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

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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, WHHR – 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 in metabolic 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/m² (de Gonzalez, AB. 2010) in non-smokers and at 24–27 kg/m² in current smokers, with risk increasing along with changes in either direction. A BMI above 32 kg/m² 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/m² reduces life expectancy by two to four years, while severe obesity (BMI > 40 kg/m²) 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 disproportionately 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 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 musculature 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:

\[
\text{BAI} = \frac{\text{hip in cm}}{\left(\text{height in m}\right)^{1.5}} - 18
\]

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. Bergman found 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 questions 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 be removed. The skin fold callipers. The left side of the body should be used for subscapular and suprailliac.

**Body Mass Index:** BMI also called as the Quetelet’s index, \( \text{(W/H}^2) \) kg/m², 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 (m²). WHO 2006 standards were followed.

<table>
<thead>
<tr>
<th>Category</th>
<th>BMI range – kg/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>less than 18.5</td>
</tr>
<tr>
<td>Normal (healthy weight)</td>
<td>from 18.5 to 25</td>
</tr>
<tr>
<td>Overweight</td>
<td>from 25 to 30</td>
</tr>
<tr>
<td>Obese Class I (Moderately obese)</td>
<td>from 30 to 35</td>
</tr>
<tr>
<td>Obese Class II (Severely obese)</td>
<td>from 35 to 40</td>
</tr>
<tr>
<td>Obese Class III (Very severely obese)</td>
<td>over 40</td>
</tr>
</tbody>
</table>

**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 (WHR) is defined as the person's waist circumference, divided by the person's height. The WHR is a measure of the distribution of body fat. Higher values of WHR 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 = \((495 \text{Body Density}) - 450\)

\[
\log (\text{Sum}) = \text{Triceps} + \text{Biceps} + \text{Suprailiac} + \text{Subscapular}
\]

\(\text{BD} = \text{Body Density}\)

**Male:**

Age 20-29

\[
\text{BD} = 1.1533 - (0.0643 \times \log (\text{Sum})/\log(10))
\]

Age 30-39

\[
\text{BD} = 1.1422 - (0.0544 \times \log (\text{Sum})/\log(10))
\]

Age 40-49

\[
\text{BD} = 1.1620 - (0.0700 \times \log (\text{Sum})/\log(10))
\]

Age >50

\[
\text{BD} = 1.1715 - (0.0779 \times \log (\text{Sum})/\log(10))
\]

**Female:**

Age 20-29

\[
\text{BD} = 1.1599 - (0.0717 \times \log (\text{Sum})/\log(10))
\]

Age 30-39

\[
\text{BD} = 1.1423 - (0.0632 \times \log (\text{Sum})/\log(10))
\]

Age 40-49

\[
\text{BD} = 1.333 - (0.0612 \times \log (\text{Sum})/\log(10))
\]

Age >50

\[
\text{BD} = 1.1339 - (0.0645 \times \log (\text{Sum})/\log(10))
\]

**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.

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

### Table 3.2: BAI classification

#### BAI Classifications for Men

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Underweight</th>
<th>Healthy</th>
<th>Overweight</th>
<th>Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 39</td>
<td>Less than 8%</td>
<td>8% to 21%</td>
<td>21% to 26%</td>
<td>Greater than 26%</td>
</tr>
<tr>
<td>40 - 59</td>
<td>Less than 11%</td>
<td>11% to 23%</td>
<td>23% to 29%</td>
<td>Greater than 29%</td>
</tr>
<tr>
<td>60 - 79</td>
<td>Less than 13%</td>
<td>13% to 25%</td>
<td>25% to 31%</td>
<td>Greater than 31%</td>
</tr>
</tbody>
</table>

#### BAI Classifications for Women

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Underweight</th>
<th>Healthy</th>
<th>Overweight</th>
<th>Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 39</td>
<td>Less than 21%</td>
<td>21% to 33%</td>
<td>33% to 39%</td>
<td>Greater than 39%</td>
</tr>
<tr>
<td>40 - 59</td>
<td>Less than 23%</td>
<td>23% to 35%</td>
<td>35% to 41%</td>
<td>Greater than 41%</td>
</tr>
<tr>
<td>60 - 79</td>
<td>Less than 25%</td>
<td>25% to 38%</td>
<td>38% to 43%</td>
<td>Greater than 43%</td>
</tr>
</tbody>
</table>

**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       |
| Total           | 97     | 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>
<thead>
<tr>
<th>Table 4.2: History of Illness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illness</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>Hypertension</td>
</tr>
<tr>
<td>Diabetes and Hypertension</td>
</tr>
<tr>
<td>Osteoarthritis</td>
</tr>
<tr>
<td>Diabetes and Osteoarthritis</td>
</tr>
<tr>
<td>Others</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Table 4.3 : Physical Activity of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Activity of Subjects</td>
</tr>
<tr>
<td>Walking</td>
</tr>
<tr>
<td>Jogging</td>
</tr>
<tr>
<td>Gym</td>
</tr>
<tr>
<td>Treadmill</td>
</tr>
<tr>
<td>Yoga</td>
</tr>
<tr>
<td>Others</td>
</tr>
<tr>
<td>None</td>
</tr>
</tbody>
</table>

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

Table 4.4: Frequency of physical activity of subjects

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>22</td>
<td>22.7</td>
</tr>
<tr>
<td>Daily</td>
<td>63</td>
<td>64.9</td>
</tr>
<tr>
<td>Once a week</td>
<td>3</td>
<td>3.1</td>
</tr>
<tr>
<td>3-4 times a week</td>
<td>8</td>
<td>8.3</td>
</tr>
<tr>
<td>Rarely</td>
<td>1</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Drug Habits</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>79</td>
<td>81.4</td>
</tr>
<tr>
<td>Smoking</td>
<td>5</td>
<td>5.2</td>
</tr>
<tr>
<td>Alcohol</td>
<td>7</td>
<td>7.2</td>
</tr>
<tr>
<td>Tobacco/Pan/Gutka</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>Smoking and Alcohol</td>
<td>5</td>
<td>5.2</td>
</tr>
</tbody>
</table>

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 4.3 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 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

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Overall (adjusted for age and sex)</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean(SD)</td>
<td>Male</td>
</tr>
<tr>
<td>Average energy intake (kcal)</td>
<td>1194.78(242.79)</td>
<td>1247.29(241.67)</td>
</tr>
<tr>
<td>Average Protein intake (g)</td>
<td>41.36(10.91)</td>
<td>44.88(11.03)</td>
</tr>
<tr>
<td>Average carbohydrate intake (g)</td>
<td>213.40(100.40)</td>
<td>207.18(91.8)</td>
</tr>
<tr>
<td>Average fat intake (g)</td>
<td>24.59(8.54)</td>
<td>27.57(9.21)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Type of Oil</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower Oil</td>
<td>73</td>
<td>70.2</td>
</tr>
<tr>
<td>Groundnut Oil</td>
<td>10</td>
<td>9.6</td>
</tr>
<tr>
<td>Rice Bran Oil</td>
<td>6</td>
<td>5.8</td>
</tr>
<tr>
<td>Any Other Oil</td>
<td>13</td>
<td>12.5</td>
</tr>
<tr>
<td>Combination of oils</td>
<td>2</td>
<td>1.9</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Overall (adjusted for age and sex)</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean(SD)</td>
<td>Mean(SD)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>162.94(9.21)</td>
<td>169.27(6.50)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>68.11(10.26)</td>
<td>72.33(8.87)</td>
</tr>
<tr>
<td>Hip circumference (cm)</td>
<td>100.92(11.87)</td>
<td>101.66(13.64)</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>89.73(12.34)</td>
<td>94.13(11.42)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Overall (adjusted for age and sex)</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean(SD)</td>
<td>Mean(SD)</td>
</tr>
<tr>
<td>Biceps (mm)</td>
<td>9.19(4.15)</td>
<td>8.05(3.23)</td>
</tr>
<tr>
<td>Triceps (mm)</td>
<td>15.83(6.37)</td>
<td>13.26(5.94)</td>
</tr>
<tr>
<td>Subscapular (mm)</td>
<td>20.13(4.40)</td>
<td>20.26(4.43)</td>
</tr>
<tr>
<td>Suprailiac (mm)</td>
<td>18.60(5.22)</td>
<td>17.48(4.34)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Overall (adjusted for age and sex)</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean(SD)</td>
<td>Mean(SD)</td>
</tr>
<tr>
<td>Waist-Hip Ratio</td>
<td>0.89(0.90)</td>
<td>0.92(0.07)</td>
</tr>
<tr>
<td>Waist-to-Height Ratio</td>
<td>0.55(0.07)</td>
<td>0.55(0.07)</td>
</tr>
<tr>
<td>BMI</td>
<td>25.45(4.44)</td>
<td>25.32(3.53)</td>
</tr>
<tr>
<td>BAI</td>
<td>30.71(7.61)</td>
<td>28.39(8.14)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Overall (adjusted for age and sex)</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean(SD)</td>
<td>Mean(SD)</td>
</tr>
<tr>
<td>Total cholesterol (mg/dL)</td>
<td>176.46(31.74)</td>
<td>174.92(31.23)</td>
</tr>
<tr>
<td>LDL (mg/dL)</td>
<td>115.91(29.43)</td>
<td>118.66(28.19)</td>
</tr>
<tr>
<td>HDL (mg/dL)</td>
<td>40.76(13.26)</td>
<td>38.37(15.25)</td>
</tr>
<tr>
<td>Triglycerides (mg/dL)</td>
<td>135.57(76.24)</td>
<td>143.58(82.23)</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>127.69(15.56)</td>
<td>128.49(15.98)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>80.98(7.80)</td>
<td>80.75(8.05)</td>
</tr>
</tbody>
</table>

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
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.

<table>
<thead>
<tr>
<th>BMI</th>
<th>BAI</th>
<th>WHR</th>
<th>WHtR</th>
<th>WC</th>
<th>Percentage body fat from sum of skinfold measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>r value</td>
<td>0.698**</td>
<td>-0.303**</td>
<td>0.684**</td>
<td>0.428**</td>
<td>0.579**</td>
</tr>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.003</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

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 significant correlation 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.

<table>
<thead>
<tr>
<th>WHR</th>
<th>BMI</th>
<th>BAI</th>
<th>WC</th>
<th>Percentage body fat from sum of skinfold measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>r value</td>
<td>-0.065</td>
<td>-0.303**</td>
<td>0.632**</td>
<td>0.368**</td>
</tr>
<tr>
<td>p-value</td>
<td>0.531</td>
<td>0.003</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

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 WHR with BMI, BAI, WC and body fat percentage from sum of skinfold measures.

<table>
<thead>
<tr>
<th>WHR</th>
<th>BMI</th>
<th>BAI</th>
<th>WC</th>
<th>Percentage body fat from sum of skinfold measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>r value</td>
<td>0.624**</td>
<td>0.684**</td>
<td>0.920**</td>
<td>0.269**</td>
</tr>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Table 4.15 showed that WHR 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 WHR ($r=0.947$ significant at $p<0.001$) had similar results.

WHR 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 WHR.

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

<table>
<thead>
<tr>
<th>WC</th>
<th>BMI</th>
<th>BAI</th>
<th>WHR</th>
<th>WHtR</th>
<th>Percentage body fat from sum of skinfold measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>r value</td>
<td>0.488**</td>
<td>0.428**</td>
<td>0.632**</td>
<td>0.920**</td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

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 ($r=0.632$, $p<0.000$) and least with BAI ($r=0.428$, $p<0.000$).

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

<table>
<thead>
<tr>
<th>BAI</th>
<th>BMI</th>
<th>WC</th>
<th>Percentage body fat from sum of skinfold measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>r value</td>
<td>0.698**</td>
<td>0.428**</td>
<td>0.579**</td>
</tr>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Coefficients of correlations among BAI, BMI, waist circumference, waist hip ratio and waist 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 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

<table>
<thead>
<tr>
<th>Measure</th>
<th>Avg. energy</th>
<th>Avg. protein</th>
<th>Avg. carbohydrate</th>
<th>Avg. fat</th>
<th>Avg. Calcium</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>-0.106</td>
<td>-0.192</td>
<td>-0.086</td>
<td>-0.026</td>
<td>-0.131</td>
</tr>
<tr>
<td></td>
<td>0.303</td>
<td>0.061</td>
<td>0.403</td>
<td>0.801</td>
<td>0.474</td>
</tr>
<tr>
<td>BAI</td>
<td>-0.189</td>
<td>-0.241*</td>
<td>-0.040</td>
<td>-0.182</td>
<td>-0.199</td>
</tr>
<tr>
<td></td>
<td>0.065</td>
<td>0.018</td>
<td>0.697</td>
<td>0.077</td>
<td>0.276</td>
</tr>
<tr>
<td>B.FAT</td>
<td>-0.171</td>
<td>-0.218*</td>
<td>0.157</td>
<td>-0.466**</td>
<td>0.080</td>
</tr>
<tr>
<td></td>
<td>0.100</td>
<td>0.035</td>
<td>0.131</td>
<td>0.000</td>
<td>0.663</td>
</tr>
</tbody>
</table>

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 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 $\kappa = 0.116$.

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 $\kappa = 0.150$.

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 $\kappa = 0.125$.

Tables 4.20 : Correlation between cardiovascular parameters and anthropometric tools

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

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).
From Table 4.22, it is concluded that none of the anthropometric tools 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 (53 men 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 30 minutes 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 24.59 g of fat, which was lower than the recommended intake suggested by Indian Council of Medical Research (ICMR).

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

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

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

Coefficients of correlations among BAI, BMI, waist circumference, waist hip ratio and waist 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).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>BAI</th>
<th>BMI</th>
<th>WHR</th>
<th>WHtR</th>
<th>WC</th>
<th>Body fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>0.88</td>
<td>0.176</td>
<td>0.135</td>
<td>0.074</td>
<td>0.172</td>
<td>0.225*</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>0.953</td>
<td>0.139</td>
<td>0.103</td>
<td>0.180</td>
<td>0.079</td>
<td>0.180</td>
</tr>
</tbody>
</table>
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, WHR 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 correlations based on age, gender and ethnicity will improve outcomes.

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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 - _______
Suprailiac Skin fold - _______

BIOCHEMICAL PARAMETERS
Lipid profile

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cholesterol</td>
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</tr>
<tr>
<td>LDL</td>
<td></td>
</tr>
<tr>
<td>HDL</td>
<td></td>
</tr>
<tr>
<td>Triglycerides</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Duration</th>
<th>Frequency</th>
</tr>
</thead>
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<td></td>
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<td>Daily</td>
</tr>
<tr>
<td>Walking</td>
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<td></td>
</tr>
<tr>
<td>Jogging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gym</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treadmill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yoga</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any other, Specify-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>MEAL</th>
<th>MENU</th>
<th>INGREDIENTS</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>On rising</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mid-morning</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Lunch</td>
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</tr>
<tr>
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<tr>
<td>Dinner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>MEAL</td>
<td>MENU</td>
<td>INGREDIENTS</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
<td>------</td>
<td>-------------</td>
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<tr>
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<tr>
<td>Breakfast</td>
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<tr>
<td>Mid-morning</td>
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</tr>
<tr>
<td>Lunch</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dinner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed-time</td>
<td></td>
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</tbody>
</table>

**DAY 3**

<table>
<thead>
<tr>
<th>Time</th>
<th>MEAL</th>
<th>MENU</th>
<th>INGREDIENTS</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>On rising</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
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<tr>
<td>Mid-morning</td>
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</tr>
<tr>
<td>Lunch</td>
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<tr>
<td>Tea</td>
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</tr>
<tr>
<td>Dinner</td>
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</tr>
<tr>
<td>Bed-time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Type of oil used**

<table>
<thead>
<tr>
<th>Type of oil</th>
<th>Quantity/day/month (specify)</th>
<th>Per person/family (specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soya bean oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundnut oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mustard oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any other, Specify-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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.

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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.

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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.

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