevalence of obesity mandates a widely accessible anthropometric tool to categorize adiposity that can best predict associated health risks. The body adiposity index (BAI) was designed as a single equation to predict body adiposity in pooled analysis of both genders. We compared body adiposity index (BAI), body mass index (BMI), and other anthropometric measures (waist circumference, waist to hip ratio, waist to height ratio, including percent body fat from skinfold measures, in their correlations with cardio metabolic risk factors. We also compared BAI with BMI to determine which index is a better predictor of percentage body fat.**

Methods: **The cohort consisted of 97 subjects (53 men, 44 women). We calculated correlations of BAI, BMI, and other anthropometric measurements (percentage body fat measured from skinfold measures, waist circumference, waist to height ratio, waist to hip ratio) with lipid parameters, cardiovascular traits (lipid parameters including total cholesterol, LDL, HDL and triglycerides) and blood. Correlations between each anthropometric measure and cardiometabolic trait were compared.**

Results: **Results of the study indicated that BAI was correlated more strongly than BMI with percentage body fat from sum of skinfold measures (r = 0.579 versus r = 0.368). BAI had weak correlations with cardiovascular risk factors than other adiposity indexes (BMI, WC, WHR and WHtR). The best correlations were found for WC and WHtR. BAI did not outperform BMI in its associations with any cardiometabolic trait.**

Conclusions: **The adiposity indexes that include the waist circumference (WHtR and WC) may be better candidates than BAI and BMI to evaluate metabolic and cardiovascular risk in both clinical practice and research.**

Key words: **BAI, Anthropometric indices, cardiovascular disease risk, Adiposity**

Abbreviations: **BAI – Body Adiposity Index, BMI – Body Mass Index, WC – Waist Circumference, WHR – Waist – Hip ratio, WHtR – Waist-height ratio, CVD – Cardiovascular disease**

I. INTRODUCTION

The human body is a storage and distribution mechanism that depends solely on the imbibed food for its composition and well-being. Changing lifestyles in the past few decades have brought about a whole new set of issues that have had a negative impact on it. One of which is Obesity.

Obesity is a chronic, multifactorial and complex disease in which excess body fat has accumulated to the extent that it will have a negative effect on health, leading to reduced life expectancy and/or increased health problems. The high occurrence of obesity has made it one of most important public health problems cutting across age groups worldwide. It has thus become the focus of investigative research focus and rightly so as the betterment of mankind depends on the ability to overcome the issue of Obesity.

Obesity is a leading preventable cause of death worldwide, with increasing rates in full grown adults and children. Authorities view it as one of the most serious public health problems of the 21st century. Obesity is stigmatized in much of the modern world (particularly in the western world), though it was widely seen as a symbol of wealth and fertility at other times in history, and still is in some parts of the world. In 2013, the American Medical Association classified obesity as a disease.

The underlying disease is the undesirable positive energy balance and weight gain. Obese individuals differ not only in the amount of excess fat that they store, but also in the regional distribution of that fat with in the body. The distribution of fat induced by weight gain affects the risks associated with obesity, and the kinds of disease that result. Excess abdominal fat is as great a risk factor for disease as is excess body fat perse. It is useful, hence, to be able to distinguish between those at increased risk as a result of abdominal fat distribution, or android obesity as it is often known, from those with the less serious gynoid fat distribution, in which fat is more evenly and peripherally distributed around the body.

The fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. Globally, there has been:

An increased intake of energy-dense foods that are high in fat; and an increase in physical inactivity due to the increasingly sedentary nature of many forms of work, changing modes of transportation, and increasing urbanization.

Changes in dietary and physical activity patterns are often the result of environmental and societal changes associated with development and lack of supportive policies in sectors such as health, agriculture, transport, urban planning, environment, food processing, distribution, marketing and education.

At an individual level, a combination of excessive food energy intake and a lack of physical activity are thought to explain most cases of obesity. A limited number of cases are due primarily to genetics, medical reasons, or psychiatric illness. In contrast, increasing rates of obesity at a societal level are felt to be due to an easily accessible and palatable diet, increased reliance on cars, and mechanized manufacturing.

A review (Keith SW et al. 2006) identified ten other possible contributors to the recent increase of obesity which include insufficient sleep, endocrine disruptors (environmental pollutants that interfere with lipid metabolism), decreased variability in ambient temperature, decreased rates of smoking, because smoking suppresses appetite, increased use of medications that can cause weight gain (e.g., atypical antipsychotics), proportional increases in ethnic and age groups that tend to be heavier, pregnancy at a later age (which may cause susceptibility to obesity in children), epigenetic risk factors passed on generationally, natural selection for higher BMI, and assortative mating leading to increased concentration of obesity risk factors (this would increase the number of obese people by increasing population variance in weight).

The global scenario

Overweight and obesity are the fifth leading risk for global deaths. At least 2.8 million adults die each year as a result of being overweight or obese. In addition, 44% of the diabetes burden, 23% of the ischaemic heart disease burden and between 7% and 41% of certain cancer burdens are attributable to overweight and obesity.

Some WHO global estimates from 2008 follow:

More than 1.4 billion adults, 20 and older, were overweight.

Of these overweight adults, over 200 million men and nearly 300 million women were obese.

Overall, more than 10% of the world’s adult population was obese.

Once considered a high-income country problem, overweight and obesity are now on the rise in low and middle-income countries, particularly in urban settings. More than 30 million overweight children are living in developing countries and 10 million in developed countries.

Overweight and obesity are linked to more deaths worldwide than underweight. For example, 65% of the world's population live in countries where overweight and obesity kill more people than underweight (this includes all high-income and most middle-income countries).

Obesity is associated with cardiovascular diseases including angina and myocardial infarction (Poirier P et al.,2006) A report in 2002 concluded that 21% of ischemic heart disease is due to obesity while a 2008 European consensus puts the number at 35%.

Morbidity

Obesity increases the risk of many physical and mental conditions. These co-morbidities are most commonly shown inmetabolic syndrome, a combination of medical disorders which includes: diabetes mellitus type 2, high blood pressure, high blood cholesterol, and high triglyceride levels.

Complications are either directly caused by obesity or indirectly related through mechanisms sharing a common cause such as a poor diet or a sedentary lifestyle. The strength of the link between obesity and specific conditions varies. One of the strongest is the link with type 2 diabetes. Excess body fat underlies 64% of cases of diabetes in men and 77% of cases in women (Seidell 2005).

Health consequences fall into two broad categories: those attributable to the effects of increased fat mass (such as osteoarthritis, obstructive sleep apnea, social stigmatization) and those due to the increased number of fat cells (diabetes, cancer, cardiovascular disease, non-alcoholic fatty liver disease). Increases in body fat alter the body's response to insulin, potentially leading to insulin resistance. Increased fat also creates a pro-inflammatory state, and a pro-thrombotic state.

Mortality

Obesity is one of the leading preventable causes of death worldwide Large-scale American and European studies have found that mortality risk is lowest at a BMI of 20–25 kg/m^2 (de Gonzalez, AB. 2010) in non-smokers and at 24–27 kg/m^2 in current smokers, with risk increasing along with changes in either direction. A BMI above 32 kg/m^2 has been associated with a doubled mortality rate among women over a 16-year period. On average, obesity reduces life expectancy by six to seven years, a BMI of 30–35 kg/m^2 reduces life expectancy by two to four years, while severe obesity (BMI > 40 kg/m^2) reduces life expectancy by ten years (Whitlock G et al.,2009).

Cardiovascular disease

Cardiovascular disease refers to any disease that affects the cardiovascular system, principally cardiac disease, vascular diseases of the brain and kidney, and peripheral arterial disease (Kelly,BB.2010). The causes of cardiovascular disease are diverse but atherosclerosis and/or hypertension are the most common. Additionally, with aging come a number of physiological and morphological changes that alter cardiovascular function and lead to subsequently increased risk of cardiovascular disease, even in healthy asymptomatic individuals

Prevalence

CVDs are the number one cause of death globally: more people die annually from CVDs than from any other cause

An estimated 17.3 million people died from CVDs in 2008, representing 30% of all global deaths. Of these deaths, an estimated 7.3 million were due to coronary heart disease and 6.2 million were due to stroke

Low- and middle-income countries are disproportionally affected: over 80% of CVD deaths take place in low- and middle-income countries and occur almost equally in men and women.

The number of people who die from CVDs, mainly from heart disease and stroke, will increase to reach 23.3 million by 2030. CVDs are projected to remain the single leading cause of death.

Most cardiovascular diseases can be prevented by addressing risk factors such as tobacco use, unhealthy diet and obesity, physical inactivity, high blood pressure, diabetes and raised lipids.

9.4 million deaths each year, or 16.5% of all deaths can be attributed to high blood pressure. This includes 51% of deaths due to strokes and 45% of deaths due to coronary heart disease. (WHO,2011)

Risk factors

Evidence suggests a number of risk factors for heart diseases: age, gender, high blood pressure, hyperlipidemia, diabetes mellitus, tobacco smoking, excessive alcohol consumption, sugar consumption, family history, obesity, lack of physical activity, psychosocial factors and air pollution.

Some of these risk factors, such as age, gender or family history, are immutable; however, many important cardiovascular risk factors are modifiable by lifestyle change, social change, drug treatment and prevention of Serrano's Cardiac Triad: hypertension, hyperlipidemia, and diabetes.

Various anatomic and physiological risk factors for atherosclerosis are known. These can be divided into various categories: congenital versus acquired, modifiable or not, classical or non-classical. The points labelled '+' in the following list form the core components of metabolic syndrome.

Risks multiply, with two factors increasing the risk of atherosclerosis fourfold. Hyperlipidemia, hypertension and cigarette smoking together increase the risk seven times (Mitchell et al. 2007).

Hypertension

Hypertension, also known as high or raised blood pressure, is a condition in which the blood vessels have persistently raised pressure. The higher the pressure in blood vessels the harder the heart has to work in order to pump blood. If left uncontrolled, hypertension can lead to a heart attack, an enlargement of the heart and eventually heart failure. Blood vessels may develop bulges (aneurysms) and weak spots due to high pressure, making them more likely to clog and burst. The pressure in the blood vessels can also cause blood to leak out into the brain. This can cause a stroke. Hypertension can also lead to kidney failure, blindness, rupture of blood vessels and cognitive impairment.

There are many behavioural risk factors for the development of hypertension including :

- consumption of food containing too much salt and fat, and not eating enough fruit and vegetables
- harmful levels of alcohol use
- physical inactivity and lack of exercise
- poor stress management.

These behavioural risk factors are highly influenced by people’s working and living conditions.

Anthropometry

Anthropometry is the study of the measurement of the human body in terms of the dimensions of bone, muscle, and adipose (fat) tissue. Measures of subcutaneous adipose tissue are important because individuals with large values are reported to be at increased risks for hypertension, adult-onset diabetes mellitus, cardiovascular disease, gallstones, arthritis, and other disease, and forms of cancer. Combined with the dietary and related questionnaire data, and the biochemical determinations, anthropometry is essential and critical information needed to assess obesity and risk of cardiovascular disease.

Underwater weighing and dual-energy X-ray absorption (DEXA) are most accurate for quantifying body fat, and computed tomography scans and magnetic resonance imaging can assess body fat distribution. However, such technologically complex methods are too costly and time consuming to be applied routinely in clinical settings. Surrogate methods such as impedance analysis and skin-fold thickness can also be used, but are notoriously inaccurate (Goran MI et al 1996, Piers LSet al. 2000). Anthropometric tools used in this study have been discussed.

Body mass index (BMI)

BMI is defined as the person’s weight in kilograms divided by the square of their height in metres (kg/m2). A frequent use of the BMI is to assess how much an individual's body weight departs from what is normal or desirable for a person of his or her height. The weight excess or deficiency may, in part, be accounted for by body fat although other factors such as muscularity also affect BMI significantly.

Waist circumference

The size of a person's waist or waist circumference, indicates abdominal obesity. Excess abdominal fat is a risk factor for developing heart disease and other obesity related diseases.

The National, Heart, Lung, and Blood Institute (NHLBI) classifies the risk of obesity-related diseases as high if men have a waist circumference greater than 102 cm (40 in) and women have a waist circumference greater than 88 cm (35 in).

Waist hip ratio

Waist–hip ratio or waist-to-hip ratio (WHR) is the ratio of the circumference of the waist to that of the hips.

The WHR has been used as an indicator or measure of the health of a person, and the risk of developing serious health conditions.

Waist to height ratio (WHtR)

The waist-to-height ratio (WHtR) of a person is defined as the person's waist circumference, divided by the person's height. The WHtR is a measure of the distribution of body fat. Higher values of WHtR indicate higher risk of obesity-related cardiovascular diseases; it is correlated with abdominal obesity (Lee, CM et al., 2008).A 2010 study that followed 11,000 subjects for up to eight years concluded that WHtR is a much better measure of the risk of heart attack, stroke or death than the more widely used body mass index (Schneider et al.2010).

Body adiposity index (BAI)

A new measure, the body adiposity index (BAI), has recently been proposed by Bergman et al. (Bergman, RN et al.2011) to provide valid estimates of percentage body fat (%fat) in adults:

$$\text{BAI} = \frac{\text{hip in cm}}{(\text{height in m})^{1.5}} - 18$$

The “BAI” is a direct estimate of percentage body fat. Unlike the BMI, the BAI provides %body fat in both males and females without statistical correction. Calculating BAI does not require a measurement of body weight. Raising height to the 1.5 power was found to maximize the correlation between this ratio and percent body fat (r ¼ 0.79); 18 was the estimated intercept of a regression model predicting percent body fat. Furthermore, these investigators found that BAI predicted the percent body fat of black adults in a second sample (r ¼ 0.85), and it was concluded that this index provides a direct estimate of percent body fat without the need for further adjustment (Bergman, RN et al.2011).

But this equation was developed in a sample of Mexican-American adults. Percentage body fat from dual-energy X-ray absorptiometry (DXA) was used as the criterion measure of body fatness. The reported correlation of BAI with %fat (ρ = 0.790) was higher than that of BMI (ρ = 0.569), although the authors did not test whether this difference in correlation coefficients was statistically significant.

Also, the agreement between BAI and %fat from DXA was rather poor at lower levels of adiposity. Bergmanfound similar results when cross-validating the BAI in a sample of African-Americans (Bergman, RN et al.2011). The utility of the BAI in other populations relies on the assumption that it not only correlates with but also accurately predicts percentage fat in those populations. The present study will test the concordance of the BAI with measured percentage fat in a sample of European-American adults to determine whether the BAI performs better than BMI as an indicator of adiposity. The BAI formula will also be optimized for this population to see if this improves performance.

II. NEED FOR THE STUDY

The main purpose of this study was to evaluate BAI as a better, more convenient method when compared to other anthropometric assessment tools. As it requires only a measuring tape and no equipments, it can be used in large sample studies and clinical practice.

According to Bergman, RN et al. (2011), correlation between DEXA-derived percentage adiposity and the BAI was R = 0.85. Hence we wish to evaluate the efficacy of BAI against BMI using DEXA done for patients as a part of the executive health check-up.

Although the limitations of the body mass index (BMI) are well known (Prentice AM 2001), this index remains widely used as a simple indicator of adiposity, and adults with a BMI of 30 kg/m2 or more are considered to be obese.

Bergman et al. suggested a new index, the body adiposity index (BAI) based on the measurements of hip circumference and height. Thus, it can be measured in places where the accurate measurement of weight is difficult. This index showed a high correlation with body fat measured using DEXA. In their study, Bergman also found that this correlation was higher than the one between BMI and body fat measured using DEXA when men and women were considered together. However, this study was conducted only in two U.S. ethnic populations, African Americans and Mexican Americans, but not in Indians.

As indicated previously, BAI calculation involves the use of hip circumference. It has been suggested that hip circumference captures male–female differences in adiposity better than the BMI. Taking into account this observation, it is expected that the BAI would be better in predicting body fat in men and women separately.

III. AIM

The aim of this study is to analyse the correlations between BAI, BMI and other adiposity indexes (percentage body fat from sum of skinfold measures, waist circumference, waist hip ratio and waist to height ratio) with cardiovascular risk factors.

To assess the behaviour of the BAI and BMI regarding the ability to discriminate overweight or obese individuals will also be analysed.

IV. OBJECTIVES

- To conduct anthropometric measures of height, weight, four site skinfold measures, hip circumference and waist circumference and determine BMI, BAI, percentage body fat from sum of skinfold measures, WC, WHR and WHtR.
- To correlate BAI with other anthropometric traits.
- To assess nutritional status through 24 hour recall.
- To correlate BAI and cardiovascular risk through lipid profile and blood pressure.

V. METHODOLOGY

Aim: The aim of this study was to correlate anthropometric tools, i.e. body adiposity index (BAI), Body Mass Index (BMI), waist circumference, waist to hip ratio and waist to height ratio, with respect to their ability to predict the percentage of body fat (PBF; confirmed by Skin fold thickness by Durnin 1973) and their effectiveness in predicting risk of cardiovascular diseases.

Objectives: The objective of the study is to compare Body Adiposity Index and Body Mass Index measurements in cardiovascular diseases and to assess the usefulness of the BAI. Furthermore, investigator's aim to correlate Body Adiposity Index and Body Mass Index with measures obtained using gold standard Skin Fold Thickness and to evaluate which is a better tool to evaluate body fat percentage.

The study was executed in six phases:

Stage I: Identification of hospital

Stage II: Identification of subjects

Stage III: Developing the tool for the study

Stage IV: Administration of questionnaire (24-hr Recall and Risk Assessment Forms)

Stage V: Biochemical Assessment

Stage VI: Analysis and Interpretation of data

Stage I: Identification of hospital

Research Setting: Different hospitals in the Bangalore were shortlisted and project proposal was prepared and hospitals were approached. A private hospital in Jayanagar, located in the south of Bangalore city of Karnataka state in Southern India where the study was carried out was finalised based on the management permission and on the co-operation to conduct the survey for the research purpose.

Research Design: A cross sectional study with pre-structured questionnaire was conducted with a random sample of 97 of the age group of 21 -76 years at the private hospital in Bangalore city, India. The respondents were approached and those who agreed were provided with the information about the purpose of this study and the questionnaires were administered. The data was collected with the help of questionnaire cum personal interview. A questionnaire is a research instrument consisting of a series of question and other prompts for the purpose of gathering informing from respondents. It is good reliable and provides quick elicitation of information. The investigator follows a rigid procedure and seeks answers to a set of pre conceived questions through personal interview. (Kothari.C.R 1990)

Stage II: Identification of subjects (Sample size, Recruitment and Selection)

Sample Size: The sample size was not pre-determined. A total of 97 subjects volunteered to involve in the research among them 53 were men and 44 were women.

Recruitment process: Random Sampling method was used for selecting the subjects for the study.

Selection: To elicit information for the study the subjects were interviewed individually. The same group of subjects were approached for the collection of biochemical data such as blood glucose tests, bone mineral density tests and lipid profile.

Characteristics: Respondents who were enrolled for the Executive Health Check and Preventive Health Check were selected.

Stage III: Developing the tool for the study

Method, Tools and Techniques:

A structured questionnaire (refer appendix A) was devised and used as a tool for the study. It contained open ended type of questions. Close-ended questions limit the respondent to the set of alternatives being offered, while open- ended questions allow the respondent to express an opinion without being influenced by the researcher (Foddy W 1993). The details obtained from the subjects were as follows:

Personal Information: Socio demographic data about clients were collected such as name, age, gender, educational qualification, occupation and number of family members, monthly income of the family.

Anthropometric measurements: Anthropometry is the science that defines physical measures of a person's size, form, and functional capacities. It includes measurement of the human body in terms of the dimensions of bone, muscle, and adipose (fat) tissue. These components are useful for evaluating over-nutrition or under-nutrition. They can be used in assessing growth, body fat distribution, etc.

This section included other anthropometric measures such as: height, weight, body mass index, waist circumferences, hip circumferences, and waist-to-hip circumferences, waist-to-height ratio, skin fold thickness and body adiposity index.(BAI)

Height- Height measurement is useful in determining the nutrition status and is valuable when used in conjunction with other anthropometric and clinical assessment measurements. The direct method involves a measuring rod stadiometer. Indirect method includes arm-span, recumbent length and knee height measurement. The height of the individual is made up of the sum four components: legs, pelvis, spine and skull.

Technique: Stadiometer was used to measure the height. After removing shoes the subjects were made to stand on a flat floor with feet parallel and with heels, buttocks, shoulders and back of the head touching the upright with arms hanging at the sides in the natural manner and with their heels in apposition with the wall taking care that there is no bending of the knees. The height was taken three times to avoid any error in reading.

The head piece of the stadiometer was gradually lowered to make contact with the top of the head. The reading was recorded. (Jelliffe, DB. 1966)

Weight –The weight is more sensitive measure compared to height and reflects recent nutritional intake. Electronic scale was used to measure weight.

Technique: The subjects were made to remove excess accessories if any and shoe, all items from pockets, watches, eye-glasses, belts, etc before measurement. The electronic digital scale in the kilogram mode was used. The subject was made to stand on the centre of the weight scale platform and weight was recorded. The weighing scale had 500g accuracy and was of the make Tanita.

Height and Weight parameters were used to calculate Body Mass Index (BMI)

Body Mass Index: BMI also called as the Quetelet's index,(W/H^2) kg/m^2,is the most widely used height-weight index (Lee and Nieman, 2003). BMI calculation requires weight and height measurements and, based on the result it can indicate over nutrition or under nutrition.

The formula for BMI is weight (in kg) / height (m^2). WHO 2006 standards were followed.

Table 3.1: WHO BMI classification

Category	BMI range – kg/m^2
Underweight	less than 18.5
Normal (healthy weight)	from 18.5 to 25
Overweight	from 25 to 30
Obese Class I (Moderately obese)	from 30 to 35
Obese Class II (Severely obese)	from 35 to 40
Obese Class III (Very severely obese)	over 40

Waist Circumference: The waist circumference is measured at a level midway between the lowest rib and the iliac crest. (Han, T. 1995) It is measured using measuring tape (in cm). A waist circumference less than 40 inches (102cm) is recommended for men and 38 inches (96 cm) is recommended for women.

Hip Circumference: The Hip circumference is measured around the widest portion of the buttocks, with the tape parallel to the floor. (WHO Using the above two parameters Waist-to-Hip ratio was calculated (WHR)

Waist-to-Hip ratio: Waist–hip ratio or waist-to-hip ratio (WHR) is the ratio of the circumference of the waist to that of the hips. It is an indicator or measure of the health of a person, and the risk of developing serious health conditions. Research shows that people with "apple-shaped" bodies (with more weight around the waist) face more health risks than those with "pear-shaped" bodies who carry more weight around the hips. WHO protocol was used to measure Waist-hip ratio.

WHO Stepwise approach to Surveillance (2008) states that abdominal obesity is defined as a waist–hip ratio above 0.90 for males and above 0.85 for females.

Waist-to-Height ratio: The waist-to-height ratio (WHtR) is defined as the person's waist circumference, divided by the person's height. The WHtR is a measure of the distribution of body fat. Higher values of WHtR indicate higher risk of obesity-related cardiovascular diseases; it is correlated with abdominal obesity. (Lee C.M et.al., July 2008)

Skin fold Thickness: Body composition studies, including information concerning the amount and distribution of human subcutaneous fat, and hence of calorie reserves, can be carried out by physical anthropometry using skin-fold callipers. The skin folds measured consists of a double layered of skin and subcutaneous fat. The left side of the body should be used for this and all other measurements. (Falkner,1960)

In this study investigator used Harpenden Callipers (Edwards et al., 1955).

Four site measurements technique was used which included Triceps, Biceps,

Sub scapular and Suprailiac.

Technique: At all sites, a length wise skin-fold was firmly grasped and slightly lifted up between finger and thumb of the left hand. Care was taken to not include the underlying muscle. The callipers were applied about 1cm below the investigator's fingers at a depth about equal to the skin fold, while the skin fold was still gently held throughout the measurement. Three measurements were made at each site and the results averaged.

Body Fat Percentage was calculated using the formula given by Durnin (1978)

Durnin Womersley Skinfold Body Fat Formula:

Body Fat Percentage = (495BodyDensity)-450

Log (Sum) = Triceps+Biceps+Suprailiac+Subscapular

BD = Body Density

Male:

Age 20-29

BD = 1.1533 – (0.0643 x log (sum)/log(10))

Age 30-39

BD = 1.1422 – (0.0544 x log (sum)/log(10))

Age 40-49

BD = 1.1620 – (0.0700 x log (sum)/log(10))

Age >50

BD = 1.1715 – (0.0779 x log (sum)/log(10))

Female:

Age 20-29

BD =1.1599– (0.0717 x log (sum)/log(10))

Age 30-39

BD = 1.1423 – (0.0632 x log (sum)/log(10))

Age 40-49

BD = 1.333 – (0.0612 x log (sum)/log(10))

Age >50

BD = 1.1339 – (0.0645 x log (sum)/log(10))

Body Adiposity Index: The body adiposity index was a method of measuring human body fat. It was proposed by Richard N. Bergman et al. 2011.

$$\mathrm{BAI} = \frac{\text{hip in cm}}{(\text{height in m})^{1.5}} - 18$$

Table 3.2: BAI classification

BAI Classifications for Men				
Age (years)	Underweight	Healthy	Overweight	Obese
20 - 39	Less than 8%	8% to 21%	21% to 26%	Greater than 26%
40 - 59	Less than 11%	11% to 23%	23% to 29%	Greater than 29%
60 - 79	Less than 13%	13% to 25%	25% to 31%	Greater than 31%

BAI Classifications for Women				
Age (years)	Underweight	Healthy	Overweight	Obese
20 - 39	Less than 21%	21% to 33%	33% to 39%	Greater than 39%
40 - 59	Less than 23%	23% to 35%	35% to 41%	Greater than 41%
60 - 79	Less than 25%	25% to 38%	38% to 43%	Greater than 43%

General food and life style habit: The information about the respondents food habits were obtained from the questionnaire, which included the type of dietary pattern respondents were following such vegetarian, non-vegetarian or ovo-vegetarian. The timings of meal consumed and if they had habit of skipping meal were also collected from them.

Respondents smoking and alcohol consumption were also collected. The other information collected were tobacco and drug usage of the respondents.

Medication or consumption of supplements by the respondents was also elicited using questionnaire.

Physical activity: The type of physical activity the respondents were involved in and the duration and frequency of participating in the physical activity were obtained through the questionnaire.

Stage IV: Administration of questionnaire (24-hr Recall And Risk Assessment Forms)

24-HOUR RECALL:

24 hour-Recall is used in most of the surveys because it is least expensive dietary technique both in time and personal. The summary of kinds and amount of all foods consumed by the subject in a 24 hour period may be recalled on the following day or a record can be kept on the day of consumption. Use of food models may help in 24-recall method. Completeness of recall maybe is improved by adroit probing by the interview method. (Robert, 1979)

Interview method of collecting data involves oral- verbal stimuli and reply in terms of oral – verbal responses (Kothari, C.R. 1990)

The 24- hour recall was conducted on all the subjects (97) who were selected for the study from the Preventive Health Check. A personal interview was carried out with each individual for this purpose. In the direct personal interview which is one of the most appropriate technique, the investigator personally comes in contact with the persons from whom information is to be obtained. (Gupta, 1987)

Through 24-hour recall method the list of foods eaten or drunk by the respondents starting from early morning, breakfast, mid-morning, lunch, tea, dinner and bedtime and the time of meal consumption were obtained. Standard cups were used to obtain the quantity of food consumed by the respondent.

Three day recall was taken. After obtaining the information of food consumed through the 24-hour recall method, the average intake of nutrients for all 97 subjects such as Energy(Kcal), Protein(g), Fat(g), Carbohydrates(g) and Calcium(mg) were calculated using the Nutritive value of Indian Foods by Gopalan,C.,(2004).

A copy of the questionnaire has been appended (Appendix-A)

Stage V: Biochemical and clinical Assessment

Lipid profile-Serum levels of total cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL) and triglycerides (TG), and blood pressure were determined for 97 subjects who enrolled for preventive health check and executive health check.

The technique of evaluating lipid profile method has been appended. (Appendix-B)

Stage VI: Analysis and Interpretation of data

Statistical Analysis of the Data:

Data was entered in Microsoft Excel and analysed using the SPSS package (13.0) The Karl Pearson's correlation coefficient and statistical significant level of $p<0.05$ was considered for all the analysis and comparison done

VI. RESULTS AND DISCUSSION

Table 4.1: Socio-demographic profile of the study subjects:

VARIABLES		Number	Percentage
AGE (in years)	20-39	39	40.2
	40-59	43	44.3
	≥60	15	15.5
Total		97	100.0
Gender	Male	53	54.6
	Female	44	45.4
Total		97	100.0
Number of family members	1-2	15	15.4
	3-4	70	72.2
	5-6	9	9.3
	≥7	3	3.1
			100.0
Educational qualification	<SSLC	6	6.2
	SSLC	9	9.2
	Pre university College	12	12.4
	Graduate	48	49.5
	Post Graduate	21	21.7
	PhD & Professional	1	1.0
Total		97	100

Table 4.1 showed that the study subjects were young and middle aged adults (40.2% and 44.3%) with a small proportion of old adults(15.5%). Men and women formed 54.6% and 45.4% of the sample respectively. Three and four member nuclear families were predominant (72.2%). 49.5% of the subjects had a graduate degree or higher education. 12.4% of them had completed pre university and 15.4% had completed SSLC or lower.

Table 4.2: History of Illness

Illness	Number	Percentage
None	66	68
Diabetes mellitus	4	4.1
Hypertension	11	11.3
Diabetes and Hypertension	3	3.2
Osteoarthritis	4	4.1
Diabetes and Osteoarthritis	1	1.0
Others	8	8.3
TOTAL	97	100

Majority (68%) of the subjects did not have any known medical illness. 11.3% were known cases of hypertension. Small proportions of the subjects suffered from diabetes mellitus (4.1%), osteoarthritis (4.15) and a combination of the two (1%).

Table 4.3 : Physical Activity of Subjects

Physical Activity of Subjects	Number	Percentage
Walking	58	59.7
Jogging	2	2.1
Gym	5	5.1
Treadmill	2	2.1
Yoga	6	6.2
Others	2	2.1
None	22	22.7

Majority (59.7%) of the subjects indulge in walking as a form of physical activity. A small proportion (6.2%) practised yoga. 22.7% of the subjects do not perform any form of physical activity.

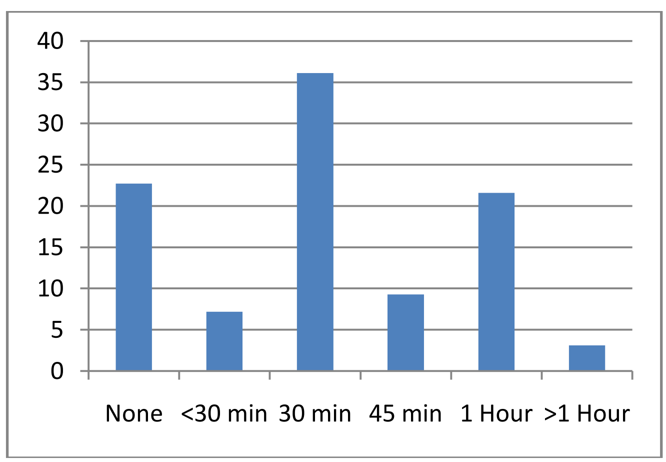

Figure 4.1 : Duration of Physical Activity of Subjects

36.1% of the subjects were involved in physical activity for 30minutes and 21.6% were physically active for 1 hour.

Table 4.4: Frequency of physical activity of subjects

Frequency	Number	Percentage
None	22	22.7
Daily	63	64.9
Once a week	3	3.1
3-4 times a week	8	8.3
Rarely	1	1.0

64.9% of the subjects were involved in physically active regularly whereas the 22.7% were completely not involved in any of the physical activity.

Table 4.5 : Drug Usage

Drug Habits	Number	Percentage
None	79	81.4
Smoking	5	5.2
Alcohol	7	7.2
Tobacco/Pan/Gutka	1	1.0
Smoking and Alcohol	5	5.2

81.4% of the subjects were not practising smoking, alcohol or tobacco abuse. 7.2% and 5.2% subjects indulged in alcohol and smoking respectively.

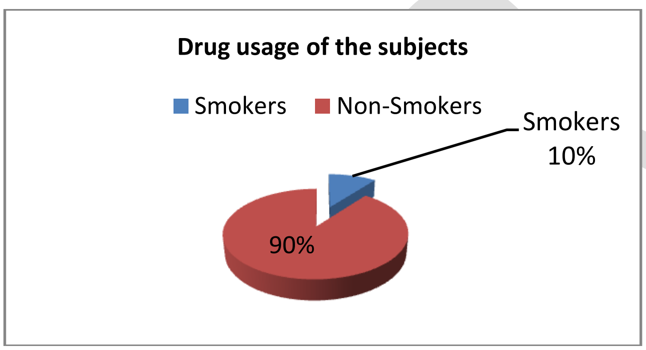

Figure 4.2 : Smokers and Non-Smokers Majority of the subjects (89.7%) were non-smokers

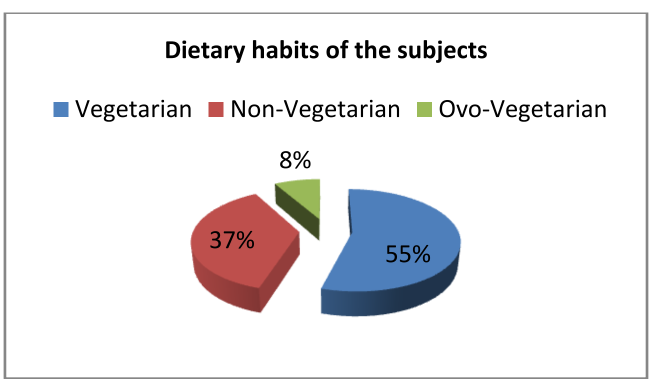

Figure 4.3: Dietary Habits

Figure 4.3 assesses the dietary habits of the subjects. More than half were Vegetarians (54.6%). 37.1% were found to be non-vegetarians and 8.3% were ovo-vegetarian.

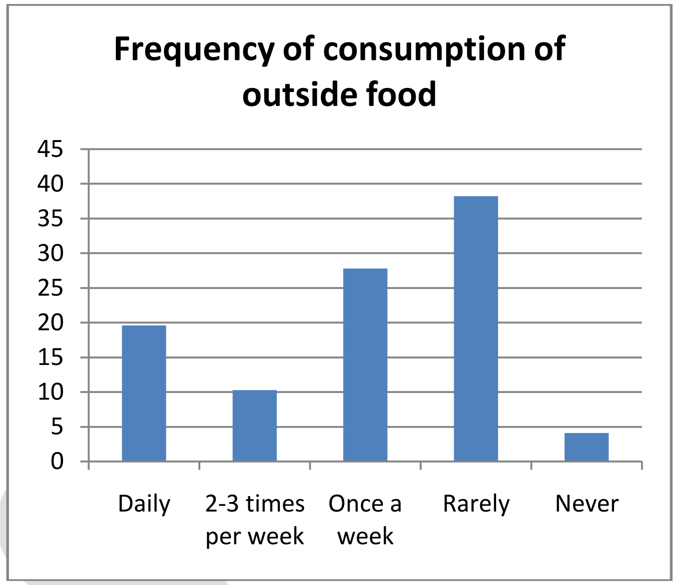

Figure 4.4: Frequency of consumption of outside food

Figure 4.4 shows that 38.2% of subjects rarely consume outside food, 27.8% were found to consume outside food weekly once and 19.3% consumed outside food daily.

Table 4.6 : Dietary assessment

Nutrients	Overall (adjusted for age and sex)	Gender	
		Male	Female
	Mean(SD)	Mean(SD)	Mean(SD)
Average energy intake (kcal)	1194.78(242.79)	1247.29(241.67)	1132.72(231.70)
Average Protein intake (g)	41.36(10.91)	44.88(11.03)	37.19(9.27)
Average carbohydrate intake (g)	213.40(100.40)	207.18(91.8)	220.72(110.32)
Average fat intake (g)	24.59(8.54)	27.57(9.21)	21.07(6.09)

From table 4.6, the 24-hour dietary recall of dietary habits of the subject was calculated. It was found that they consumed a mean of 1194.78 (242.79) Kcals of energy which was lower than the recommended intake suggested by Indian Council of Medical Research (ICMR). The subjects consumed average of 41.36 (10.91) g of protein which is lower than the recommended values suggested by ICMR. The subjects consumed average of 213.40 (100.40) g of carbohydrate and average of 24.59 (8.54) g of fat.

Table 4.7: Type of Oil used by the subjects

Type of Oil	Number	Percentage
Sunflower Oil	73	70.2
Groundnut Oil	10	9.6
Rice Bran Oil	6	5.8
Any Other Oil	13	12.5
Combination of oils	2	1.9

Sunflower oil (70.2%) is used majorly among the study subjects, followed by other oils such as olive oil, mustard oil (12.5).

Table 4.8: Anthropometric measures

	Overall (adjusted for age and sex)	Gender	
		Male	Female
	Mean(SD)	Mean(SD)	Mean(SD)
Height (cm)	162.94(9.21)	169.27(6.50)	155.31(5.41)
Weight (kg)	68.11(10.26)	72.33(8.87)	63.01(9.56)
Hip circumference (cm)	100.92(11.87)	101.66(13.64)	99.45(9.42)
Waist circumference (cm)	89.73(12.34)	94.13(11.42)	83.60(11.33)

Table 4.8 shows that the average height of the subjects is 162.9cm with mean height 169.27cm and 155.31cm for men and women respectively. The average weight is higher for men (72.3Kg) compared to women (63.01Kg) while the overall mean is 68.11Kg.

Average hip and waist circumference were found to be 110.9cm and 89.7cm respectively. Waist circumference of men was higher (94.13cm) when compared to women(83.6cm).

Table 4.9 : Skin fold measures

	Overall (adjusted for age and sex)	Gender	
		Male	Female
	Mean(SD)	Mean(SD)	Mean(SD)
Biceps (mm)	9.197(4.15)	8.05(3.23)	10.68(4.78)
Triceps (mm0	15.83(6.37)	13.26(5.94)	18.61(5.62)
Subscapular (mm)	20.13(4.40)	20.26(4.43)	19.75(4.42)
Supralilac (mm)	18.60(5.22)	17.48(4.34)	19.85(5.83

The mean and SD of the skinfold thickness is measured in 4 regions and mentioned in table. There is a difference in between the mean of triceps thickness in male (13.26) and in female (18.61).

Table 4.10 : Anthropometric Tools

	Overall (adjusted for age and sex)	Gender	
		Male	Female
	Mean(SD)	Mean(SD)	Mean(SD)
Waist-Hip Ratio	0.89(0.90)	0.92(0.07)	0.84(0.08)
Waist-to-Height Ratio	0.55(0.07)	0.55(0.07)	0.54(0.07)
BMI	25.45(4.44)	25.32(3.53)	25.61(5.39)
BAI	30.71(7.61)	28.39(8.14)	33.81(5.51)

The mean Waist-to-Hip ratio among the subjects were 0.89 (0.90) and mean waist-height ratio was 0.55 (0.07). Mean of body mass index was 25.45 (4.44) which indicates that majority of the subject belong to normal category (WHO 2006) and Body adiposity index was 30.71 (7.61).

Table 4.11 : Cardiovascular parameters

	Overall (adjusted for age and sex)	Gender	
		Male	Female
	Mean(SD)	Mean(SD)	Mean(SD)
Total cholesterol (mg/dL)	176.46(31.742)	174.92(31.23)	177.18(32.15
LDL (mg/dL)	115.91(29.437)	118.66(28.195)	111.38(30.26)
HDL (mg/dL)	40.76(13.264)	38.37(15.25)	43.77(9.11)
Triglycerides (mg/dL)	135.57(76.243)	143.58(82.23)	122.68(65.88)
Systolic blood pressure (mmHg)	127.69(15.56)	128.49(15.98)	126.72(15.17)
Diastolic blood pressure (mmHg)	80.98(7.80)	80.75(8.05)	81.27(7.57)

Table 4.11 shows that the average cholesterol of the subjects is 176.46mg/dL with mean 174.92mg/dL and 177.18mg/dL for men and women respectively. The average LDL and triglycerides were higher for men compared to women. HDL of women was higher (43.77mg/dL) when compared to men(38.37mg/dL).

Average systolic and diastolic blood pressures were found to be 127.69mmHg and 80.98mmHg respectively without significant difference between men and women.

II-COMPARISON TABLES

Table 4.12 : Correlation of BAI with BMI, WHR, WHtR and WC and body fat percentage from sum of skinfold measures

BAI	BMI	WHR	WHtR	WC	Percentage body fat from sum of skinfold measures
r value	0.698**	-0.303**	0.684**	0.428**	0.579**
p-value	0.000	0.003	0.000	0.000	0.000

Body adiposity index is the focal point of this study. Table 4.12 depicts a significant relation between body adiposity index and all anthropometric tools which include body mass index, waist hip ratio, waist to height ratio and waist circumference.

Body adiposity index had significant and strongest association with body mass index with r=0.698 and p<0.000 when compared to the other tools. This is in tune with the study conducted by Lo´pez, AA. et al. (2012) which showed similar correlation (r= 0.64, p,0.001).

BAI correlated significantly with the anthropometric tools (in decreasing order), with waist to height ratio (r=0.684 and p<0.000), waist circumference (r=0.428 and p<0.000) and waist hip ratio at (r= -0.303 and p<0.003).

Body adiposity index exhibited a significant correlation with percentage body fat from skinfold measures (r=0.579 and p<0.000)

Table 4.13: Correlations of BMI with BAI, WHR, WHtR, WC and body fat percentage from sum of skinfold measures.

BMI	BAI	WHR	WHtR	WC	Percentage body fat from sum of skinfold measures
r value	0.698**	-0.065	0.624**	0.488**	0.368**
p-value	0.000	0.531	0.000	0.000	0.000

The above table 4.13 indicates the correlations between BMI and anthropometric tools such as BAI, WHR, WHtR and WC.

BAI, WHtR, WC, PBF showed a significance with BMI.

It is noticed that there is a negative correlation between BMI and WHR.BMI had significant and strongest association with BAI with r=0.698 and p<0.000 when compared to the other tools. This is in tune with the study conducted by Lo´pez, AA. et al. (2012) which showed similar correlation (r= 0.64, p,0.001).

The WHtR and WC have showed significance of r= 0.624 and p<0.000 and r=0.488 and p< 0.000 with BMI respectively.

Table 4.14: Correlations of WHR with BMI, BAI, WC and body fat percentage from sum of skinfold measures

WHR	BMI	BAI	WC	Percentage body fat from sum of skinfold measures
r value	-0.065	-0.303**	0.632**	-0.300**
p-value	0.531	0.003	0.000	0.003

From above table 4.14 it was observed that WHR had positive and strong correlation with waist circumference which is in tune with the findings of a study done by Dobbelsteyn CJ et al. 2001.

There were moderate to strong correlations among the anthropometric measures at baseline, with the strongest correlations occurring between WC and WHR.

Table 4.15 : Correlations of WHtR with BMI, BAI, WC and body fat percentage from sum of skinfold measures

WHtR	BMI	BAI	WC	Percentage body fat from sum of skinfold measures
r value	0.624**	0.684**	0.920**	0.269**
p-value	0.000	0.000	0.000	0.008

Table 4.15 showed that WHtR has significant correlation with WC with r= 0.920 and p<0.000. This finding is supported by a study conducted by Savva, SC et al. (2000) in which waist circumference vs WHtR (r=0.947 significant at p<0.001) had similar results.

WHtR has significant correlation with both BAI and BMI. Its correlation with BAI (r=0.684 p<0.000) is stronger than its correlation with BMI (r=0.624 p<0.000)

BAI correlates better with body fat percentage when compared to WHtR.

Table 4.16 : Correlations of WC with BMI, BAI, WHR and WHtR

WC	BMI	BAI	WHR	WHtR
r value	0.488**	0.428**	0.632**	0.920**
p-value	0.000	0.000	0.000	0.000

Table 4.16 shows that WC has the strongest correlation with WHtR (r=0.920 p<0.000) followed by WHR (r=0.632 p<0.000). This has been validated in other studies done by Rexrode KM et al 1998, Hsieh SD et al. 1995 and Pouliot SC et al. 1994.

Waist circumference exhibits significant correlations (in decreasing order) with WHR (r=0.632 p<0.000), BMI (r=0.488 p<0.000) and least with BAI (r=0.428 p<0.000).

Table 4.17 : Correlations between anthropometric measures BAI, BMI, WC WHtR and Percentage body fat from sum of skinfold measures

		BMI	BAI	WC	Percentage body fat from sum of skinfold measures
BMI	r value p value		0.698** 0.000	0.488** 0.000	0.368** 0.000
BAI	r value p value	0.698** 0.000`		0.428** 0.000	0.579** 0.000

WHR	r value p value	-0.065 0.531	-0.303** 0.003	0.632** 0.000	-0.300** 0.003
WHtR	r value p value	0.624** 0.000	0.684** 0.000	0.920** 0.000	0.269** 0.008

Coefficients of correlations among BAI, BMI, waist circumference, wasit hip ratio and wasit to height ratio and percentage body fat determined by Durnin's formula for skinfold measures were calculated. When all the subjects were considered together, significant correlations were found for all parameters.

BAI and BMI showed a good correlation (r= 0.698, p<0.000). Amongst all the anthropometric tools, BAI was found to have the highest correlation with percentage body fat (r = 0.579, p,0.001), which includes the one between BMI and percentage fat (r =0.368, p<0.000).

Strong correlations were also found between BAI and waist hip ratio (r=0.303, p<0.003), whereas the correlation between BMI and waist hip ratio (r=0.065, p<0.531) is not significant.
Correlation between the BMI and waist circumference was much stronger (r= 0.488, p,0.000) than the one between BAI and waist circumference (r= 0.428, p,0.000).
Correlation between the BAI and waist to height ratio were stronger (r= 0.684, p<0.000) than the ones obtained when the BMI (r= 0.624, p<0.000).

Table 4.18: Correlations between anthropometric measures BAI, BMI, Percentage body fat from sum of skinfold measures with average nutrient intake

		Avg. energy	Avg. protein	Avg. carbohydrate	Avg. fat	Avg. calcium
BMI	r value p value	-0.106 0.303	-0.192 0.061	-0.086 0.403	-0.026 0.801	-0.131 0.474
BAI	r value p value	-0.189 0.065	-0.241* 0.018	-0.040 0.697	-0.182 0.077	-0.199 0.276
B.FAT	r value p value	-0.171 0.100	-0.218* 0.035	0.157 0.131	-0.466** 0.000	0.080 0.663

Table 4.18 shows that there is a significant negative correlation between the Body fat percentage and the average intake of fat (p= -0.466) this might be due to an under reporting of food intake by the subjects. An inverse association was reported in a study that showed that women with a higher BMI reported a lower fat intake than women with a lower BMI (Hjartåker and Lund 1998).

There was also negative correlation between Body adiposity index and Average protein intake (p= -0.241) and Body fat percentage and Average protein intake (p= -0.218)

Table 4.19.1: Correlation between Body Mass Index and Body Adiposity Index

BMI*BAI Cross tabulation

			BAI.CAT			Total
			Normal	Over weight	Obese	
BMI.CATE	Normal	Count	16	21	6	43
		row %	37.2%	48.8%	14.0%	100.0%
	Over weight	Count	14	18	11	43
		row %	32.6%	41.9%	25.6%	100.0%
	Obese	Count	2	1	8	11
		row %	18.2%	9.1%	72.7%	100.0%
Total		Count	32	40	25	97
		row %	33.0%	41.2%	25.8%	100.0%

Symmetric Measures			
		Value	Approx. Sig.
Measure of Agreement	Kappa	.116	.105

Table 4.19.2: Correlation between percentage body fat from sum of skin fold measures and Body Adiposity Index

Percentage body fat from sum of skinfold measures*BAI Cross tabulation

			BAI.CAT			Total
			Normal	Over weight	Obese	
b.fat.cat	Healthy	Count	13	8	2	23
		row %	56.5%	34.8%	8.7%	100.0%
	Overweight	Count	17	19	12	48
		row %	35.4%	39.6%	25.0%	100.0%
	Obese	Count	0	13	11	24
		row %	.0%	54.2%	45.8%	100.0%
Total		Count	30	40	25	95
		row %	31.6%	42.1%	26.3%	100.0%

Symmetric Measures			
		Value	Approx. Sig.
Measure of Agreement	Kappa	.150	.038

Table 4.19.3 : Correlation between Body fat percentage by Durnin and Body Mass Index

Percentage body fat from sum of skinfold measures*BAI Cross tabulation

			BMI.CATE			Total
			Normal	Over weight	Obese	
fat.cat	Healthy	Count	13	10	0	23
		row %	56.5%	43.5%	.0%	100.0%
	Over weight	Count	21	23	4	48
		row %	43.8%	47.9%	8.3%	100.0%
	Obese	Count	8	10	6	24
		row %	33.3%	41.7%	25.0%	100.0%
Total		Count	42	43	10	95
		row %	44.2%	45.3%	10.5%	100.0%

Symmetric Measures			
		Value	Approx. Sig.
Measure of Agreement	Kappa	.125	.076

Table 4.19.1 indicates that both BAI and BMI classify 16 subjects as normal, 18 subjects as overweight and 8 subjects as obese. The measure of agreement between BAI and BMI is indicated by the kappa value κ=0.116.

Table 4.19.2 indicates that both TSF and BAI classify 13 subjects as normal, 19 subjects as overweight and 11 subjects as obese. The measure of agreement between TSF and BAI is indicated by kappa value κ = 0.150

Table 4.19.3 indicates that both TSF and BMI classify 13 subjects as normal, 23 subjects as overweight and 6 subjects as obese. The measure of agreement between TSF and BMI is indicated by kappa value κ = 0.125.

Tables 4.20 : Correlation between cardiovascular parameters and anthropometric tools

Parameter	BAI	BMI	WHR	WHtR	WC	Body fat percentage from sum of skinfold measures
Total cholesterol (mg/dL)	0.004 0.968	0.019 0.351	0.070 0.502	0.049 0.638	0.044 0.668	0.132 0.204
LDL (mg/dL)	0.022 0.831	0.097 0.351	0.052 0.617	0.083 0.425	0.141 0.169	-0.069 0.507
HDL(mg/dL)	-0.089 0.392	-0.218* 0.034	-0.126 0.226	-0.212* 0.041	-0.277** 0.006	0.180 0.083
Triglycerides (mg/dL)	-0.005 0.959	0.019 0.855	0.235* 0.022	0.163 0.117	0.184 0.071	-0.038 0.715

From table 4.20, it is observed that of the cardiovascular risk parameters, HDL has significant and negative correlations with BMI, WHtR and WC. HDL had the strongest correlation with WC (r= -0.277, p<0.006) which is in supported by a study conducted by M.Dalton et al. (2003) with r=-0.310, p<0.001.

BAI and body fat percentage from TSF did not have any significant correlations with any of the cardiovascular parameters.

WHR has a significant and positive correlation with triglycerides (r=0.235, p<0.022). This is tune with a study conducted by R R Wing et al. (1991)

Table 4.21 : Correlations between average fat intake and cardiovascular parameters

Parameter	Average fat intake
Total cholesterol (mg/dL)	-0.080 0.445
LDL (mg/dL)	0.014 0.896
HDL(mg/dL)	-0.118 0.260
Triglycerides (mg/dL)	0.072 0.491

Table 4.21 : Correlations between average fat intake and cardiovascular parameters

Table 4.21 depicts no significant correlations between any of the average nutrient intake and cardiovascular parameters. This could be attributed to the under-reporting of food intake by the subjects. An inverse association was reported in a study that showed that women with a higher BMI reported a lower fat intake than women with a lower BMI (Hjartåker and Lund 1998)

Table 4.22 : Correlations between blood pressure and anthropometric tools

Parameter	BAI	BMI	WHR	WHtR	WC	Body fat
Systolic blood pressure(mmHg)	0.088 0.393	0.176 0.084	0.135 0.191	0.074 0.475	0.172 0.091	0.225* 0.028
Diastolic blood pressure (mmHg)	0.006 0.953	0.139 0.175	0.103 0.319	0.180 0.081	0.079 0.441	0.180 0.081

From table 4.22, it is concluded that none of the anthropometric tool have a significant correlation with blood pressure.

Body fat percentage from TSF had a positive and significant correlation with systolic blood pressure (r=0,225, p<0.028). This result is similar to a study conducted by Daniel P. Williams et al. (1992).

VII. SUMMARY

Anthropometry is the study of the measurement of the human body in terms of the dimensions of bone, muscle, and adipose (fat) tissue. Measures of subcutaneous adipose tissue are important because individuals with large values are reported to be at increased risks for hypertension, adult-onset diabetes mellitus, cardiovascular disease, gallstones, arthritis, and other disease, and forms of cancer.

In this cross sectional observational study, random sampling was used. Subjects were selected from patients who enrolled for the preventive health check and executive health check at a private Hospital, Jayanagar, Bangalore. Anthropometric tools were used to assess body fat, these include, body mass index (BMI), skinfold thickness, waist circumference (WC), waist hip ratio (WHR), waist to height ratio (WHtR) and recently proposed body adiposity index (BAI). Combined with the biochemical data (lipid profile and blood pressure), lifestyle and dietary information, anthropometric data was collected from 97 subjects (53men and 44 women) through questionnaire cum interview method.

Summary of the major findings of the study:

72.2% of the subjects belonged to three and four member nuclear families. 49.5% of the subjects had a graduate degree or higher education. 12.4% of them had completed pre-university and 15.4% had completed SSLC or lower.

Majority (68%) of the subjects did not have any known medical illness. 11.3% were known cases of hypertension. Small proportions of the subjects suffered from diabetes mellitus (4.1%), osteoarthritis (4.15) and a combination of the two (1%).

Majority (59.7%) of the subjects indulge in walking as a form of physical activity. A small proportion (6.2%) practised yoga. 64.9% of the subjects were involved in physically active regularly. 36.1% of the subjects were involved in physical activity for 30minutes and 21.6% were physically active for 1 hour. 22.7% of the subjects do not perform any form of physical activity.

81.4% of the subjects were not involved in smoking, alcohol or tobacco abuse. 7.2% and 5.2% subjects indulged in alcohol and smoking respectively.

54.6% of the subjects were vegetarians, 37.1% were non-vegetarians and 8.3% were ovo-vegetarians. 38.2% of subjects rarely consume outside food, 27.8% were found to consume outside food weekly once and 19.3% consumed outside food daily. Sunflower oil (70.2%) is used majorly among the study subjects, followed by other oils such as olive oil, mustard oil (12.5).

The average nutrient intake was found to be 1194.78 Kcals of energy, 41.36 (10.91) g of protein, 213.40 g of carbohydrate and 24.59g of fat, which was lower than the recommended intake suggested by Indian Council of Medical Research (ICMR).

Average height of the subjects was 162.9cm with mean height 169.27cm and 155.31cm for men and women respectively. The average weight was higher for men (72.3Kg) compared to women (63.01Kg) while the overall mean was 68.11Kg. Average hip and waist circumference were found to be 110.9cm and 89.7cm respectively. Waist circumference of men was higher (94.13cm) when compared to women(83.6cm).

The mean waist-to-hip ratio among the subjects were 0.89 and mean waist-height ratio was 0.55. Mean of body mass index was 25.45 and body adiposity index was 30.71. Body Adiposity Index was higher than the Body Mass Index.

The lipid profile od subjects was found to be normal with average cholesterol 176.46mg/dL and mean 174.92mg/dL and 177.18mg/dL for men and women respectively. The average LDL and triglycerides were higher for men compared to women. HDL of women was higher (43.77mg/dL) when compared to men (38.37mg/dL).

Average systolic and diastolic blood pressures were found to be 127.69mmHg and 80.98mmHg respectively without significant difference between men and women.

Coefficients of correlations among BAI, BMI, waist circumference, wasit hip ratio and wasit to height ratio and percentage body fat determined by Durnin's formula for skinfold measures were calculated. When all the subjects were considered together, significant correlations were found for all parameters.

BAI and BMI showed a good correlation (r= 0.698, p<0.000). Amongst all the anthropometric tools, BAI was found to have the highest correlation with percentage body fat (r = 0.579, p,0.001), which includes the one between BMI and percentage fat (r =0.368, p<0.000).

Strong correlations were also found between BAI and waist hip ratio (r=0.303, p<0.003), whereas the correlation between BMI and waist hip ratio (r=0.065, p<0.531) is not significant.

Correlation between the BMI and waist circumference was much stronger (r= 0.488, p,0.000) than the one between BAI and waist circumference (r= 0.428, p,0.000).

Correlation between the BAI and waist to height ratio were stronger (r= 0.684, p<0.000) than the ones obtained when the BMI (r= 0.624, p<0.000).

Amongst the cardiovascular risk parameters, HDL had significant and negative correlations with BMI, WHtR and WC. HDL had the strongest correlation with WC (r= -0.277, p<0.006). WHR has a significant and positive correlation with triglycerides(r=0.235, p<0.022).

There were no significant correlations between any of the average nutrient intake and cardiovascular parameters. This could be attributed to the under-reporting of food intake by the subjects.

None of the anthropometric tools indicated significant correlation with blood pressure. Body fat percentage from TSF had a positive and significant correlation with systolic blood pressure (r=0,225, p<0.028).

VIII. CONCLUSION

In conclusion, results of the present study suggest that the BAI is a good tool to measure adiposity as it had significant and positive correlation with percentage body fat from sum of skinfold measures when compared to BMI. Since only a measuring tape was required, it has advantages over other more complex mechanical or electrical systems. Probably, the most important advantage of BAI over BMI was that weight was not needed.

Data collected about diet and lifestyle of subjects in the present study indicated absence of erratic diet pattern, smoking, alcoholism, illnesses and use of medications. Majority of the subjects were physically active and made conscious diet choices. This reflected well on their anthropometric and biochemical parameters.

Several researchers have concluded that abdominal obesity, usually evaluated by the WC, is more strongly associated with cardiovascular risk factor levels than BMI (Freedman DS et al. 2012, de Lima JG et al. 2012). Results obtained in the present study were in agreement with these observations because the correlations between WC, WHR and WHtR and cardiovascular risk factors were better than the one with BMI, which is also in agreement with results obtained by Snijder et al. 2012. Also the usefulness of BAI as a cardiovascular health risk marker was evaluated. Since the BAI, as BMI, does not consider the waist circumference, it could be expected that the correlations between cardiovascular risk and the BAI are not better than the ones with other adiposity indexes. In fact, Freedman et al. found that the BAI was less associated with cardiovascular risk factors than BMI or WC (Freedman DS et al. 2012). Results from the present study show that the correlation between BAI and cardiovascular risk was weak when compared to the ones with more simple indexes which are WHtR, WHR, WC and, also, with BMI. Thus, the utilization of WHtR or the WC could be recommended as simple and practical indicators for assessing cardiovascular risk.

The main finding of the present study is that BAI, in spite of being a good adiposity predictor, does not overcome the limitations of BMI. Of the other indexes analyzed, waist circumference offers the best correlations hence it is recommended for estimating cardiovascular risk.

IX. LIMITATIONS OF THE STUDY

The gold standard to calculate body fat percentage Dual-energy X-ray absorptiometry could not be incorporated because of constraints of expenses.

The sample size was insufficient to prove relations between certain anthropometric tools and cardiovascular risk factors,

Rather than an analysis of cross-sectional associations, it would be optimal to assess the importance of BAI and BMI in a longitudinal study that focused on disease development.

The effectiveness of this study could have been proportionately higher if a population of high risk patients (elucidated from family history) had been addressed as a part of cardiovascular disease prevention.

X. RECOMMENDATIONS

A large scale study with longitudinal follow-up data on study subjects would provide cardiovascular and metabolic disease outcomes, such as incident myocardial infarction and diabetes. Further studies are needed to examine BAI, WHtR and WC as they relate to disease outcomes, and to clarify the clinical role that they may play in the diagnosis and evaluation of metabolic syndrome risk factors in the absence of biochemical assessment in large scale studies and rural regions.

Studies can be done taking into account the recently proposed body frame index (Krakauer et al. 2012) with the anthropometric tools.

Large sample with disease specific cohorts which include correltions based on age, gender and ethnicity will improve outcomes.

REFERENCES

[1]. Alberti, K. G. & Zimmet, P. Z. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. Diabet. Med. 15, 539–553 (1998).

[2]. Alberti, K. G., Zimmet, P. & Shaw, J. The metabolic syndrome — a new worldwide definition. Lancet 366, 1059–1062 (2005).

[3]. Ashwell M, Lejeune S, McPherson K. Ratio of waist circumference to height may be better indicator of need for weight management. BMJ 1996; 312: 377.

[4]. Banerji MA, Chaiken RL, Gordon D, Kral JG, Lebvitz HE. Does intra-abdominal adipose tissue in black men determine whether NIDDM is insulin-resistant or insulin-sensitive? Diabetes. 1995;44: 141-6.
[5]. Barness, LA, Opitz, JM, Gilbert-Barness, E (December 2007). "Obesity: genetic, molecular, and environmental aspects". American Journal of Medical Genetics 143A (24): 3016–34. doi:10.1002/ajmg.a.32035. PMID 18000969.
[6]. Bergman RN, Stefanovski D, Buchanan TA, Sumner AE, Reynolds JC, et al. (2011) A better index of body adiposity. Obesity (Silver Spring) 19: 1083–1089.
[7]. Berrington de Gonzalez A (December 2010). "Body-Mass Index and Mortality among 1.46 Million White Adults". N. Engl. J. Med. 363 (23): 2211–9.doi:10.1056/NEJMoa1000367. PMC 3066051. PMID 21121834.
[8]. Bingham, S. A. (1987) The dietary assessment of individuals; methods, accuracy, new techniques and recommendations. NutrAbst Rev (Series A) 57:705-742.
[9]. Bjorntorp P. 'Portal' adipose tissue as a generator of risk factors for cardiovascular disease and diabetes. Arteriosclerosis.1990; 10:493-6.
[10]. Bridget B. Kelly; Institute of Medicine; Fuster, Valentin (2010). Promoting Cardiovascular Health in the Developing World: A Critical Challenge to Achieve Global Health. Washington, D.C: National Academies Press. ISBN 0-309-14774-3.
[11]. Caballero B (2007). "The global epidemic of obesity: An overview". Epidemiol Rev 29: 1–5. doi:10.1093/epirev/mxm012. PMID 17569676.
[12]. Campbell, V. A. & Dodds, M. L. (1967) Collecting dietary information from groups of older people. /. Am. Diet. Assoc. 51:29-33.
[13]. Conway JM, Yanovski SZ, Avila NA, Hubbard VS. Visceral adipose tissue differences in black and white women. Am J Clin Nutr. 1995:61:765-71.
[14]. Cox BD, Whichelow MJ, Ashwell MA, Prevost AT. 1996. Comparison of anthropometric indices as predictors of mortality in British adults. Int J Obes Relat Metab Disord 20(Suppl 4):141.
[15]. de Ferranti SD, Osganian SK, Epidemiology of paediatric . metabolic syndrome and type 2 diabetes mellitus. Diab Vasc Dis Res 2007; 4 : 283-4.
[16]. de Lima JG, Nobrega LH, de Souza AB (2012) Body adiposity index indicates only total adiposity, not risk. Obesity (Silver Spring) 20: 1140.
[17]. Dennis, B., Ernst, N., Hjortland, M., Tillotson, J.& Grambsch, V. (1980) The NHLBI nutrition data system. /. Am. Diet. Assoc. 77:641-647.
[18]. DesprCs JP. Obesity and lipid metabolism: relevance of body fat distribution. Curr Opin Lipidol. 1991 ;2:5-15.
[19]. Dobbelsteyn CJ, Joffres MR, MacLean DR, Flowerdew G and The Canadian Heart Health SurveysResearch Group; A comparative evaluation of waist circumference, waist-to-hip ratio and body mass index as indicators of cardiovascular risk factors. The Canadian Heart Health Surveys; Int J of Obesity (2001) 25, 652-661
[20]. Eckel RH, Alberti KG, Grundy SM, Zimmet PZ (2010) The metabolic syndrome. Lancet 375: 181–183.
[21]. Edwards AD, Hammond WH, Healy MIR, Tanner IM, Whitehouse RH (1955): Design and accuracy of calipers for measuring subcutaneous tissue thickness. Br J Nutr 9: 133-143
[22]. Eknoyan G. Adolphe Quetelet (1796–1874)–the average man and indices of obesity. Nephrol Dial Transplant. 2008; 23:47–51. [PubMed: 17890752]
[23]. Engeland A, Bjorge T, Sogaard AJ, Tverdal A. Body mass index in adolescence in relation to total mortality: 32-year follow-up of 227,000 Norwegian boys and girls. Am J Epidemiol. 2003;157:517–523.
[24]. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). J. Am. Med. Assoc. 285, 2486–2497 (2001).
[25]. Falkner, F. Some physical growth standards for white North American children. Pediatrics 29: 467, 1962.
[26]. Foddy, W. (1993): Constructing Questions for Interviews and Questionnaires: Theory and Practice in Social Research. Cambridge: Cambridge University Press.
[27]. Fontaine KR, Redden DT, Wang C, Westfall AO, Allison DB. Years of life lost due to obesity. JAMA. 2003;289:187–193.
[28]. Frank, G. C., Hollatz, A. T., Webber, L. S. & Berenson, G. S. (1984) Effect of interviewer recording practices on nutrient intake Bogalusa Heart Study. /. Am. Diet. Assoc. 84:1432-1436.
[29]. Freedman DS, Thornton J, Pi-Sunyer FX, Heymsfield SB, Wang J, et al. (2012) The body adiposity index (hip circumference/height(1.5)) is not a more accurate measure of adiposity than is BMI, waist circumference, or hip circumference. Obesity (Silver Spring).
[30]. Garrido-Chamorro RP, Sirvent-Belando JE, Gonzalez-Lorenzo M, Martin-Carratala ML, Roche E. Correlation between body mass index and body composition in elite athletes. J Sports Med Phys Fitness. 2009; 49:278–284. [PubMed: 19884877]
[31]. Gersovitz, M., Madden, J. P. &.Smiciklas-Wright, H. (1978) Validity of the 24-hr, dietary recall and seven-day record for group comparisons. /. Am. Diet. Assoc. 73:48-55.
[32]. Giuseppe, Mancia; Fagard, R; Narkiewicz, K; Redon, J; Zanchetti, A; Bohm, M; Christiaens, T; Cifkova, R; De Backer, G; Dominiczak, A; Galderisi, M; Grobbee, DE; Jaarsma, T; Kirchhof, P; Kjeldsen, SE; Laurent, S; Manolis, AJ; Nilsson, PM; Ruilope, LM; Schmieder, RE; Sirnes, PA; Sleight, P; Viigimaa, M; Waeber, B; Zannad, F; Redon, J; Dominiczak, A; Narkiewicz, K; Nilsson, PM et al. (July 2013). "2013 ESH/ESC Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC)". European heart journal 34 (28): 2159–219. doi:10.1093/eurheartj/eht151. PMID 23771844
[33]. Golden SH, Folsom AR, Coresh J et al. Risk factor grouping related to insulin resistance and their synergistic effects on subclinical atherosclerosis: the atherosclerosis risk in communities study. Diabetes 2002;51:3069-76
[34]. Goran MI, Driscoll P, Johnson R, Nagy TR, Hunter G. Cross-calibration of body-composition techniques against dual-energy X-ray absorptiometry in young children. Am J Clin Nutr. 1996;63:299–305. [PubMed: 8602584]
[35]. Gupta AK, Samuel KC, Kurian PM, Rallan RC. Preliminary study of the incidence and aetiology of femoral neck fracture in Indians. Indian J Med Res 1967; 55:1341-8.
[36]. Gupta, SP 1987 Statistical Methods, Ninth revised edition, published by Sultan Chand and sons, New Delhi, p.E-3.4 to 3.5.
[37]. Haffner S, Mitchell B, Stern M, Hazuda H, Patterson J. Public health significance of upper body adiposity for non-insulin dependent diabetes mellitus in Mexican Americans. Int J Obes Relat Metab Disord 1992; 16: 177–84.
[38]. Han T, van Leer E, Seidell J, Lean M. Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample. BMJ 1995; 311: 1401–5.
[39]. Han TS, McNeill G, Seidell JC, Lean ME. Predicting intra abdominal fatness from anthropometric measures: the influence of stature. Int J Obes Relat Metab Disord 1997; 21: 587–93.
[40]. Han, T.; Van Leer, E.; Seidell, J.; Lean, M. (1995). "Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample". BMJ (Clinical research ed.) 311 (7017): 1401–1405
[41]. Hartz A, Rupley D, Rimm A. The association of girth measurements with disease in 32,856 women. Am J Epidemiol 1984; 119: 71–80.
[42]. Haslam DW, James WP (2005). "Obesity". Lancet 366 (9492): 1197–209. doi:10.1016/S0140-6736(05)67483-1. PMID 16198769.
[43]. Henriksson KM, Lindblad U, Agren B, Nilsson-Ehle P, Rastam L. 2001. Associations between body height, body composition and

cholesterol levels in middle-aged men. The coronary risk factor study in southern Sweden. CRISS. Eur J Epidemiol 17(6):521_/526.
[44]. Hjartåker A, Lund E. Relationship between dietary habits, age, lifestyle, and socio-economic status among adult Norwegian women. The Norwegian Women and Cancer Study. Eur J Clin Nutr 1998;52:565-72.
[45]. Ho SC, Chen YM, Woo JL, Leung SS, Lam TH, Janus ED. Association between simple anthropometric indices and cardiovascular risk factors. Int J Obes Relat Metab Disord 2001; 25: 1689–97.
[46]. Hsieh SD, Yoshinaga H, Muto T, Sakurai Y, Kosaka K. 2000. Health risks among Japanese men with moderate body mass index. Int J Obes Relat Metab Disord 24(3):358_/362.
[47]. Hsieh SD, Yoshinaga H, Muto T. 2003. Waist-to-height ratio, a simple and practical index for assessing central fat distribution and metabolic risk in Japanese men and women. Int J Obes Relat Metab Disord 27(5):610_/616.
[48]. Hsieh SD, Yoshinaga H. Abdominal fat distribution and coronary heart disease risk factors in men-waist/height ratio as a simple and useful predictor. Int J Obes Relat Metab Disord 1995; 19: 585-9.
[49]. Hsieh SD, Yoshinaga H. Waist/height ratio as a simple and useful predictor of coronary heart disease risk factors in women. Intern Med 1995; 34: 1147-52.
[50]. Hsieh SD, Yoshinaga H. Waist-height ratio as a simple and useful predictor of coronary heart disease risk factors in women. Intern Med 1995; 34: 1147 ± 1152.
[51]. Hu G, Qiao Q, Tuomilehto J et al for the DECODE Study Group. Prevalence of the metabolic syndrome and its relation to all-cause and cardiovascular mortality in nondiabetic European men and women. Arch Intern Med 2004;164:1066-76
[52]. International Diabetes Federation (IDF) and International Association for the Study of Obesity (IASO), 2004 Diabetes and Obesity: Time to Act.
[53]. Kannel WB, Dawber TR, Kagan A, Revotskie N, Stokes J 3rd (1961) Factors of risk in the development of coronary heart disease–six year follow-up experience. The Framingham Study. Ann Intern Med 55: 33–50.
[54]. Katzmarzyk PT, Gagnon J, Leon AS, Skinner JS, Wilmore JH, et al. (2001) Fitness, fatness, and estimated coronary heart disease risk: the HERITAGE Family Study. Med Sci Sports Exerc 33: 585–590.
[55]. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J (2005). "Global burden of hypertension: analysis of worldwide data". Lancet 365 (9455): 217–23. doi:10.1016/S0140-6736(05)17741-1. PMID 15652604.
[56]. Keith SW, Redden DT, Katzmarzyk PT et al. (2006). "Putative contributors to the secular increase in obesity: Exploring the roads less traveled". Int J Obes (Lond) 30(11): 1585–94. doi:10.1038/sj.ijo.0803326. PMID 16801930.
[57]. Keys A, Fidanza F, Karvonen MJ, Kimura N, Taylor HL. Indices of relative weight and obesity. J Chronic Dis. 1972; 25:329–343. [PubMed: 4650929]
[58]. Kothari, CR 1990 Research Methodology- Method and techniques. Second edition published by Wiley Easters Limited, New Delhi, p.20.
[59]. Lauer RM, Lee J, Clarke WR. Factors affecting the relationship between childhood and adult cholesterol levels: the Muscatine Study. Pediatrics 1988; 82 : 309-18.
[60]. Lee JS, Aoki K, Kawakubo K, Gunji A. A study on indices of body fat distribution for screening for obesity. Sangyo Eiseigaku Zasshi 1995; 37: 9-18.
[61]. Lee, CM Huxley RR, Wildman RP, Woodward M (July 2008). "Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis'". Journal of Clinical Epidemiology 61 (7): 646–653.
[62]. Lee, R. D. and D. C. Nieman. 2003. Nutritional Assessment. New York: McGraw Hill .
[63]. Lemieux S, Prud'homme D, Bouchard C, Tremblay A, Despres JP. A single threshold value of waist girth identifies normal weight and overweight subjects with excess visceral adipose tissue. Am J Clin Nutr 1996; 64: 685–93.
[64]. Lim SS, Vos T, Flaxman AD, Danaei G, et al A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010 : a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012 ; 380 (9859) : 2224-60
[65]. Lin WY, Lee LT, Chen CY, Lo H, Hsia HH, Liu IL, Lin RS, Shau WY, Huang KC. 2002. Optimal cut-off values for obesity: using simple anthropometric indices to predict cardiovascular risk factors in Taiwan. Int J Obes Relat Metab Disord 26(9):1232_/1238.
[66]. Lopez AA, Cespedes ML, Vicente T, Tomas M, Bennasar-Veny M, et al. (2012) Body adiposity index utilization in a Spanish Mediterranean population: comparison with the body mass index. PLoS One 7: e35281.
[67]. Loscalzo, Joseph; Fauci, Anthony S.; Braunwald, Eugene; Dennis L. Kasper; Hauser, Stephen L; Longo, Dan L. (2008). Harrison's principles of internal medicine. McGraw-Hill Medical. ISBN 0-07-146633-9.
[68]. Marrugat J, Solanas P, D'Agostino R, Sullivan L, Ordovas J, et al. (2003) [Coronary risk estimation in Spain using a calibrated Framingham function]. Rev Esp Cardiol 56: 253–261.
[69]. Mathieu P, Poirier P, Pibarot P, Lemieux I, Despres JP (2009) Visceral obesity: the link among inflammation, hypertension, and cardiovascular disease. Hypertension 53: 577–584.
[70]. McCarthy HD. Body fat measurements in children as predictors for the metabolic syndrome: focus on waist circumference. Proc Nutr Soc. 2006; 65:385–392. [PubMed: 17181905]
[71]. Mitchell, Richard Sheppard; Kumar, Vinay; Abbas, Abul K.; Fausto, Nelson (2007). Robbins Basic Pathology: With STUDENT CONSULT Online Access (8th ed.). Philadelphia: Saunders. p. 345. ISBN 1-4160-2973-7.
[72]. NHANES-lII Dietary Interviewer's Manual (1989) Westat, Inc., Rockville, MD.
[73]. Ohlson L-O, Larsson B, Svardsudd K, et al. The influence of body fat distribution on the incidence of diabetes mellitus. 13.5 years of follow-up of the participants in the study of men born in 1913. Diabetes 1985; 35: 1055–8.
[74]. Patel S, Unwin N, Bhopal R, White M, Harland J, Ayis SA, Watson W, Alberti KG. 1999. A comparison of proxy measures of abdominal obesity in Chinese, European and South Asian adults. Diabet Med 16(10):853_/860.
[75]. Piers LS, Soares MJ, Frandsen SL, O'Dea K. Indirect estimates of body composition are useful for groups but unreliable in individuals. Int J Obes Relat Metab Disord. 2000; 24:1145–1152. [PubMed:11033983]
[76]. Poirier P, Eckel RH. The heart and obesity. In: Fuster V, Alexander RW, Rep. 2002;4:448–453. Teixeira PJ, Sardinha LB, Going SB, Lohman TG. Total and regional fat and serum cardiovascular disease risk factors in lean and obese children and adolescents. Obes Res. 2001;9:432– 442.
[77]. Poirier P, Giles TD, Bray GA, et al. (May 2006). "Obesity and cardiovascular disease: pathophysiology, evaluation, and effect of weight loss". Arterioscler. Thromb. Vasc. Biol.26 (5): 968-76. doi:10.1161/01.ATV.0000216787.85457.f3. PMID 16627822
[78]. Pouliot M-C, Despre´s J-P, Lemieux S, et al. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. Am J Cardiol 1994; 73: 460–8.
[79]. Pouliot MC, Despres JP, Nadeau A, Moorjani S, Prud'homme D, Lupien PJ Tremblay A, Bouchard C. Visceral obesity in men. Associations with glucose tolerance, plasma insulin, and lipoprotein levels. Diabetes 1992;41:826–834.
[80]. Prentice AM, Jebb SA. Beyond body mass index. Obes. Rev. 2001; 2:141–147. [PubMed:12120099]
[81]. Rahman M, Berenson AB. Accuracy of current body mass index obesity classification for white, black, and Hispanic reproductive-age women. Obstet Gynecol. 2010; 115:982–988. [PubMed: 20410772]

[82]. Raitakari OT, Juonala M, Viikari JS. Obesity in childhood and. vascular changes in adulthood: insights into the Cardiovascular Risk in Young Finns Study. Int J Obes (Lond.) 2005; 29 (Suppl 2) : S101-4.

[83]. Richelsen B, Pedersen SB. Associations between different anthropometric measurements of fatness and metabolic risk parameters in non-obese, healthy, middle-aged men. Int J Obes Relat Metab Disord 1995; 19: 169–74.

[84]. Satcher D. The Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity. U.S. Dept. of Health and Human Services, Public Health Service, Office ofSurgeon General. 2001.

[85]. Savva SC, Tornaritis M, Savva ME, et al. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int J Obes Relat Metab Disord 2000; 24: 14538.

[86]. Sayeed MA, Mahtab H, Latif ZA, Khanam PA, Ahsan KA, Banu A, Azad Khan AK. 2003. Waist-to-height ratio is a better obesity index than body mass index and waist-to-hip ratio for predicting diabetes, hypertension and lipidemia. Bangladesh Med Res Counc Bull 29(1):1_/10.

[87]. Schneider et al. (2010). "The predictive value of different measures of obesity for incident cardiovascular events and mortality.". The Journal of Clinical Endocrinology & Metabolism 95(4): 1777–1785. doi:10.1210/jc.2009-1584. PMID 20130075.

[88]. Seidell 2005 p.9

[89]. Seidell JC, Andres R, Sorkin JD, Muller DC. The sagittal waist diameter and mortality in men: the Baltimore Longitudinal Study on Aging. Int J Obes Relat Metab Disord 1994;18:61–67.

[90]. Seidell JC, Perusse L, Despres JP, Bouchard C. Waist and hip circumferences have independent and opposite effects on cardiovascular disease risk factors: the Quebec Family Study. Am J Clin Nutr 2001;74:315–321.

[91]. Sivanandam S, Sinaiko AR, Jacobs DR Jr, Steffen L, Moran A, Steinberger J. Relation of increase in adiposity to increase in left ventricular mass from childhood to young adulthood. Am J Cardiol 2006; 98 : 411-5.

[92]. Snijder MB, Nicolaou M, van Valkengoed IG, Brewster LM, Stronks K (2012) Newly proposed body adiposity index (bai) by Bergman et al. is not strongly related to cardiovascular health risk. Obesity (Silver Spring) 20: 1138–1139.

[93]. Tanaka H, Clevenger CM, Jones PP, Seals DR, DeSouza CA (1998) Influence of body fatness on the coronary risk profile of physically active postmenopausal women. Metabolism 47: 1112–1120.

[94]. Tillotson, J. L., Corder, D. D., Duchene, A. G., Grambsch, P. V. & Wenz, J. (1986) Quality control in the Multiple Risk Factor Intervention Trial Nutrition Modality. Controlled Clin. Trials. 7:66S-90S.

[95]. Tracy RE, Wattigney WA. Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. The Bogalusa Heart Study. N Engl J Med 1998; 338 : 1650-6.

[96]. UKPDS Group. UK Prospective Diabetes Study 17: A nine-year update of a randomized, controlled trial on the effect of improved metabolic control on complications in non-insulin-dependent diabetes mellitus. Ann Intern Med 1996;124:136–45.

[97]. Visscher TL, Kromhout D, Seidell JC. Long-term and recent time trends in the prevalence of obesity among Dutch men and women. Int J Obes Relat Metab Disord 2002; 26: 1218–24.

[98]. Wang G, Dietz WH. Economic burden of obesity in youths aged 6 to 17 years: 1979-1999. Pediatrics 2002; 109 : E81-1.

[99]. Wang Y, Rimm EB, Stampfer MJ, Willett WC, Hu FB. Comparison of abdominal adiposity and overall obesity in predicting risk of type 2 diabetes among men. Am J Clin Nutr 2005;81:555–563.

[100]. Whitlock G, Lewington S, Sherliker P et al. (March 2009). "Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies". Lancet 373 (9669): 1083–96. doi:10.1016/S0140-6736(09)60318-4.PMC 2662372. PMID 19299006.

[101]. Whitlock G, Lewington S, Sherliker P, Clarke R, Emberson J, et al. (2009) Bodymass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. Lancet 373: 1083–1096.

[102]. WITSCHI, J., PORTER, D., VOGEL, S., BUXBAUM, R., STARE, F. J. & SLACK, W. (1976) A computer-based dietary counseling system. /. Am. Diet. Assoc. 69:385-390.

[103]. World Health Organization Causes of Death 2008 [online database]. Geneva,

[104]. World Health Organization. "WHO: Obesity and overweight". Archived from the original on December 18, 2008. Retrieved January 10, 2009

[105]. World Health Organization. "Obesity and overweight". Fact sheet N°311: World HealthOrganization. Updated March 2011; P 1-4.

[106]. World Health Organization. 2006. "BMI Classification". Global Database on Body Mass Index. Retrieved July 27, 2012.

[107]. World Health Organization. Global status report on noncommunicable diseases 2010. Geneva, World Health Organization, 2011.

[108]. World Heart Federation (5 October 2011). "World Heart Federation: Cardiovascular disease risk factors". Retrieved 5 October 2011.

[109]. Zhu S, Wang Z, Heshka S, Heo M, Faith MS, Heymsfield SB. Waist circumference and obesity-associated risk factors among whites in the third National Health and Nutrition Examination Survey: clinical action thresholds. Am J Clin Nutr 2002; 76: 743.

[110]. Zimmet P, Alberti KGMM, Shaw J. Global and societal implications of the diabetes epidemic. Nature 2001;414:782-7

APPENDIX A: QUESTIONNARIE

GENERAL INFORMATION

Name of the respondent - _______________

Age – _______________

Gender - Male ☐ Female ☐

Education Qualification – _______________

Occupation – _______________

Number of family members – _______________

Income – _______________

CLINICAL ANTHROPOMETRY

Height – _________ cms

Weight – _________ kg

BMI – _________ kg/m^2

Hip circumference – _________ cms

Waist circumference –_________ cms

Skin fold thickness – _________

Biceps Skin fold – _________

Triceps Skin fold – _________

Sub scapular Skin fold – _________

Supraliac Skin fold – _________

BIOCHEMICAL PARAMETERS

Lipid profile

Parameters	Value
Total cholesterol	
LDL	
HDL	
Triglycerides	

Blood pressure – _________ mm/Hg

MEDICAL DATA

Are you suffering from any illness? Please tick

Diabetes Mellitus ☐

Hypertension ☐

Cardiovascular Disease ☐

Osteoarthritis ☐

Irregular menstrual cycles ☐

Anemia ☐

Any other, specify ____________

Duration of illness ____________ days/weeks/months/years.

Are you taking any medications? Yes ☐ No ☐

If Yes, Specify ____________

How often do you go for a medical check-up? ______ times a month/year.

LIFESTYLE

Exercise habits

Type	Duration	Frequency			
		Daily	3-4 times/week	Once a week	Rarely
Walking					
Jogging					
Gym					
Treadmill					
Yoga					
Any other, Specify-					

2. Alcohol/Tobacco/recreational Drug use

Do you smoke now: Yes ☐ No ☐

If no, when did you discontinue? ______

How many cigarettes do you smoke? ______ /day

Do you have history of alcohol use? Yes ☐ No ☐

Do you chew tobacco/pan/gutka? Yes ☐ No ☐

How often do you consume food from outside/eat outside? ____________ times a week/month.

DIETARY ASSESSMENT

Number of meals/day – ____________

Vegetarian/ Non-vegetarian/ ovovegetarian/ Vegan

24- HOUR DIETARY RECALL

DAY 1

MEAL	MENU	INGREDIENTS	QUANTITY
On rising			
Breakfast			
Mid-morning			
Lunch			
Tea			
Dinner			

Bed-time			

DAY 2

MEAL	MENU	INGREDIENTS	QUANTITY
On rising			
Breakfast			
Mid-morning			
Lunch			
Tea			
Dinner			
Bed-time			

DAY 3

MEAL	MENU	INGREDIENTS	QUANTITY
On rising			
Breakfast			
Mid-morning			
Lunch			
Tea			
Dinner			
Bed-time			

Type of oil used

Type of oil	Quantity/day/month (specify)	Per person/family (specify)
Sunflower oil		
Soya bean oil		
Groundnut oil		
Mustard oil		
Palm oil		
Any other, Specify-		

APPENDIX B:

Method used at this private Hospital, Jayanagar, Bangalore for the analysis of lipid profile parameters:

Total cholesterol- Cholesterol oxidase peroxidase

Low density lipoprotein- Direct method

High density lipoprotein- Direct method

Triglycerides – Glycerol phosphatise oxidase/peroxidise

The equipment used for estimation is AU 480 and Dimension RXL Max.

ACKNOWLEDGEMENTS

It gives me great pleasure to acknowledging with gratitude and cherish the active guidance, welcome hope and endearing encouragement and continued support of many who have walked with me in this eye opening travelogue.

Firstly I pay obeisance to the Almighty, as every act of mine is but an instrumentation of his will and I am but an insignificant stream born out of His divinity.

I would like to express my gratitude to the institution Mount Carmel College Autonomous for providing me with this opportunity. The generous help and kind support of Present Principal, and Former Principal, of Mount Carmel College Autonomous, Bangalore, has instilled faith in me that students who strive to be future academicians can do so with dedication, all thanks to the presence of people like them.

My complete obeisance and heartfelt gratitude to my guide and mentor Mary Regi who has been pivotal in enhancing the essence of this thesis.

My sincere thanks to, HOD of the Nutrition and Dietetics Department, Mount Carmel College Autonomous, and the faculty members of the Department of Nutrition and Dietetics without whose motivation I might not have walked on the paths and reached the stage I am on.

A big and meaningful thank you to the Chief Nutritionist,of the Private Hospital, Jayanagar, Bangalore and all the dieticians of Sagar hospital for having given me the permission to carry out the study in their premises and also for extending their full support.

The acknowledgement would be incomplete without expressing sincere thanks for assistance lent by the subjects in the research who have willingly walked their way towards me to aid in enhancing my thesis with a smile.

I also wish to extend my sincere gratitude to the statistian for her help with the statistical analysis of the data.

I am blessed to have the parents that I have, whose wisdom and kindness have shaped me in ways that surpass what mere words can express. It is my sincere duty to acknowledge the outstanding work of my friends, who has been a companion in my travelogue from a very early point and has made it possible for me to reach further heights.

Last but definitely not the least, my sincere thanks to all my classmates who have always encouraged me and been a source of strength to me.