Developing appropriate anthropometric indicators for early detection of metabolic syndrome and risk of chronic non-communicable diseases in Jimma university workers, Southwest Ethiopia

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Abstract

Background: Metabolic syndrome is a condition that includes group of coexisting metabolic risk factors specific for cardiovascular disease.Also it is becoming an important problem in low income countries since few years back. Review of available evidences showed that the international cut-off for different anthropometric measures of body composition is not appropriate for Ethiopians because of differences in body frames. For early detection, prevention, and treatment of the metabolic syndromeknowledge of anthropometric indicators based on locally driven data is crucialin resource limited settings like Ethiopia.

Objectives: This study is designed to develop appropriate anthropometric indicator for early detection of metabolic syndrome amongacademic and administrative staffs of Jimma University.

Method: An institution based cross sectional study was conducted on JU workers from February- April 2015 in Jimma University. Data were collected by five trained nurses. Structured questionnaire containing the relevant history, anthropometry measurement, laboratory data and body composition analyses using air displacement Platysmography was used. Data were entered using Epidata version 3.1 and exported to SPSS 20 version for analysis. Receiver operating characteristic analysis and area under curve were used to identify the sensitivity, specificity and youden's index of anthropometric indices. Cut-off point for the detection of metabolic risk was identified.Significant association was declared at $p<0.05$.

Result: Body fat percent highly and significantly correlated with BMI in women and with Waist Circumference in men. AUC for BMI to detect body fattens is higher than others on female participants. The appropriate cut-off valuesto predict the presence of multiple metabolic risk factors for BMI, WC, WHtR and WHR were 26.1, 80.57, 0.52, 0.88 for females and 22.87, 80.9, 0.49 and 0.88 for males, respectively.

Conclusion and recommendation: Waist circumference is better,in predicting the presence of multiple metabolic risk factors.These findings indicate to strengthening early and on time preventive life style modification program based on the revised cutoffs.

Keywords: Metabolic syndrome, body composition, Anthropometric indicators, Jimma University

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Acronyms

MetS- Metabolic Syndrome

CVD-Cardiovascular Disease

JU- Jimma University

BMI-Body Mass Index

WC- Waist Circumference

WHR-Waist to Hip Ratio

WHtR-Waist to Height Ratio

BF%- Body Fat Percent

AUC-Area Under Curve

ROC-Receiver Operating Characteristic

ADP-Air Displacement Plethysmography

IDF-International Diabetes Federation

NCDs-Non Communicable Diseases

WHO- World Health Organization

PPS- Population Proportional to Size

SRS- Simple Random Sampling

SPSS-Statistical Package for Social Science

PCA- Principal Component Analysis

BP-Blood Pressure

TG- Triglycerides

HDL-C- High-Density Lipoprotein Cholesterol

FBG- Fasting Blood Glucose

JUSH- Jimma University Specialized Hospital

JUCAN- Jimma University and University of Copenhagen Alliance in Nutrition

Chapter 1Introduction

1.1Background

Metabolic syndrome is a condition that includes group of coexisting metabolic risk factors specific for cardiovascular disease (CVD). Metabolic syndrome is also known as insulin resistance syndrome or syndrome 'X'(1). The criteria used for the diagnosis of metabolic syndrome includes abdominal obesity (waist circumference, >94 cm in men and >80 cm in women), elevated triglycerides (≥1.69 mmol/liter (≥150 mg/dl)), low high density lipoprotein (HDL) cholesterol (<1.04 mmol/liter (<40 mg/dl) in men and <1.29 mmol/liter (<50 mg/dl) in women), hypertension or use of antihypertensive medication (≥130/85 mm Hg), elevated fasting blood glucose(≥6.1 mmol/liter (≥100 mg/dl)) and other risk factors. However, the individual diagnosis of the metabolic syndrome is made when three or more of the risk factors present(2,3). More recently, a redefinition of the metabolic syndrome has been suggested by the International Diabetes Foundation, using adapted waist circumferences for different ethnic groups(4).

World-wide, the prevalence of MetS ranges from 10% to 50% (5) while it is also becoming the important problem in low income countries as well. The detection, prevention, and treatment of MetS should become a very important approach for the decrement of cardiovascular disease burden in the world(6). Hence, the identification of the population at risk is important.

Anthropometric measurement of body parts has been used in different age categories, as a sensitive indicator of wellness, maturation and development in humans. It is the single most universally applicable, inexpensive and non-invasive method available for the assessment of size, proportion and composition of human body(7). Height and weight are the two most easily obtained anthropometric measures and have been used extensively in screening and monitoring programs because abnormal weight categories (overweight and obesity) have been considered as risk factors for various diseases including metabolic syndrome(8). Body mass index (BMI), which is defined as body weight (in kilograms) divided by the square of body height (in meters), is the simplest, most practical, and most widely used anthropometry measuring of body weight. The index divides patients into appropriate categories: underweight, normal weight, overweight, and obese(9).

Obesity has been defined as an abnormal accumulation of fat in the adipose tissue throughout the body. BMI value of greater than or equal to 25 Kg/m2 is considered as overweight and BMI greater than equal to 30 Kg/m2 is considered as obesity. Obesity is the most common nutritional disorder in humans. It is a medical condition which disposes the individual to a complex health condition termed metabolic syndrome characterized by diabetes, lipid disorders, sleep apnea, certain type of cancer, osteoarthritis and hypertension leading to accelerated aging and cardiovascular disease(10).

Waist circumference (WC) is mainly used to reveal abdominal obesity plays a very important role in the development of metabolic disorders and in the assessment of cardiovascular risk. However, the WC has been criticized for not taking into account differences in body height and the ratio of WC to height (waist-to-height ratio, WHtR) has been proposed as a better predictor of cardiovascular risk (11,12), mortality(13), and intra-abdominal fat(14).

Besides anthropometric measurements body composition is also used to detect individuals at risk of developing metabolic syndrome despite their price. The recent introduction of air displacement plethysmography(ADP) provides another means by which body density measures in research and clinical settings(15). The ADP procedure, provided commercially as the BOD POD system, uses variation in pressure and volume, while the subject rests inside a sealed chamber, to estimate body density. The ADP method has been validated in normal weight adults (16).

1.2Statement of the problem

Metabolic syndrome (MetS) is a constellation of risk factors of cardiovascular disease (CVD) such as diabetes and impaired glucose regulation, central obesity, hypertension, and dyslipidemia(17). It is one of the major public health issues globally. Consumption of calorie-dense foods, sedentary lifestyle, tobacco consumption, genetic susceptibility and use of antiretroviral medications are risk factors for MetS. The International Diabetes Federation (IDF) believes that this cluster of factors is driving the twin global epidemics of type two diabetes and cardiovascular disease. If current trends continue, the premature deaths and disabilities resulting from these conditions will cripple the health budgets of many nations both developed and developing. People with metabolic syndrome have three times the risk of suffering a heart attack or stroke and twice the risk of dying from such an event compared with people without the syndrome(18).

Several decades ago, the burden of diseases among African population was from infectious diseases. Cardiovascular disorders were then seen as rare among these populations but today, these nations are witnessing epidemiological transition which has placed them on a double burden of disease. This implies that while infections and infestations are still a major health burden in these countries, non-communicable diseases have also become a problem(19,20). Early in the century, the point prevalence rate of diabetes mellitus in Africa was 0-1% but today available data show that this is no longer the position. It reaches to 50% depending on population setting(19,21).

The global prevalence of chronic non communicable diseases (NCDs) is on the rise, with the majority of the growth occurring among populations in developing countries(22). In sub-Saharan Africa, NCDs are projected to surpass infectious diseases by 2030(23). Limited available evidence suggests an increasing prevalence of MetS among populations in sub- Saharan African countries over the past decade. Information concerning the prevalence and risk factors of MetS among sub-Saharan Africa is sparse, as most studies have been conducted in North America, Europe, and Asia(24). In 2008, roughly four out of five NCD deaths occurred in low- and middle-income countries(25).

In cross-sectional survey conducted in 1995 among 15–24-year-old young adults in Addis Ababa, Ethiopia, about 6.0% of the females and 0.7% of the males were obese. In this study, the prevalence of elevated blood pressure (diastolic BP > 90 mmHG) was 7.1%(26). However, on a study conducted in the same area, Addis Ababa, in 2011 46.0% of men and 31.0% of women were pre hypersensitive (systolic BP 120–130 mmHg or diastolic BP 80–89 mmHg); 15.6% of men and 10.8% of women had stage 1 hypertension (systolic BP 140–159 mmHg or diastolic BP 90–99 mmHg)(24). This indicates that the risks for developing MetS are rising from time to time in our population that warrants the need for having appropriate indicators to detect the problems as early as possible.

Although BMI is commonly used for monitoring the occurrence of obesity in the population, it has numerous limitations. For one, it does not provide any information on the distribution of the adipose tissue in the organism. Second, it does not take into consideration physiological differences in the proportions between the adipose, osseous, and muscular tissues (9).Besides, its value is affected by sex, age, constitution, and training. It is only a proxy indicator of body fatness; factorssuch as fitness (muscle mass), ethnic origin and puberty can alter the relationship between BMI and body fatness(27).

There is increasing evidence of the emerging high prevalence of type 2 diabetes and increased cardiovascular risk factors in different parts of the world where the average BMI is below the cut-off point of 25 kg/m2 that defines overweight in the current WHO classification(28).

Similarly, there is increasing body of evidence that indicated the relation between BMI, percentage of body fat, and body fat distribution differ across populations. This difference depends on environmental factors, such as the amount of physical activity, as observed in the differences between rural and urban populations in India and Thailand,(29) as well as physiological factors. In particular, for the same level of body fat, age, and gender, BMIs of Ethiopians are 4.6 kg/m^2 lower compared to whites, which may also contributed to the growing debates on whether there are possible needs for developing different BMI cut-off points for different ethnic groups(30).

In the same case for WC, the current definitions of central adiposity (waist circumference ≥ 94 cm for men and ≥ 80 cm for women) recommended by the World Health Organization are based on data from Western populations. However, a growing body of literature indicates that these cutoffs likely need to be lower among different population. For instance Several epidemiologic studies in Asian populations have shown that Asians have higher amounts of body fat at lower waist circumferences than do Western populations perhaps leading to the greater prevalence of cardiovascular disease risk factors at lower WC in Asian populations than in Western populations(31).

Generally, though the burden of metabolic syndrome is significantly raising both in developed and developing nations, awareness and attention given to early detection of metabolic syndrome is not adequate. Additionally, the prevalence of chronic non-communicable disease increase on individuals with lower BMI, and WHO reaches on agreement on development of cut off point for anthropometric indicators in different settings(32). There are also a very limited data's related to developments of appropriate anthropometric indicator for early detection of metabolic syndrome in Ethiopia. So, this study is intended to develop cut off point for anthropometric indicators of metabolic syndrome among Ethiopian adults.

Chapter 2. Literature review

2.1Review of available evidence

Measures of adiposity such as BMI, waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) have been shown to correlate differently with CVD risk. BMI is the most frequently used measure of adiposity in epidemiologic studies(33).Some investigators have reported that using BMI alone is not the most accurate measure of increased CVD risk; instead, other studies argued that WC and WHtR as better predictors of future CVD risk(33,34).

2.1.1Correlations between anthropometric indicators and markers of metabolic syndrome

A cross-sectional study conducted in Israel, Sheba Medical Center, 2010 on 403 adults showed that coefficient between BMI and waist circumference was statistically significant for both men: r = 0.896 and women: r = 0.889(35).

Another cross sectional study conducted in Poland, 2013 on adultsshowed that waist circumference was found to be significantly correlated with BMI. (R = 0.78). The correlation was stronger among women (r = 0.80) than among men (r = 0.76)(36).

A cross-sectional study conducted in US civilian, 2004 showed that WC and BMI were significantly more correlated with each other than with percentage body fat. Percentage body fat tended to be significantly more correlated with WC than with BMI in men but significantly more correlated with BMI than with WC in women except in the oldest age group(37).

A cross sectional study conducted in south Asia,2010showed BMI strongly correlate with BF % estimated by bioelectrical impedance(38).

A cross sectional study conducted in America, 2009 showed that WC, WSR, BMI, and DXA-derived percentage body fat were all highly correlated with each other within sex-age groups. BMI, WC, and WSR all performed very similarly as indirect measures of body fat, and they were more closely related to each other than with percentage body fat. Percentage fat tended to be slightly but significantly more correlated with WC than with BMI among men, but significantly more correlated with BMI than with WC among women(39).

2.1.2ROC analysis for anthropometric indicators for predicting metabolic risk

A cross sectional study conducted in Liaoning Province, China, 2009 on 772 adult showed that BMI, waist circumference and WHtR values were all significantly associated with blood pressure, glucose, triglyceride and also with the number of metabolic risk factors in both male and female subjects. According to receiver operating characteristic (ROC) analysis, the area under curve values of BMI, waist circumference and WHtR did not differ in male and female subjects, indicating that the three values could be useful in detecting the occurrence of multiple metabolic risk factors. The appropriate cut-off values of BMI, waist circumference and WHtR to predict the presence of multiple metabolic risk factors were 22.85 and 23.30 kg/m2 in males and females, respectively. Those of waist circumference and WHtR were 91.3cm and 87.1cm, 0.51 and 0.53 in males and females, respectively(40).

A study conducted byLS Piers1 in Australian, 2000 on 117 adults using cross sectional study design the finding is BMI had poor sensitivity (47.7) and positive predictive (67.7) value in identifying individuals as being overweight-obese as classified by BF%DD(41).

A cross sectional study in Tehran ,on 2004 showed that Range of areas under ROC curves for BMI and WC was 0.55–0.94 and 0.56–0.93 for men and 0.41–0.94 and 0.53–0.92 for women in various age groups, respectively. Range of areas for WHR and WHtR in men was between 0.58–0.87 and 0.56–0.94, respectively, and for women varied between 0.53–0.91 and 0.53–0.90 in various age groups, respectively. Cutoff points of BMI for various risk factors were between 24 and 29 kg/m2 in men and 25–31 kg/m2 in women. Range of WHR was between 0.86 and 0.97 in men and between 0.78 and 0.92 in women. Cutoff points for WC and WHtR were between 80 and 93cm and 0.47 and 0.56 for men and between 79 and 96cm and 0.50 and 0.63 for women in different age groups to detect various risk factors, respectively. In general, values were lowest for the most prevalent risk factors and highest for less prevalent conditions(32).

A cross sectional study conducted in Qatar, on 2013 showed that WC followed by WHR and WHtR yielded the highest area under the curve 0.78 and 0.75 respectively. Among women,WC followed byWHtR yielded the highest AUC 0.81 & 0.79respectively. Among men,WC at a cut-off 99.5 cmresulted in the highest Youden's index with sensitivity 81.6% and 63.9% specificity. Among women,WC at a cut-off 91 cm resulted in the highest Youden's index with the corresponding sensitivity and specificity of 86.5% and 64.7%, respectively. BMI had the lowest sensitivity and specificity in both genders(42).

A cross sectional study conducted in Japan, on 2008 showed that the predictive power of waist circumference was not inferior to those of other indices. Therefore, waist circumference is practically the most convenient measure for predicting MS because of its simplicity(43).

A cross sectional study conducted in India, 2003 showed that Normal cutoff values for BMI was 23 kg/m2 for both sexes. Cutoff values for WC were 85 and 80 cm for men and women, respectively; the corresponding WHRs were 0.88 and 0.81, respectively. Optimum sensitivity and specificity obtained from the receiver operator characteristic curve corresponded to these cutoff values(44).

A cross sectional study done in Canada, on 2001 showed that Waist circumference may be the best single indicator of other individual and multiple cardiovascular risk factors. Optimal cut-off points of all anthropometric measures are dependent on age, sex and the prevalence of the risk factor(s) being considered. For waist circumference, cut-off points of 90cm in men and 80cm in women may be most appropriate for prediction of individual and multiple risk factors in Caucasian populations(45).

A cross sectional study conducted in Nigeria on 400 adults showed that In women, significant correlation exist between BMI and WC, BMI and WHR, WC and WHR whereas, in men, the correlation was only significant for BMI and WC(46).

A cross sectional study conducted in Addis Ababa on 2010 showed that on ROC curves WC (AUC = 70%) and WHR (AUC = 70%) perform best in identifying risk of elevated BP among men. On the other hand, WHR (AUC = 60%) and WHtR (AUC = 60%) are better predictors than other measures of adiposity for elevated FBG. Among women, ROC curves show that WC (AUC = 73%) performs best in identifying risk of elevated BP. For elevated FBG, WC (AUC = 62%) was a better predictor than other measures of adiposity(47).

2.2 Significance of the study

In recent years, several studies have shown the increasing importance of MetS not only in developed countries but also in low-income countries. The most important fact is that these chronic non-communicable diseases can be prevented. There is abundant evidence to support the argument that a large percentage of chronic non-communicable diseases are preventable by changing modifiable and intermediate risk factors(48). So identification of the population at risk is important but few studies have focused on developing countries.

Secondly, development of public health interventions also demands the knowledge of anthropometric indicators based on locally driven data for educating the public. Evidences show that anthropometric measure can be used to generate simple and cost-effective indicators for early detection of metabolic syndromerisk in resource limited settings like Ethiopia. Review of available evidences showed that the international cut-off for different anthropometric measures of body composition is not appropriate for Ethiopians because of differences in body frames.

Therefore, this study was conducted to develop appropriate anthropometric indicators to detect risk of metabolic syndrome in Jimma University, Jimma town, Ethiopia. These results could be used to design and develop polices targeting early detection of metabolic syndrome, to prepare national advocacy and behavior change communication on nutrition programs at population level, It can also be a baseline for further researches.

Chapter 3. Objectives

3.1 General objective

- To develop appropriate anthropometric indicators for early detection of metabolic syndrome and chronic non-communicable diseases in Jimma University Workers, February-April 2015

3.2 Specific objectives

- To assescorrelation between anthropometric indicators with markers of metabolic syndrome in Jimma University workers
- To determine the validity of anthropometric indicators compared to Air Displacement Plethysmographyin Jimma university workers
- To determine the validity of anthropometric indicators compared to markers of Metabolic Syndrome in predicting the risk of metabolic syndrome in Jimma university workers
- To determine optimal cut-off points for anthropometric indicatorsof adiposity for detecting metabolic risk in Jimma university workers

Chapter4. Methods and materials

4.1 Study area and period

The study was conducted at Jimma University, in Jimma Town capital of Jimma zone, Oromia. The university campus is located in the city of Jimma, situated around 352 kilometers southwest of Addis Ababa. Its grounds cover some 167 hectares.Itwas established in December 1999 and has six colleges and two Institutes training various professionals. There are a total of 5444 workers from this 1341 are academic staff.

The study was conducted from February 2015 up to April 2015.

4.2. Study design

Institution based cross sectional study from the baseline data of the intervention study was employed to answer the objectives of this study.It was a part of mega project then required variables were extracted from it.

4.3. Population

4.3.1 Source population

All administrative and academic staffs of Jimma Universitywere taken as source population.

4.3.2 Study population

Workers of Jimma University who are randomly selected to participate were used as study population.

4.3.3 Sample size and Sampling technique

Sample size was calculated by using sensitivity estimation formula taking Prevalence of the most common component of metabolic syndrome (abdominal obesity) of 19% among Ethiopian adults(24),margin of error 5%, and using 95% confidence level and anticipated sensitivity(SN)90%.

$$n = \frac{(Z(1-\alpha/2)^2\, SN\,(1-SN)}{d^2(p)}$$

$$n = \frac{(1.96)^2 0.9(0.1)}{(0.05)^2(0.19)} = 727$$

Therefore the final sample size is 727.

4.3.4 Exclusion criteria and inclusion criteria

Inclusion criteria

All administrative and academic staffs of Jimma University actively working in the university were included in the study.

Exclusion criteria

All administrative and academic staffs of Jimma University who had physical disability including deformity (Kyphosis, Scoliosis), pregnant women, and limb deformity that prevents standing andseriously ill staffs during the study period were excluded from the study.

4.4 Sampling method

A gender stratified simple random sampling was used to select the study participants. First total sample size was allocated to each stratum using population proportional to size allocation formula. Then, the allocated samples to each stratum were selected using SRS from sampling frames that were developed from list of the staffs obtained from JU human resource office.

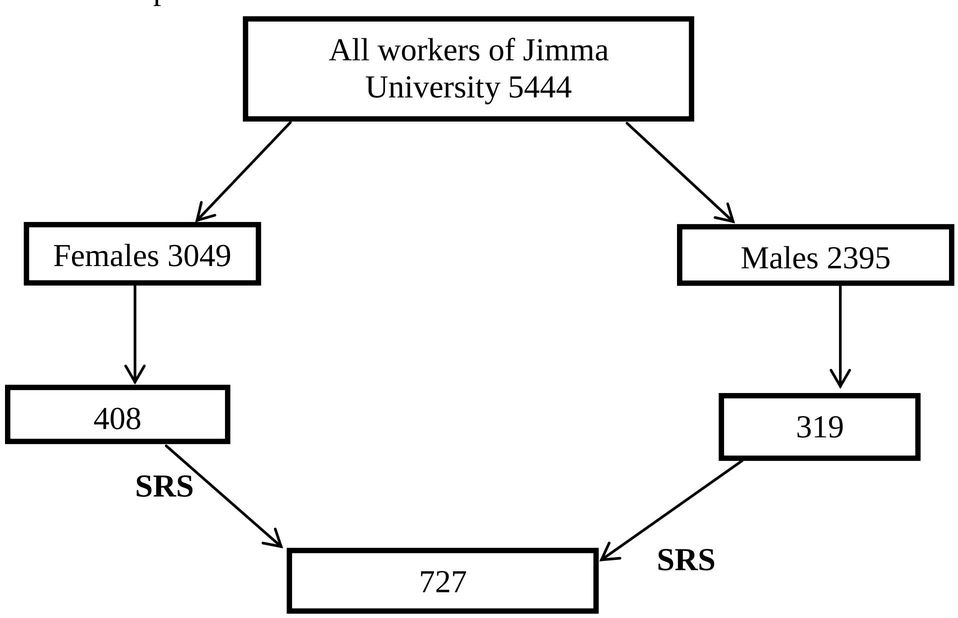

Figure 1.Schematic presentation of sampling procedure

4.5 Variables

4.5.1 Dependent variable

- Metabolic syndrome and its markers (blood pressure, Fasting blood sugar, WC, dyslipidaemia (high TG, HDL)

4.5.2 Independent variables

- Age
- Sex
- Occupation
- Ethnicity
- Religion
- Educational level
- Income
- Marital Status
- BMI
- Body fat percent (BF %)

4.6. Data collection instrument and procedure

4.6.1 Data collection instrument

Data werecollected by adapting WHO STEPwise approach to collect socio-demographic data, anthropometric measurements, blood sample, and body composition.

4.6.2 Data collectors

The data were collected byfive clinical nursesthat were recruited based on the qualification needed for conducting the data collection. The interviewers were trained for five days before the actual data collection oninterviewing approach, anthropometric measurement and data recording. All the measurements and interviewing weredone under close supervision.

4.6.3 Data collection procedures

Interviewer administered questionnaire included information on socio demographic factors and direct anthropometric measurements and body composition.All anthropometric and blood pressure measurements were done in triplicate using the following procedure.

Weight was measured with minimum clothing and without shoes using a solar powered scale (Model 871, Seca, Germany) to the nearest 0.1 kg and height wastaken barefooted using adjustable portable stadiometer which was accurate to 0.1 cm. Body mass index (BMI) was calculated as the weight in kg divided by height square in m^2.

Waist circumference (at the midpoint between the anterior superior iliac spine and the lowest costal margin at the level of midclavicular line) was obtained by using fixed tension tape wrapped around this point, parallel to the floor, ensuring that it is adjusted withoutcompressing the skin. The reading is taken at the end of a normal breath. Hip circumference (at the level of maximal gluteal protrusion) was measured by using fixed tension tape.Body composition was measured by wearing tight cloth using air displacement Plethysmography.

Figure 2.Air displacements Plethysmography(http://www.bodpod.com/en/products/body-composition/adult-children-bod-pod-gs/bod-pod)

Blood pressure was recorded in triplicate after 5 min of rest by using random-zero mercury sphygmomanometers with participants in a semi recumbent position. In accordance with the WHO recommendation the mean systolic and diastolic BP from the second and third measurements was considered for analyses.

The collected 5ml blood was used to determine participants' fasting blood glucose concentrations and lipid profiles. Blood serum was used for the measurement of triglycerides (TG)and high-density lipoprotein cholesterol (HDL-C). The subjects were instructed to fast - nothing to eat or drink 8 hours before taking the blood samples.

4.7 Data Quality Management

To ensure data quality, pre-test was conducted;discussion was made with data collectors on the objective of the study, familiarization on data collection tool and each variable on the questionnaire and its implication. There wasalso demonstration and practical session on interviewing and anthropometric measurements. Questionnaire prepared in English was translated into Amharic and back to English for checking language consistency.

ADP was calibrated every morningwith known weight object regularly. Furthermore, the weight scale indicator was checked against zero reading after weighing every individual.The measurements were also randomly rechecked during data collection.

Lipid Profiles were determined using humastar80 chine in star III laboratory of Mettu Karl Hospital. Fasting Blood sugar was determined using humastarwithin 30 minutes in Jimma University specialized hospital(JUSH) at JUCAN project laboratory.

4.8 Data processing and Analysis

First the data were checked for completeness and consistency. Then it was double entered in the computer using EPI data version 3.1 software. Then, the data were exported to SPSS version 20 program for analysis. Descriptive analysis,including frequency and cross tabulation was done to describe study participants.PCA was used for wealth index from 21 items and ranked in tertiles. Data of the study subjects were expressed as means ± SD. Normality was checked for all continuous variables and all of them were normally distributed.

Pearson correlation coefficients were calculated between anthropometric measurements (BMI, WC, WHR, and WHtR), markers of metabolic syndrome(Fasting blood glucose, dyslipidemia, and high blood pressure) and body fat percent.

Receiver operating characteristic (ROC) analysis and area under curve (AUC) was used to identify sensitivity, specificity and youden's index values of anthropometric indicators cut-off point for the detection of MetS and its components using body fat percentage of ≥25% for males and ≥32% for females as gold standard binary classifier. Specifically, ROC curves were used to determine the discriminatory power of anthropometric indices in distinguishing adults with high blood pressure, high fasting blood glucose, dyslipidaemia and metabolic syndrome. Those anthropometric indicators with the largest AUC were considered as having better performance.

The optimal cut-off values was defined as a point on the curve where “(sensitivity + specificity)− 1” (youden’s index)is maximum. Finally results were presented by using text, tables and graphs.

4.9 Ethical consideration

Ethical clearance was obtained from JU ERC office. Administration office and collage deans were informed about the study objectives through letter written from JU ERC office to enhance cooperation.

Written consent was taken from each selected participant to confirm willingness. Honestexplanation of the survey purpose, description of the benefits and an offer to answer all inquiries was made to the respondents. Also affirmation that they are free to withdraw consent and to discontinue participation without any form of prejudice wasmade.Privacy and confidentiality of collected information was ensured throughout the process.

4.10 Operational Definition

- High blood pressure:- systolic blood pressure ≥130 mmHg and/or diastolic blood pressure ≥85 mmHg(49).
- High fasting glucose:- when fasting plasma glucose (FBG) ≧100 mg/dl(50).
- Elevated triglyceride:-When TG≥150 mg/dl(50).
- Low HDL-C:- When HDL-C <40 mg/dl for females or <50 mg/dl for males(50).
- Metabolic syndrome :-Having three or more risk factors were defined
- Body fatness:-when BF%≥25 for males and BF%≥32 for females(51).
- Optimal cut off:-The point in which (sensitivity+ specificity)-1 is maximum.
- Actively working:-employees whose service year is at list two month.
- Wealth index: -Developed based on ownership of fixed assent using PCA thenit was rankedtertiles and recorded as low, middle and high.
- Sensitivity-the ability of anthropometric indicators to be correctly positive when the disease is present.
- Specificity- the ability of anthropometric indicators to be correctly negative when the disease is absent.

4.11 Dissemination plan

After approval from Jimma University, the findings of the study will be disseminated to all relevant stakeholders. Copies of the research will be given to Jimma University, Collage of

Health Sciences and the Department of Population and Family Health. Further effort will be made to publish in peer- reviewed international journals.

Chapter 5.Results

5.1 Socio demographic characteristics

A total of 667 Jimma university employees completed the study giving a response rate of 91.7%. More than half (56.2%) were females. Larger proportion of females (40.8%) and males (46.6%) were in the age group of 31-40 and 20-30, respectively. The majority (65.1%) of females and (56.2%) of males were Orthodox Christians. A little more than one third (34.9%) of female participants were Amhara and majority of males (47.6%) were Oromo. Most of (61.3% males and 67.5% females) were married. Slightly over half (51.9%)of males and 16.8 % of females reported having first degree and above. Larger proportion (45.9%) of males and 83.2% females were administrative staff. From all, 24.5% of females and 33.5%of males were in middle tertiles income. (Table 1)

Table 1Socio demographic characteristics of Jimma University employees, June2015

Socio demographic variable		Sex	
		Female(n=375)	Male(n=292)
Age			
	20-30	119(31.7%)	136(46.6%)
	31-40	153(40.8%)	81(27.7%)
	>40	103(27.5%)	75(25.7%)
Ethnicity			
	Oromo	102(27.2%)	139(47.6%)
	Amhara	131(34.9%)	71(24.3%)
	Gurage	21(5.6%)	15(5.1%)
	Dawro	38(10.1%)	17(5.8%)
	Yem	28(7.5%)	12(4.1%)
	Kefa	35(9.3%)	11(3.8)
	Tigre	9(2.5%)	15(5.1%)
	Others(Sidama, wolaita...)	11(2.9%)	12(4.1%)
Religion			
	Orthodox	244(65.1%)	164(56.2%)
	Protestant	86(22.9%)	71(24.3%)
	Muslim	41(10.9%)	50(17.1%)
	Others(Catholic, Jouva...)	4(1%)	7(2.4%)
Marital status	Married	253(67.5%)	179(61.3%)
	Never married	83(22.1%)	105(36.0%)
	Widowed	16(4.3%)	3(1%)
	Divorced	19(5.1%)	3(1%)
	Others(separated, refuse)	4(1.1%)	2(0.7%)
Education			
	Primary and below	100(26.7%)	25(8.6%)
	Secondary	103(27.5%)	61(20.9%)
	Diploma	109(29.1%)	54(18.5%)
	First degree	52(13.9%)	73(25.0%)
	Second degree &above	11(2.9%)	79(27.1%)
Occupation			
	Administrative staff	312(83.2%)	134(45.9%)
	Academic staff	32(8.5%)	119(40.8%)
	Hospital staff	31(8.3%)	39(13.3%)
Wealth index	Low	167(44.5%)	76(26.0%)
	Medium	92(24.5%)	98(33.5%)
	High	116(30.9%)	118(40.5%)

2. Bivariate analysis of anthropometric indicators, body fat percent and biochemical analysis by sex

The mean age was 34.7 ±9.5 years in male and 36.32± 9.8 in female. Females(25.3)had a highermean BMI compared with males (22.6). Waist circumference was almost similar for both groups (84, 83.3). However, mean height, WHR and fat free masswas higher among males (170, 0.9, and 75.5) as compared with females (156, 0.8, and 60.7). The mean systolic blood pressure and diastolic blood pressure were significantly higher for males (118.5 mmHg, 79mmHg) than for females (115 mmHg, 76.2 mmHg). Females had higher mean fat mass percentage than male. Mean of fasting blood glucose and triglyceride were higher among males (100.6, 153.5) than females (96.3, 128.8).(Table 2)

Table 2.Bivariate analysis of anthropometric indicators, body fat percent and markers of metabolic syndrome stratified by sex among JU employees, June2015

Variable	Male		Female		P
	Mean	S. D	Mean	S. D	
Age	34.72	9.5	36.49	9.4	0.014
Weight	65.9	11.7	62.3	12.9	<0.001
Height	170	7.2	156	6	<0.001
BMI	22.6	3.7	25.3	5	<0.001
Waist circumference	84	11.4	83.3	12.8	0.459
Hip circumference	92.1	7.4	98.8	10.8	<0.001
WHR	0.9	0.083	0.8	0.09	<0.001
WHtR	0.49	0.068	0.53	0.083	<0.001
Fat mass	24.1	8.9	38.9	10	<0.001
Fat free mass	75.5	9.8	60.7	10.6	<0.001
Systolic BP	118.5	12.5	115	13.7	0.002
Diastolic BP	79	9.4	76.2	9.3	<0.001
FBG	100.6	32.8	96.3	25.8	<0.001
TG	153	63.1	128.8	67.7	<0.001
HDL	61.7	14.5	61.7	17.8	0.79

BMI= body mass index, WC= waist circumference, WHtR= waist to height ratio, WHR= waist to hip ratio SBP= systolic blood pressure, FBG= fasting blood glucose, HDL= high density lipoprotein, TG= triglyceride

3. Correlation between anthropometric indicators and body composition

The most evident correlation was verified between WHtR and WC for men (r=0.92; p<0.001) as much as for women (r=0.97; p<0.001). Among females, %BF was more strongly related to BMI (r=0.82; p<0.001) than among men. Among male %BF was more correlated with WHtR and WC. Triglyceride had relatively strongcorrelation(r=0.17 in male and r=0.43 in females) with WC in both sex. Fasting blood glucose had relatively high correlation with BMI(r=0.12) and

WC(r=0.12) in females and with WC (r=0.27) among males. Systolic blood pressure more correlates with BMI(r=0.36) in females and with WC(r=0.41) in males.(Table 3)

Table 3. Pearson correlation between anthropometric indicators, body fat percentage and markers of metabolic syndrome among JU employeesJune 2015

Sex		WC	BMI	WHtR	WHR	BF%
Female	BMI	0.69**				
	WHtR	0.97**	0.69**			
	WHR	0.27**	0.05	0.26**		
	BF%	0.60**	0.82**	0.59**	0.02	
	SBP	0.29**	0.36**	0.28**	-0.01	0.35**
	DBP	0.19**	0.25**	0.18**	0.02	0.22**
	FBS	0.16*	0.12*	0.09	0.01	0.15**
	HDL	0.03	0.01	0.04	-0.01	-0.02
	TG	0.18**	0.17**	0.17**	0.01	0.16**
Males	BMI	0.83**				
	WHtR	0.92**	0.89**			
	WHR	0.73**	0.53**	0.72**		
	BF%	0.78**	0.69**	0.78**	0.55**	
	SBP	0.41**	0.35**	0.36**	0.25**	0.31**
	DBP	0.42**	0.34**	0.35**	0.27**	0.36**
	FBS	0.27**	0.18**	0.25**	0.23**	0.2**
	HDL	0.01	0.01	0.01	-0.01	-0.04
	TG	0.43**	0.3**	0.36**	0.29**	0.32**

** P value <0.01, * P value<0.05,BMI= body mass index, WC= waist circumference, WHtR= waist to height ratio, WHR= waist to hip ratio, BF%=body fat percent, SBP= systolic blood pressure, FBG= fasting blood glucose, HDL= high density lipoprotein, TG= triglyceride

4. ROC curve analysis for anthropometric indicators and body fat percentage

The area under ROC curve for BMI was 0.941.In female subjects, areas under ROC curve for BMI, WHtR and WC was 0.954, 0.911 and 0.905 respectively. In male subjects area under the curve was higher for WC (0.945) followed by WHtR (0.942) and then BMI (0.921). (Table 4)(Fig 3-fig 5)

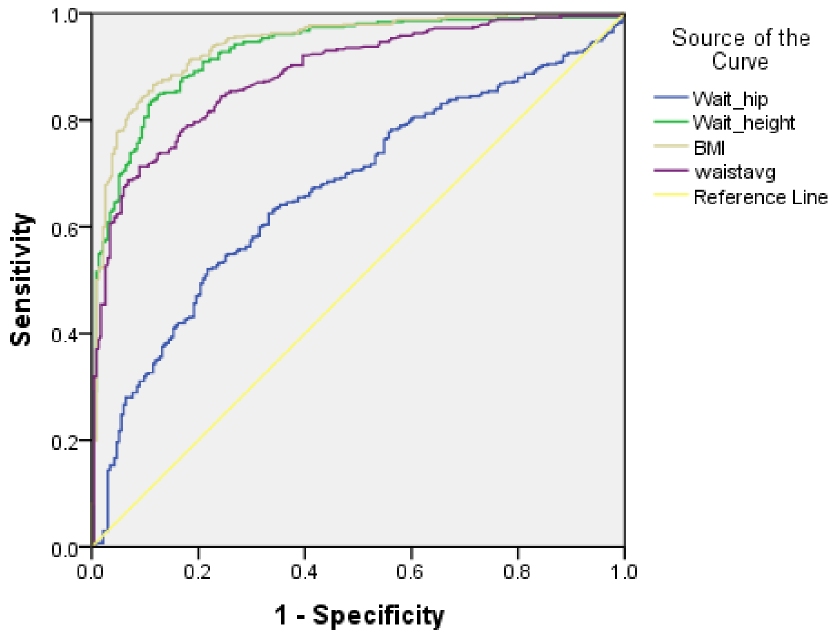

Figure 3 ROC curves for BMI, WC, WHR and WHtR values to detect body fatness among JUemployeesJune 2015

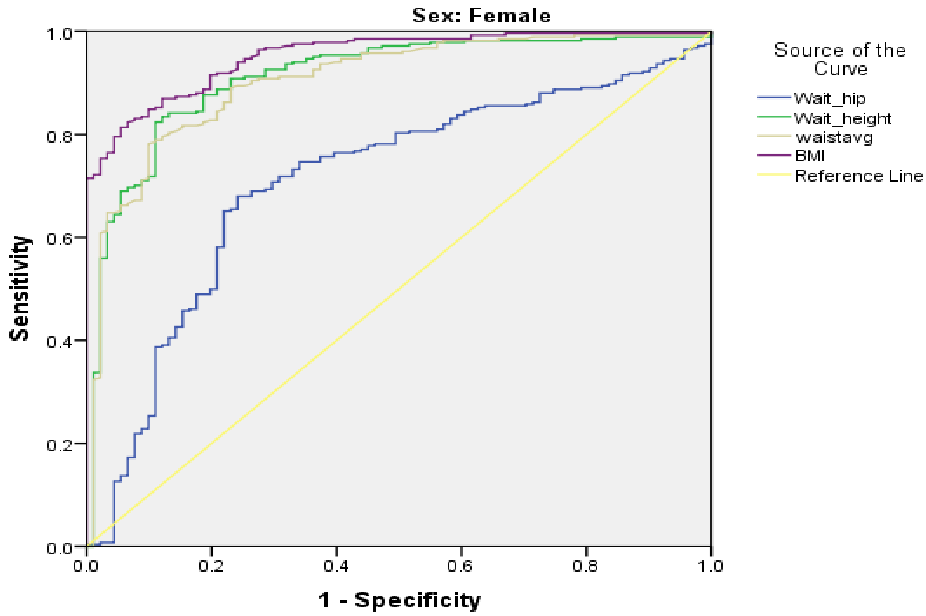

Figure 4. ROC curves for BMI, WC, WHR and WHtR values to detect body fatness among JU female employeesJune 2015

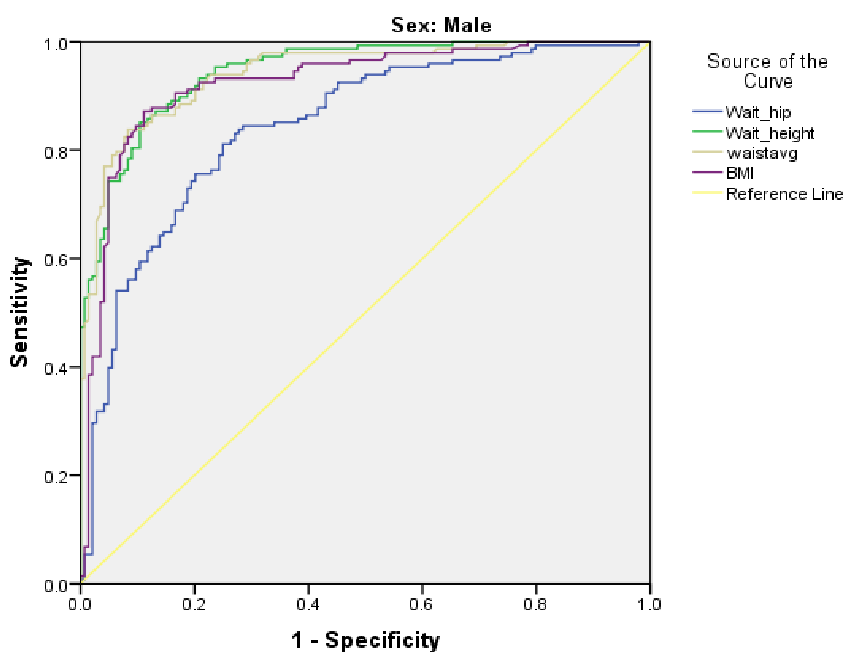

Figure 5 ROC curves for BMI, WC, WHR and WHtR values to detect body fatness among male JU employees,June 2015

The analyses showed that the optimal BMI cut point was 22.28 with sensitivity = 87%, specificity =89% and youden's index =75%. Optimal cut points for WC was77.97 (sensitivity = 78%, specificity = 90% and Youden's index =68%) in females. For malesthe cut off was 83.72 with sensitivity = 84%, specificity = 92% and Youden's index =75%. Optimal cut-off point for WHR was 0.49 for both sexes (sensitivity = 82%, specificity = 89% and Youden's index =71% for females and sensitivity = 85%, specificity = 90% and Youden's index =75% for males).In female subjects optimal cut off for WHR was 0.82(sensitivity = 68%, specificity = 76% and Youden's index =44%) while in male subjects, it is 0.90(sensitivity = 81%, specificity = 75% and Youden's index =56%). (Table 4)

Table 4 Area under Curves of BMI, waist circumference, WHR and WHtR for body fatness among JU employees,June 2015

Anthropometric indicators	AUC	Optimal cut-off	Sensitivity	Specificity	Yuden index
BMI	0.941(0.923-0.959)*	22.28	87%	89%	75%
Females					
WC	0.905(0.869-0.941)*	77.97	78%	90%	68%
WHR	0.709(0.648-0.771)*	0.82	68%	76%	44%
WHtR	0.911(0.876-0.947)*	0.49	82%	89%	71%
BMI	0.954(0.936-0.973)*	23.15	81%	95%	76%
Males					
WC	0.945(0.917-0.967)*	83.72	84%	92%	75%
WHR	0.844(0.798-0.889)*	0.90	81%	75%	56%
WHtR	0.942(0.922-0.968)*	0.49	85%	90%	75%
BMI	0.921(0.889-0.953)*	22.16	87%	88%	75%

*= p <0.001, AUC= area under the curve, BMI= body mass index, WC= waist circumference, WHR= waist to hip ratio, WHtR= waist to height ratio

BMI cut off 22.28 kg/m^2 had higher sensitivity(87%) and youden'sindex (75%) than cut off recommended by WHO which is 25$kg/m^{2.}$ (Figure 6)

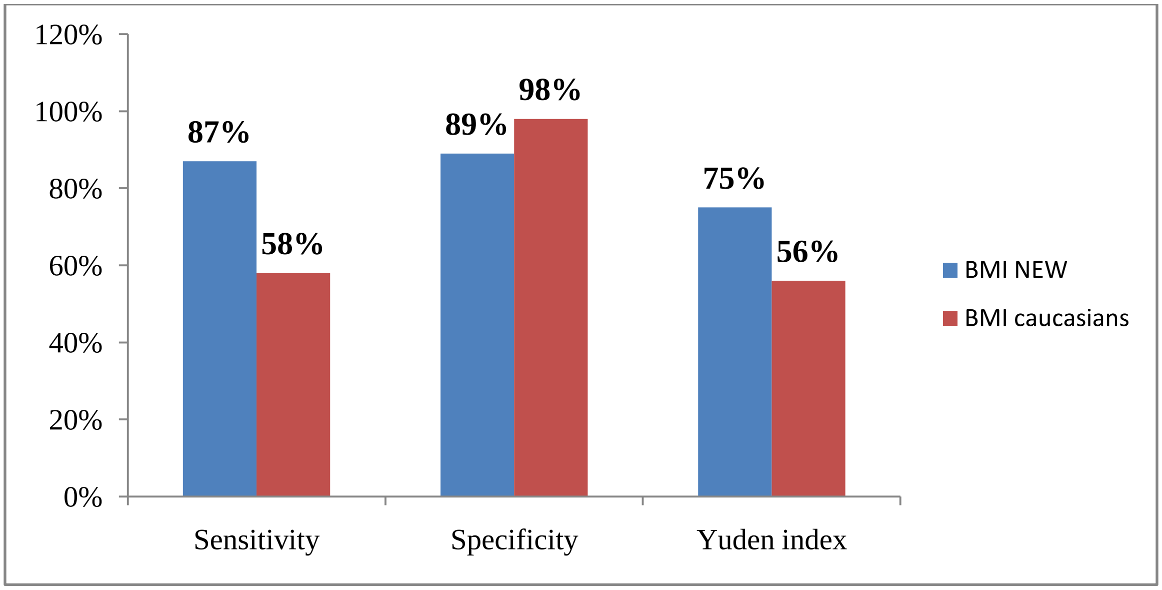

Figure 6 comparison between Caucasians cutoff and newly developed cut off for BMI among JU employees June 2015

The cut off for WC on both sexes (77.97 for females and 83.7 for males) had higher sensitivity and youden's index than the cut off recommended for Caucasians.(Figure 7)

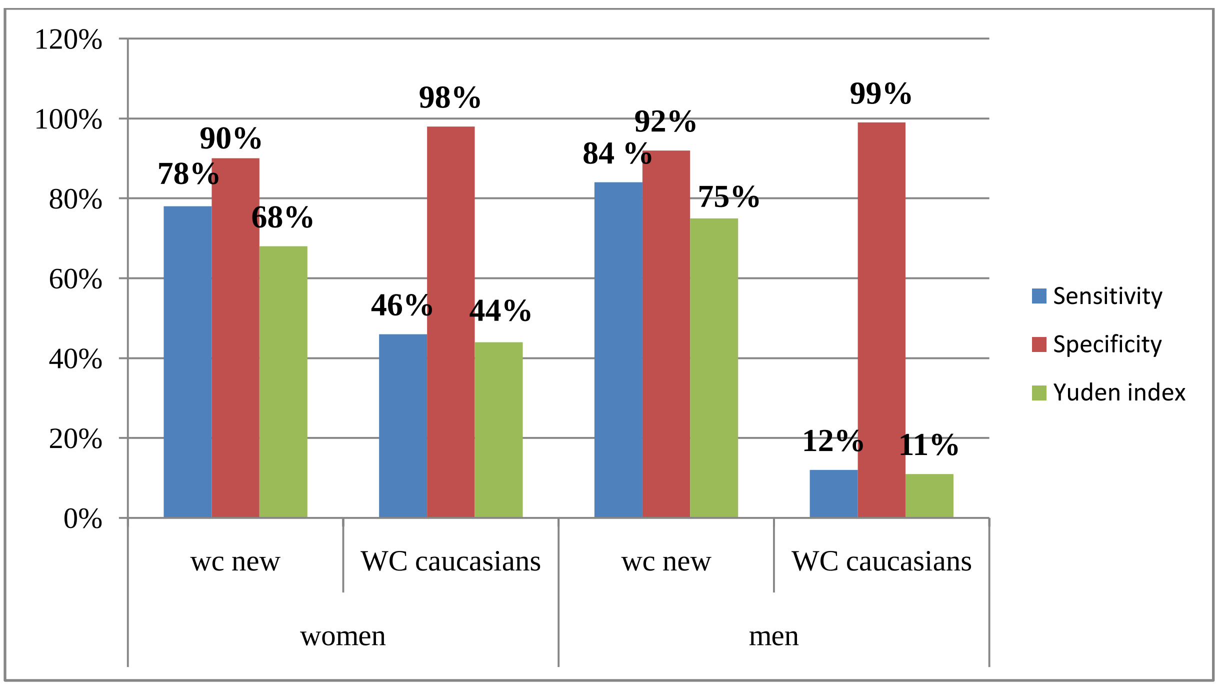

Figure 7comparison between Caucasians cutoff and newly developed cut off for WC among JU employees June 2015

6. ROCcurve analysis of anthropometric indicators for detection of metabolic syndrome

The area under the ROC curve todetecting high blood pressure on males for BMI, WC, WHtR and WHR was 0.719, 0.761, 0.732 and 0.712 respectively .The largest area under ROC curve for detecting high fasting blood glucose on males was for WC (0.711).The area under the curve for detecting high triglyceride were 0.764(for BMI), 0.686(for WC), 0.709(for WHtR) and 0.715(for WHR) in male. The area under the curve for metabolic syndrome was 0.81(for BMI), 0.845(for WC), 0.814(for WHtR) and 0.775(for WHR) in males. (Table 5)(Fig 9, 11, 13, 15, 17)

In females the area under the ROC curves to detecting high blood pressure for BMI, WC, WHtR and WHR was 0.652, 0.655, 0.66 and 0.592 respectively .The largest area under ROC curve for detecting high fasting blood glucose on males was WC (0.592).The area under the curve for detecting high triglyceride were 0.594(for BMI), 0.591(for WC), 0.59(for WHtR) and 0.569(for WHR). The areas under the curve for metabolic syndrome were 0.72(for BMI), 0.726(for WC), 0.716(for WHtR) and 0.643(for WHR) in males. (Table 5)(Fig 8, 10, 12, 14, 16)

High blood pressure

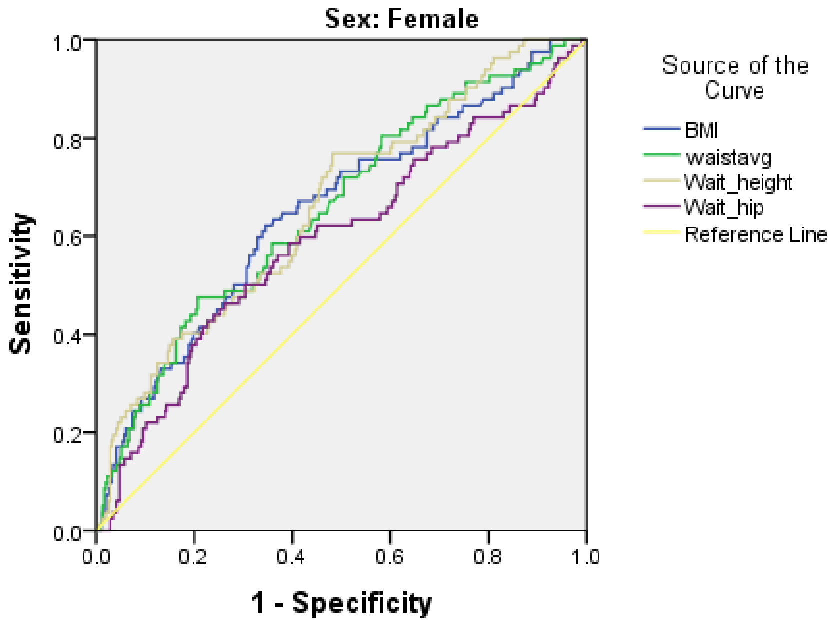

Figure 8ROC curves for BMI, WC, WHR and WHtR values to detect high blood pressure in females Jimma UniversityemployeesJune 2015

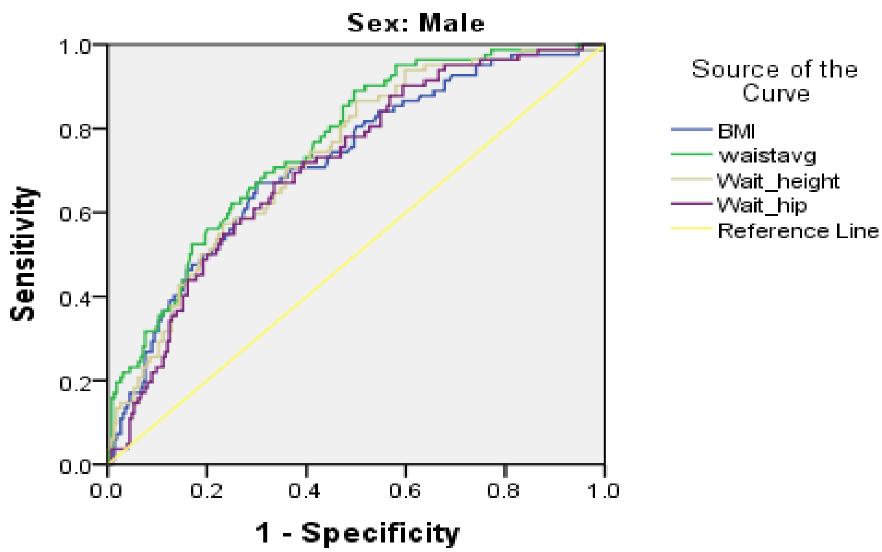

Figure 9 ROC curves for BMI, WC, WHR and WHtR values to detect high blood pressure in male Jimma university employeesJune 2015

Triglyceride

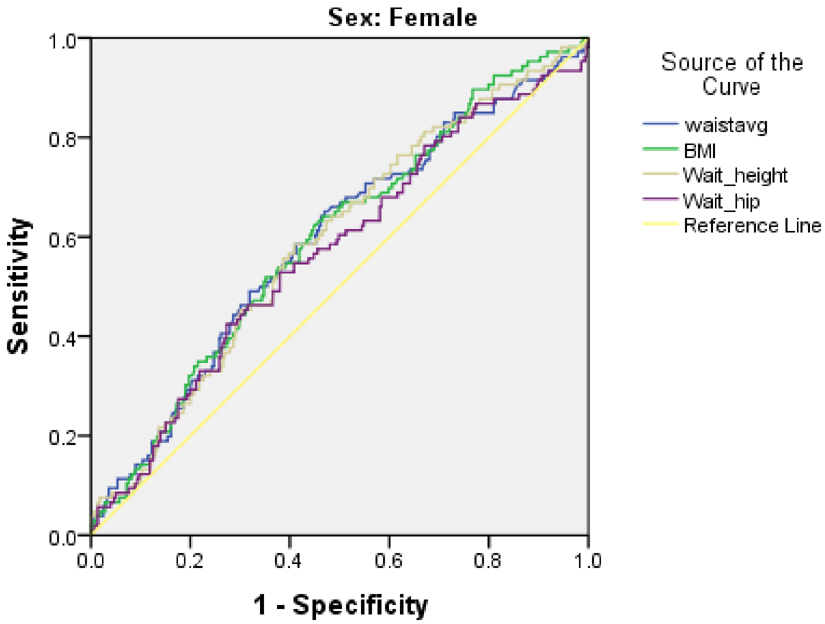

Figure 10 ROC curves for BMI, WC, WHR and WHtR values to detect high triglyceride among female JU employeesJune 2015

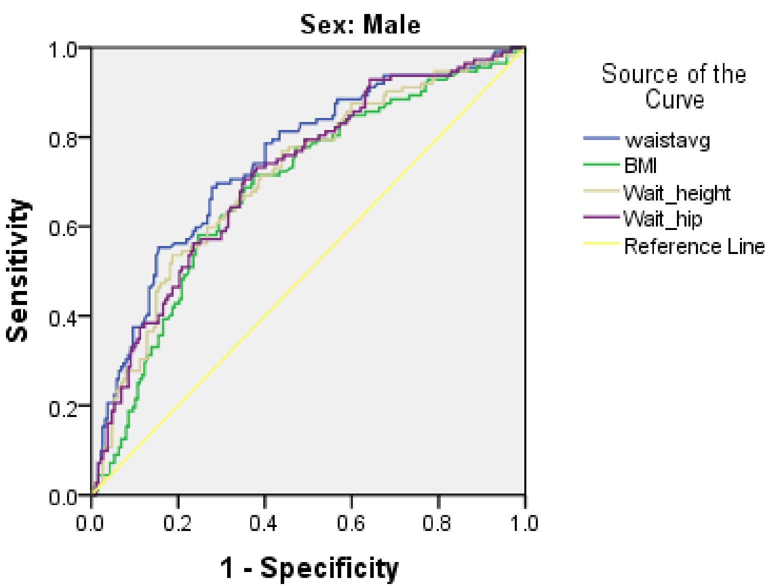

Figure 11ROC curves for BMI, WC, WHR and WHtR values to detect high triglyceride among male Jimma university employeesJune 2015

Fasting blood glucose

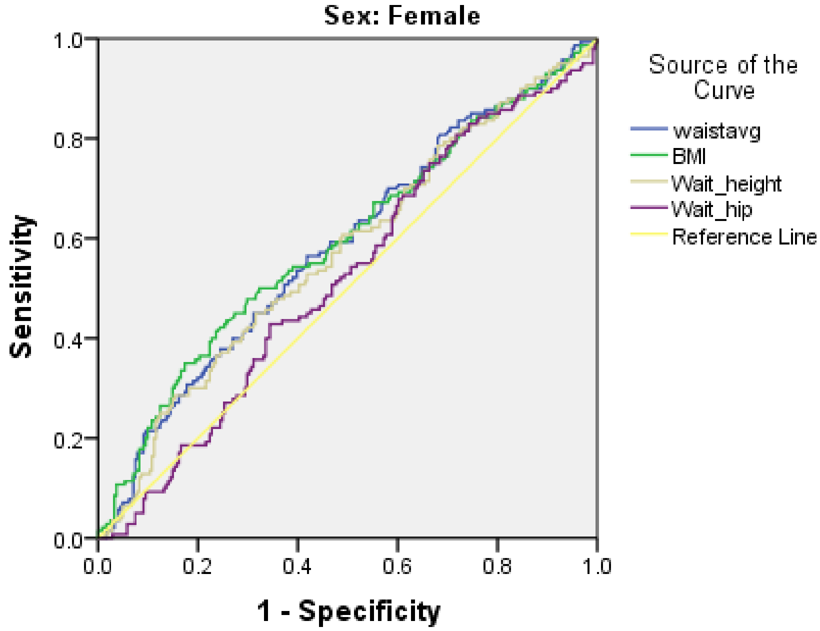

Figure 12ROC curves for BMI, WHR, WHtR and WC for detecting high fasting blood sugar among female JU employeesJune 2015

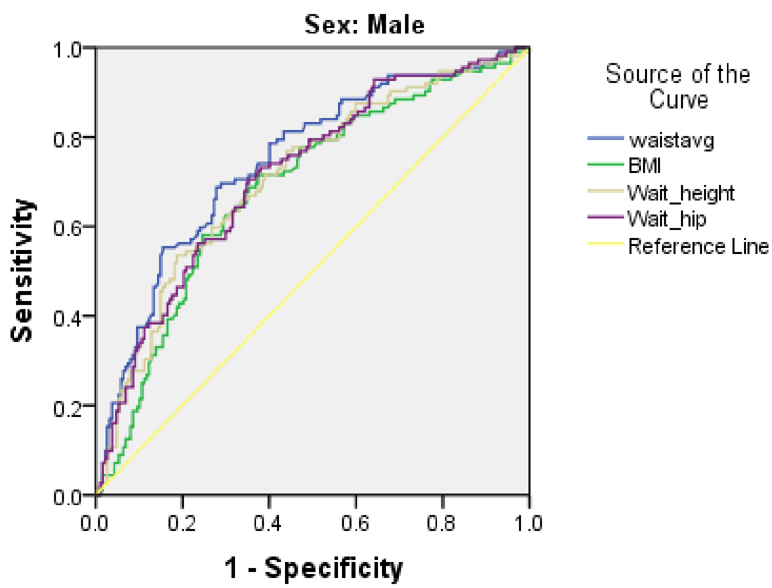

Figure 13. ROC curves for BMI, WC, WHR and WHtR values to detect high fasting blood glucose among male JU employsJune 2015

Low HDL

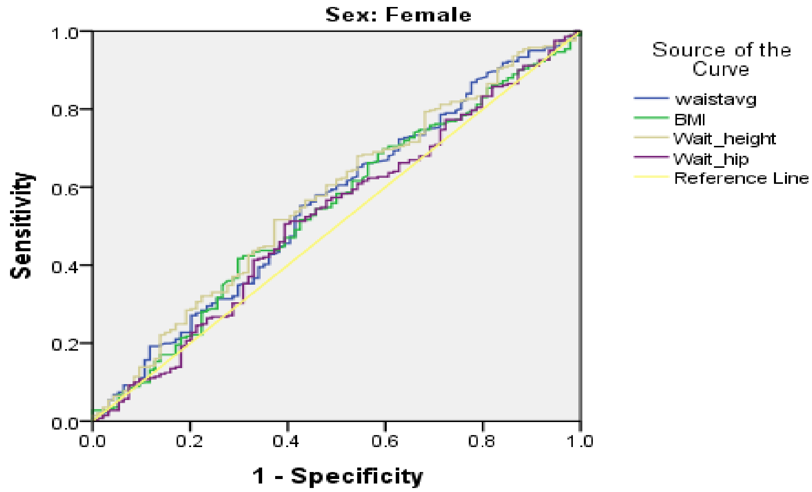

Figure 14.ROC curves for BMI, WC, WHR and WHtR values to detect low HDL among female JU employeesJune 2015

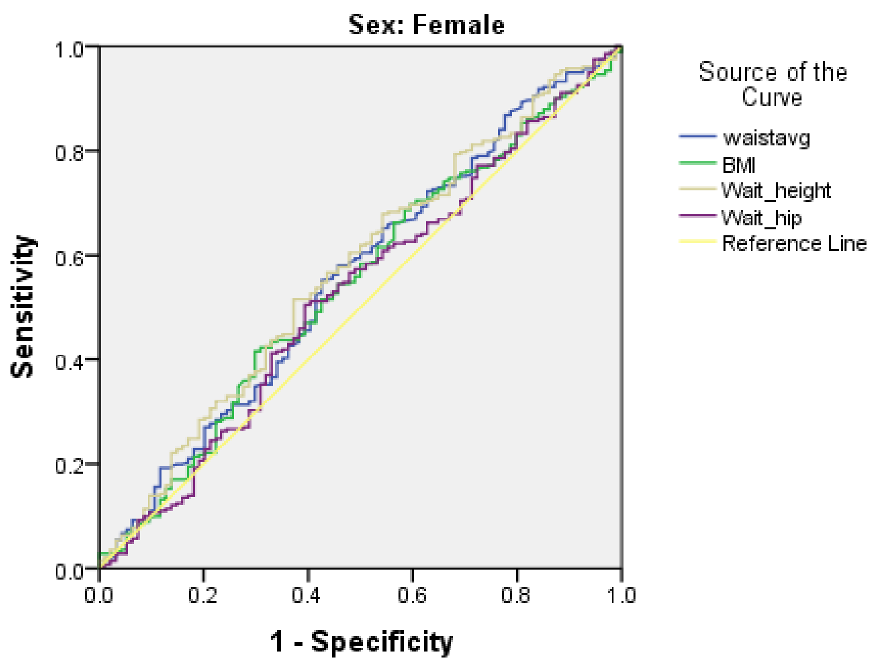

Figure 15.ROC curves for BMI, WC, WHR and WHtR values to detect low HDL among male JU employeesJune 2015

Multiple metabolic risks

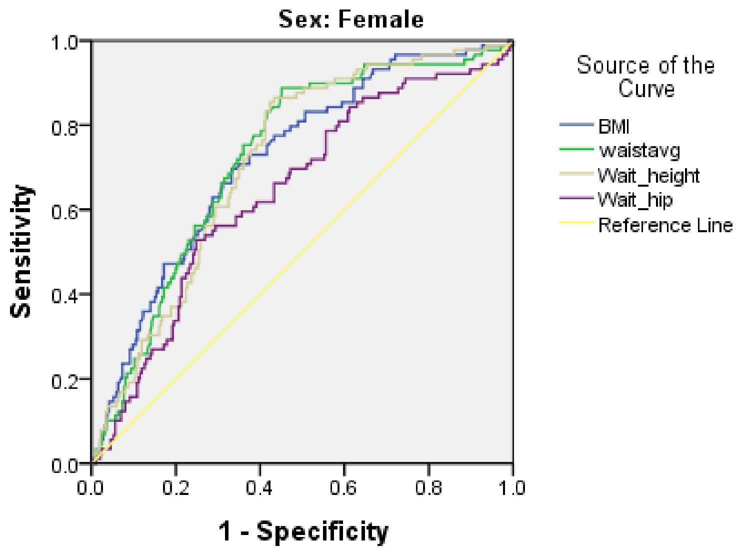

Figure 16 ROC curves for BMI, WC, WHR and WHtR values to detect multiple metabolic risk factors among female JU employeesJune 2015

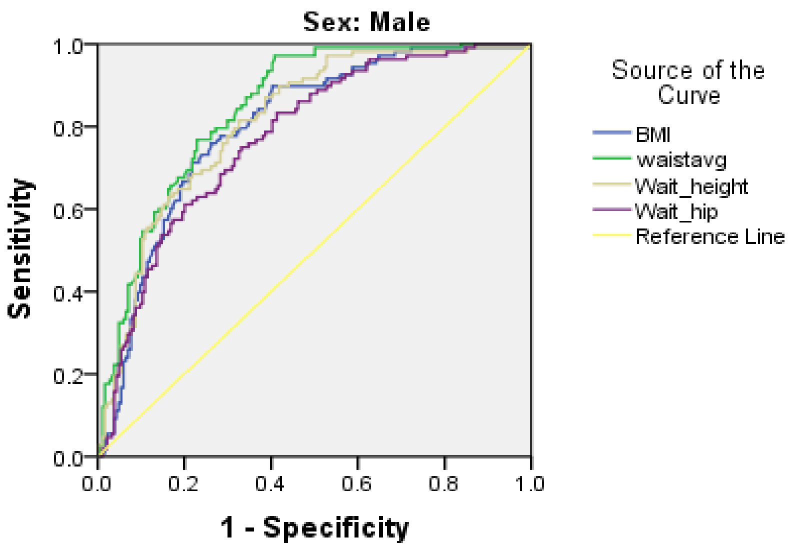

Figure 17. ROC curves for BMI, WC, WHR and WHtR values to detect multiple metabolic risk factors among male JU employeesJune 2015

Table 5 Area under Curves of BMI, waist circumference, WHR and WHtR for Multiple metabolic risk factor among JU employeesJune 2015

	BMI	WC	WHtR	WHR
Males				
Blood pressure	0.719	0.761	0.732	0.712
	(0.655-0.782)*	(0.704-0.818)*	(0.671-0.792)*	(0.65-0.774)*
Fasting glucose	0.686	0.711	0.692	0.656
	(0.625-0.746)*	(0.651-0.771)*	(0.631-0.752)*	(0.591-0.721)*
Triglyceride	0.764	0.686	0.709	0.715
	(0.688-0.804)*	(0.624-0.748)*	(0.649-0.77)*	(0.655-0.774)*
Metabolic syndrome	0.81	0.845	0.814	0.775
	(0.75-0.878)*	(0.801-0.889)*	(0.764-0.863)*	(0.722-0.829)*
Females				
Blood pressure	0.652	0.655	0.66	0.592
	(0.583-0.72)*	(0.589-0.722)*	(0.595-0.726)*	(0.519-0.665)*
Fasting glucose	0.592	0.584	0.57	0.521
	(0.532-0.653)*	(0.525-0.644)*	(0.51-0.63)*	(0.461-0.58)*
Triglyceride	0.594	0.591	0.59	0.569
	(0.532-0.657)*	(0.527-0.655)*	(0.527-0.653)*	(0.504-0.634)*
Metabolic syndrome	0.72	0.726	0.716	0.643
	(0.662-0.778)*	(0.668-0.783)*	(0.66-0.773)*	(0.578-0.708)*

* P<0.001, BMI= body mass index, WC= waist circumference, WHR= waist to hip ratio, WHtR= waist to height ratio

In female subjects with the cutoff value of 26.22kg/m2 (for BMI), 92.5cm (for waist circumference),0.88 (for WHR), 0.51(for WHtR), the sensitivity, specificity and youden's index were 62% , 66% and 28%, 48%,79% and 27%, 46%, 74% and 20% and 77%, 52% and 29%, respectively, which were found to be the cut-off values to detect high blood pressure. The cutoff values for detecting high fasting glucose were 26.76kg/m2 (for BMI), 83.12cm (for waist circumference), 0.78 (for WHR), 0.56 (for WHtR), and the corresponding sensitivity , specificity and youden's index were 48% ,70% and 18%, 56% , 58% and 15%, 81% , 28% and 90%, 45%, 69% and 14%, respectively. The cut-off values to detect high triglyceride were 24.5kg/m2 for BMI (sensitivity, specificity and youden's index were 64%, 53% and 18%), 82.9cm for waist circumference (sensitivity specificity and youden's index were 65%, 53% and 18%), 0.88 for

WHR (sensitivity specificity and youden's index were 43%, 73% and 15%), 0.53 for WHtR (sensitivity, specificity and youden's index were 59%, 59% and 18%). The cut-off values to detect multiple risk factors in females were 26.1kg/m2 (for BMI), 80.57cm (for waist circumference), 0.88 (for WHR), 0.52 (for WHtR), and the corresponding sensitivity, specificity and youden's index were 70%,67% and 36%, 89% ,55% and 44%, 53%,75% and 28%, 85% ,58% and 43%, respectively.(Table 6)

In male subjects with the cutoff value of 23.45kg/m2 (for BMI),80.15cm (for waist circumference),0.91 (for WHR), 0.47 (for WHtR), the sensitivity, specificity and youden's index were 67% , 70% and 37%, 89%, 50% and 39%, 67%,67% and 34%, 87%,50% and 37%, respectively, which were found to be the cut-off values to detect high blood pressure. The cutoff values for fasting glucose were 21.5kg/m2 (for BMI), 81.7cm (for waist circumference), 0.95 (for WHR), 0.47 (for WHtR), and the corresponding sensitivity, specificity and youden's index were 79% , 54% and 34%, 76%, 57% and 33%, 46%, 82% and 27%, 78%, 52% and 30%, respectively in males. The cut-off values to detect high triglyceride were 22.5kg/m2 for BMI (sensitivity and specificity were 71% and 63%), 85.25cm for waist circumference (sensitivity and specificity were 69% and 72%), 0.9 for WHR (sensitivity and specificity were 71% and 65%), 0.53 for WHtR (sensitivity and specificity were 54% and 81%). The cut-off values to detect multiple metabolic risk factors in males were 22.87kg/m2 (for BMI), 80.9cm (for waist circumference), 0.88 (for WHR), 0.49 (for WHtR), and the corresponding sensitivity and specificity were 76% and 74%, 97% and 59%, 83% and 59%, 82% and 67%, respectively.(Table 6)

Table 6Optimal cut off points for componentsof metabolic syndrome among JU employeesJune 2015

	Obesity index	Optimal cut off	Sensitivity	Specificity	Yuden index
Females					
Blood pressure	WC	92.5	48%	79%	27%
	WHR	0.88	46%	74%	20%
	BMI	26.22	62%	66%	28%
	WHtR	0.51	77%	52%	29%
Fasting glucose	WC	83.12	56%	58%	15%
	WHR	0.78	81%	28%	9%
	BMI	26.76	48%	70%	18%
	WHtR	0.56	45%	69%	14%
Triglyceride	WC	82.9	65%	53%	18%
	WHR	0.88	43%	73%	15%
	BMI	24.5	64%	53%	18%
	WHtR	0.53	59%	59%	18%
Metabolic syndrome	WC	80.57	89%	55%	44%
	WHR	0.88	53%	75%	28%
	BMI	26.1	70%	67%	36%
	WHtR	0.52	85%	58%	43%
Males					
Blood pressure	WC	80.15	89%	50%	39%
	WHR	0.91	67%	67%	34%
	BMI	23.45	67%	70%	37%
	WHtR	0.47	87%	50%	37%
Fasting glucose	WC	81.7	76%	57%	33%
	WHR	0.95	46%	82%	27%
	BMI	21.5	79%	54%	34%
	WHtR	0.47	78%	52%	30%
Triglyceride	WC	85.25	69%	72%	41%
	WHR	0.9	71%	65%	35%
	BMI	22.5	71%	63%	34%
	WHtR	0.53	54%	81%	35%
Metabolic syndrome	WC	80.9	97%	59%	56%
	WHR	0.88	83%	59%	42%
	BMI	22.87	76%	74%	50%
	WHtR	0.49	82%	67%	49%

BMI= body mass index, WC= waist circumference, WHR= waist to hip ratio, WHtR= waist to height ratio

Chapter 6. Discussion

In recent years numerous studies have been done to find the best anthropometric indices for detecting MetS, especially, among different ethnic groups.In the present research,the correlation between body fat percent and anthropometric indicators showed that body fat percent was more strongly related to WC and WHtR than to BMI in males and with BMI in females. This finding also suggested that WHR would be less dependent on total adiposity. Such results were similar to those observed in other studiesconducted in Brazil and United states where WHR had week correlation (37,38). The reason might be due tothe fact that Waist−hip ratio is a measure of relative accumulation of abdominal fat, while WC is a measure of absolute abdominal fat as well as total body weight. Two circumference measures are required for waist−hip ratio calculation in which both measurements are subject to measurement errors.The correlation coefficient between BMI and waist circumference was statistically significant for both sex groups.This is consistent with other studies(35,36).

The results of the study showed that FBG, SBP, DBP and triglyceridesare most strongly correlated with WC in males.SBP and DBP are most strongly associated with BMI among women. FBG and triglyceride is most closely correlated with WC among females. Most of the studies are consistent with this finding where WC highly correlates with markers of metabolic syndrome(38,52).The reason could bethat WC is advocated as a better indicator of abdominal fat. There is a large body of evidence that suggests abdominal fat distribution (measured by WC) may be more closely tied to metabolic risks than BMI.

In Females, BMI followed by WHtR had the highest AUC for identifying individuals as being overweight-obese as classified by BF% air displacement pletysmography.This is inconsistent with a study conducted in Australia(41) in which BMI performed poorly. Thereasonsmight be related to the fact that central obesity is more common in men than women so women’s fat is expected to distribute throughout body which can be assessed by BMI.WHtR performed high in both gender groupswhich goes with the results of a study in china(40).

In the present study, cutoff values of BMI to predict body fatness was 22.2 kg/m2. In spite of many studies with regard to obesity, choosing an optimal and appropriate cut-point of BMI for defining obesity is inconsistent. According to WHO recommendations, the BMI threshold for increasing disease risk in Caucasian population is 25 kg/m2 for both men and women. This value was suggested to be 23 kg/m2 in Asian men and women(28). Cut-points reached by this study are lower than those recommended for Caucasians and Asians.This finding confirms the existing body of literature on the fact the using the European cut-off as suggested by WHO for predicting adiposity in Ethiopian population would underestimate adiposity and misclassifies the risk of metabolic syndrome significantly. The reason might be due to the fact thatEthiopians have slender body build which has high body fat with lower BMI. With same level of body fat, age, and gender, BMIs of Ethiopians are 4.6 kg/m^2 lower compared to white(30).

Cut off for detection of metabolic syndrome is 26 kg/m^2 in female and 23 kg/m^2 in male has highest youden's index .This is lower than Qatar,and Iran(42,53).Male's cut off is similar with chaises(40). The reasonmight be dueto Ethiopians have slender body build which has high body fat with lower BMI. So lowering BMI cut off may identify underdiagnosed individuals that must get desired intervention.

A study in Qatar population suggested that the optimal waist circumference values were 99.5 cm for men and 91 cm for women to detect multiple cardiovascular risk factors(42). Other study determined that in Chinese population waist circumference of 91.3cm in men and 87.1cm in women were the optimal cutoff values to predict high multiple metabolic risks by ROC analysis(40). In Iran population the cut off is 90.3 and 90 in male and females respectively(54). The optimal cut-off values of waist circumference in this study were lower than those of these previous studies. The reason might be due to difference in ethnicities, dietary and physical activity pattern.

Although different studies found different cut-points for BMI, investigators have suggested this index as a good screening tool for cardiovascular risk factors.However, it is emphasized that using BMI as classificatory measure of nutritional status may be useful in population studies, yet it is less accurate with regard to body fat distribution.Abdominal obesity is the one which has higher risk of metabolic complications. In this manner, the measures like WC and WHtR may give additional information concerning obesity.

Our study also showed that in terms of detecting the components of metabolic syndrome, WC performed better than BMI in most of the cases in both sexes which is consistent with many other studies(43,45,47). The reason the better predictive capacity of WC compared to other anthropometric parameters in detecting central adiposity, which is labile fat that can easily be gained, lost and per oxidized in the tissues to generate the metabolic complications such as atherosclerosis(55). Consequently, these findings pose arguments to use measures like WC and WHtR in screening the risk of metabolic syndrome and risk of degenerative diseases at population level as they are affordable and noninvasive to use.

As the new cutoffs developed by this has a net gainin sensitivity, than the Caucasians cut offwhich is important because treatment is easy to apply, the penalty of losing a case is high and anthropometric measurements are non-invasive and affordable to use. The number of individuals diagnosed as having risk will increase.This might be a chance to get interventions since once the disease occur its incurable and has many consequences for the individual and for the country as well.

Strength of the study

The study used a three star laboratory for analyzing blood. It also used a gold standard body composition measuring instrument. Data were collected by well trained and experienced individuals.

Limitation of the study

This studywas conducted in institution.

Chapter 7. Conclusion

- Waist circumference (WC) is better indicator of body fatness for males while in women, BMI is a betterindicator.
- WC is better indicators of metabolic syndrome in both men and female.
- For female subjects Cut- off to detect body fatness for BMI, WC, WHtR and WHR were 23.15, 77.9cm, 0.49 and 0.82, respectively. For male’s cutoff point for detecting body fatness to BMI, WC, WHtR and WHR were 22.16, 83.72, 0.49 and 0.9 respectively.
- For females Cut off for detecting multiple metabolic risk factors for BMI, WC, WHtR and WHR were 26.1, 80.57, 0.52 and 0.88, respectively. For male’s cutoff point for BMI, WC, WHtR and WHR were 22.87, 80.9, 0.49 and 0.88, respectively.

Chapter8. Recommendation

For the government (FMOH)

- To strengthening polices targeting early detection of metabolic syndrome, to prepare national advocacy and health information on nutrition programs at population level
- To promote self-screening at household level by using WC measurement so that they can improve their life style as early as possible
- To shift the focus from treatment approach to preventive approach for chronic diseases by using affordable and sensitive indicators like waist circumference
- To strengthening early and on time preventive life style modification program based on the revised cutoffs
- To consider this cutoffs while preparing guidelines
- To promote screening program for early intervention

For researcher

- To develop cutoffs for anthropometric indicators by community based study andtaking sample from different regions of Ethiopia.

Annexes I, References

1. Reaven GM. Role of Insulin Resistance in Human Disease. Diabetes. 1988 Jan 12;37(12):1595–607.

2. Emma-Okon, B. O.; Onayade, A. A.; Adegoke, A. O. Metabolic syndrome in an elite African community. African Journal of Diabetes Medicine. Nov2013;21(2):42.

3. Anonymous 2001 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). JAMA 285:2486 – 2497.

4. Alberti KG, Zimmet P, Shaw J; IDF Epidemiology Task Force Consensus Group 2005 The metabolic syndrome--a new worldwide definition. Lancet 366:1059-1062.

5. Cameron AJ, Shaw JE, Zimmet PZ. The metabolic syndrome: prevalence in worldwide populations. Endocrinol Metab Clin North Am. 2004 Jun;33(2):351–75, table of contents.

6. Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. Lancet. 2005 Apr 16;365(9468):1415–28.

7. WHO | Description [Internet]. WHO. [cited 2015 Jan 26]. Available from: http://www.who.int/nutgrowthdb/about/introduction/en/index8.html

8. Knowler WC, Pettitt DJ, Saad MF, Charles MA, Nelson RG, Howard BV, et al. Obesity in the Pima Indians: its magnitude and relationship with diabetes. Am J Clin Nutr. 1991 Jun;53(6 Suppl):1543S – 1551S.

9. Margot S, Mark S. T, Sarah CG, Ian J. Abdominal obesity and cardiovascular disease risk factors within body mass index categories. Health Rep [Internet]. 23(2). Available from: http://www.statcan.gc.ca/pub/82-003-x/2012002/article/11653-eng.htm

10. WHO | Obesity: preventing and managing the global epidemic [Internet]. WHO. [cited 2015 Jan 27]. Available from: http://www.who.int/nutrition/publications/obesity/WHO_TRS_894/en/

11. Ashwell M, Lejeune S, McPherson K. Ratio of waist circumference to height may be better indicator of need for weight management. BMJ. 1996 Feb 10;312(7027):377.

12. Wilding J, Finer N. Obesity and risk of myocardial infarction: the INTERHEART study. The Lancet. 2006 Apr;367(9516):1053.

13. Ashwell M, Mayhew L, Richardson J, Rickayzen B. Waist-to-Height Ratio Is More Predictive of Years of Life Lost than Body Mass Index. PLoS ONE [Internet]. 2014 Sep 8 [cited2015Jan27];9(9).Availablefrom:http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4157748/

14. Ashwell M., Cole TJ, Dixon AK. Ratio of waist circumference to height is strong predictor of intra-abdominal fat. BMJ. 1996 Aug 31;313(7056):559–60.

15. McCrory MA, Gomez TD, Bernauer EM, Molé PA. Evaluation of a new air displacement plethysmograph for measuring human body composition. Med Sci Sports Exerc. 1995 Dec;27(12):1686–91.

16. Dempster, P., Aitkens, S. A new air displacement method for the determination of human body composition. Med Sci Sports Exerc. 37(3):1692–7.

17. Wadden TA, Brownell KD, Foster GD. Obesity: responding to the global epidemic. J Consult Clin Psychol. 2002 Jun;70(3):510–25.

18. Paul Zimmet George Alberti Jonathan Sha. A new IDF worldwide definition of the metabolic syndrome: Clin Care. 50:31.

19. Okafor C. The metabolic syndrome in Africa: Current trends. Indian J Endocrinol Metab. 2012;16(1):56.

20. Mbanya JCN, Motala AA, Sobngwi E, Assah FK, Enoru ST. Diabetes in sub-Saharan Africa. The Lancet. 2010 Jun;375(9733):2254–66.

21. Fezeu L, Balkau B, Kengne A-P, Sobngwi E, Mbanya J-C. Metabolic syndrome in a sub-Saharan African setting: central obesity may be the key determinant. Atherosclerosis. 2007 Jul;193(1):70–6.

22. Miranda JJ, Kinra S, Casas JP, Smith GD, Ebrahim S. Non-communicable diseases in low- and middle-income countries: context, determinants and health policy. Trop Med Int Health TM IH. 2008 Oct;13(10):1225–34.

23. Ayah R, Joshi MD, Wanjiru R, Njau EK, Otieno CF, Njeru EK, et al. A population-based survey of prevalence of diabetes and correlates in an urban slum community in Nairobi, Kenya. BMC Public Health. 2013 Apr 20;13(1):371.

24. Tran A, Gelaye B, Girma B, Lemma S, Berhane Y, Bekele T, et al. Prevalence of Metabolic Syndrome among Working Adults in Ethiopia. Int J Hypertens. 2011 May 26;2011:e193719.

25. Global status report on non-communicable diseases 2010 . World Health Organ.

26. Betre M, Kebede D, Kassaye M. Modifiable risk factors for coronary heart disease among young people in Addis Ababa. East Afr Med J. 1997 Jun;74(6):376–81.

27. NHS. Body Mass Index as a measure of obesity [Internet]. 2009. Available from: http://www.noo.org.uk/uploads/doc789_40_noo_BMI.pdf

28. WHO. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. 2004;363:157–63.

29. James WPT, Chunming C, Inoue S. Appropriate Asian body mass indices? Obes Rev Off J Int Assoc Study Obes. 2002 Aug;3(3):139.

30. Body mass index and percent body fat: a meta analysis among different ethnic groups. Publ Online 26 Novemb 1998 Doi101038sjijo0800741 [Internet]. 1998 Nov 26 [cited 2015 Jan 28];22(12). Available from: http://www.nature.com/ijo/journal/v22/n12/abs/0800741a.html

31. Wildman RP, Gu D, Reynolds K, Duan X, He J. Appropriate body mass index and waist circumference cutoffs for categorization of overweight and central adiposity among Chinese adults. Am J Clin Nutr. 2004 Jan 11;80(5):1129–36.

32. Mirmiran P, Esmaillzadeh A, Azizi F. Detection of cardiovascular risk factors by anthropometric measures in Tehranian adults: receiver operating characteristic (ROC) curve analysis. Eur J Clin Nutr. 2004;58(8):1110–8.

33. Menke A, Muntner P, Wildman RP, Reynolds K, He J. Measures of adiposity and cardiovascular disease risk factors. Obes Silver Spring Md. 2007 Mar;15(3):785–95.

34. Lee CMY, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. J Clin Epidemiol. 2008 Jul;61(7):646–53.

35. Dagan SS, Segev S, Novikov I, Dankner R. Waist circumference vs body mass index in association with cardiorespiratory fitness in healthy men and women: a cross sectional analysis of 403 subjects. Nutr J. 2013 Jan 15;12(1):12.

36. Gierach M, Gierach J, Ewertowska M, Arndt A, Junik R. Correlation between Body Mass Index and Waist Circumference in Patients with Metabolic Syndrome. Int Sch Res Not. 2014 Mar 4;2014:e514589.

37. Flegal KM, Shepherd JA, Looker AC, Graubard BI, Borrud LG, Ogden CL, et al. Comparisons of percentage body fat, body mass index, waist circumference, and waist-stature ratio in adults. Am J Clin Nutr. 2009 Jan 13;89(2):500–8.

38. Oliveira MAM de, Fagundes RLM, Moreira EAM, Trindade EBS de M, Carvalho T de. Relation between anthropometric indicators and risk factors for cardiovascular disease. Arq Bras Cardiol. 2010 Apr;94(4):478–85.

39. Flegal KM, Shepherd JA, Looker AC, Graubard BI, Borrud LG, Ogden CL, et al. Comparisons of percentage body fat, body mass index, waist circumference, and waist-stature ratio in adults123. Am J Clin Nutr. 2009 Feb;89(2):500–8.

40. Liu Y, Tong G, Tong W, Lu L, Qin X. Can body mass index, waist circumference, waist-hip ratio and waist-height ratio predict the presence of multiple metabolic risk factors in Chinese subjects? BMC Public Health. 2011 Jan 13;11(1):35.

41. LS P, MJ S, SL F, K O. Indirect estimates of body composition are useful for groups but unreliable in individuals. Int J Obes. 24:1145–52.

42. Bener A, Yousafzai MT, Darwish S, Al-Hamaq AOAA, Nasralla EA, Abdul-Ghani M. Obesity index that better predict metabolic syndrome: body mass index, waist circumference, waist hip ratio, or waist height ratio. J Obes. 2013;2013:269038.

43. Kato M, Takahashi Y, Inoue M, Tsugane S, Kadowaki T, Noda M, et al. Comparisons between anthropometric indices for predicting the metabolic syndrome in Japanese. Asia Pac J Clin Nutr. 2008;17(2):223–8.

44. Snehalatha C, Viswanathan V, Ramachandran A. Cutoff values for normal anthropometric variables in asian Indian adults. Diabetes Care. 2003 May;26(5):1380–4.

45. Dobbelsteyn CJ, Joffres MR, MacLean DR, Flowerdew G. 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 Obes Relat Metab Disord J Int Assoc Study Obes. 2001 May;25(5):652–61.

46. Odenigbo U., Odenigbo U., Oguejiofor O., Adogu PO. Relationship of Waist Circumference, Waist Hip Ratio and Body Mass Index as Predictors of Obesity in Adult Nigerians. Pak J Nutr. 2011;10(1):15–6.

47. Wai WS, Dhami RS, Gelaye B, Girma B, Lemma S, Berhane Y, et al. Comparison of Measures of Adiposity in Identifying Cardiovascular Disease Risk Among Ethiopian Adults. Obesity. 2012;20(9):1887–95.

48. MRC. Chronic Diseases of Lifestyle Research Unit [Internet]. Available from: http://www.mrc.ac.za/chronic/overview.htm

49. Products - Data Briefs - Number 107 - October 2012 [Internet]. [cited 2015 Jan 30]. Available from: http://www.cdc.gov/nchs/data/databriefs/db107.htm

50. IDF Worldwide Definition of the Metabolic Syndrome [Internet]. International Diabetes Federation. [cited 2015 Jun 14]. Available from: http://www.idf.org/metabolic-syndrome

51. Understanding Your Body Fat Percentage [Internet]. [cited 2015 Jun 14]. Available from: http://www.healthchecksystems.com/bodyfat.htm

52. Wang Z, Hoy WE. Waist circumference, body mass index, hip circumference and waist-to-hip ratio as predictors of cardiovascular disease in Aboriginal people. Eur J Clin Nutr. 2004 Jun;58(6):888–93.

53. Gharipour M, Sarrafzadegan N, Sadeghi M, Andalib E, Talaie M, Shafie D, et al. Predictors of Metabolic Syndrome in the Iranian Population: Waist Circumference, Body Mass Index, or Waist to Hip Ratio? Cholesterol. 2013 Mar 24;2013:e198384.

54. Gharipour M, Sadeghi M, Dianatkhah M, Bidmeshgi S, Ahmadi A, Tahri M, et al. The Cut-Off Values of Anthropometric Indices for Identifying Subjects at Risk for Metabolic Syndrome in Iranian Elderly Men. J Obes. 2014 Mar 23;2014:e907149.

55. Noeman SA, Hamooda HE, Baalash AA. Biochemical Study of Oxidative Stress Markers in the Liver, Kidney and Heart of High Fat Diet Induced Obesity in Rats. Diabetol Metab Syndr. 2011 Aug 3;3(1):17.

AnnexesII: Questionnaire

Jimma University College of health science

Jimma University Department of Population and Family Health-English version questionnaire for development of appropriate anthropometric indicators for early detection of metabolic syndrome study. March 2015

Hello! My name is ___________________________________ am from Jimma University and I am going to collect some information about your-self. Plus 5ml blood sample will be taken to measure fasting blood glucose and lipid profile. Body fat percentage will be measured by using air displacement plethysmography. The main objective of this study is to develop appropriate anthropometric indicators for early detection of metabolic syndrome. You are one of the randomly selected participants. Your name will not be written in this form and the information you give and result is kept confidential. Your participation is important for the success of this research, besides the findings of this research will help further studies in this area. You are selected randomly to participate in this study, your willingness and support to answer all of the questions and measurements would be appreciated.

Are you willing to participate in this study? If yes confirm it by signing

Yes___________________ signature------------------------ date-----------------------

No_____________________

If No, acknowledge the respondent and proceed to the next respondent

QUESTIONNAIRE

Date of data collection _____ / _____ / ______
(European calendar: Day Month Year)

FIRST, I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT YOURSELF.

A. DEMOGRAPHIC INFORMATION

	ID___________________________
A1.Sexof respondent Circle ONLY ONE answer	Male …………………………………..1 Female ………………………………0
A2. What is your Ethnic Group?	1.Tigre 7.Oromo 2.Dawro 8.Amhara 3.Yem 9.Gurage 4.Kefa 10.other(specify) 5.Sidama 6.Wolaita
A3.How old are you? Age in years completed at the last birthday	___________________Years
A4. What is your religion? Circle ONLY ONE answer	1. Orthodox 2. Protestant 3. Muslim 4. Catholic 5. Other specify_________________
A5. Which of the following best describes your mainwork status In Jimma University? Circle ONLY ONE answer	1. Administrative staff 2. Academic staff 3. Hospital staff Technical 4. Hospital staff Administartive
A6.What is your martial status? Circle ONLY ONE answer	1. Married 2. Single/never married 3. Widowed 4. Divorced 5. Separated 6. Refused answer
A7. What is the highest level of education you have completed? Circle ONLY ONE answer.	0. Iliterate or informal education 1. primary(1-8) 2. Secondary(9-12) 3. Diploma 4. First Degree(BSc, MD, DMD, BA) 5. Master(second degree)/ Specialist

	6. Terminal degree(PhD)/ Subspecialist

C. PHYSICAL MEASUREMENTS	
Blood Pressure(BP)(mmHg)	
C1. Cuff Size used to measure BP	1.Small 2.Mdeium 3.Large
C2. Reading 1	Systolic(mmHg)______________
	Diastolic(mmHg) _____________
C3. Reading 2	Systolic(mmHg) ______________
	Diastolic(mmHg) _____________
C4. Reading 3	Systolic(mmHg) ______________
	Diastolic(mmHg) _____________
C5.1 Height	Height (cm)
C5.2 Height	Height (cm)
C5.3 Height	Height (Cm) .
C6. Weight	Weight (kg) .
C7.1. Waist Circumference	WC(cm)
C7.2. Waist Circumference	WC(cm)
C7.3. Waist Circumference	WC(cm)
C8.1. Hip Circumference	HC(cm)
C8.1. Hip Circumference	HC(cm)
C8.1. Hip Circumference	HC(cm)
C18. Platysmography (body fat mass %)	ADP (BF %) .
C19. Platysmography (body fat free mass %)	ADP (BFF %) .
D. BIOCHEMICAL MEASUREMENTS	
D2. High density Lipoprotein(HDL)(mg/dl)	HDL(mg/dl) .
D4. Triglycerides (TG)	TG(mg/dl) .
D5. Fasting Blood Glucose (FBS)	FBS(mg/dl) .
E. HOUSEHOLD WEALTH	

Does the household have any of the following properties? (Circle)	Yes	No

E1	Functioning CD player	1	0
E2	Functioning Flat screen Television	1	0
E3	Gas Stove/Cylinder	1	0
E4	Refrigerator(fridge)	1	0
E5	Electric stove	1	0
E6	Bicycle	1	0
E7	Motor Cycle	1	0
E8	Cart/Gari	1	0
E9	Sofa	1	0
E10	Spring mattress	1	0
E11	Car	1	0
E13	Bajaj	1	0
E14	Taxi	1	0
E15	Own house	1	0
E16	Ipad	1	0
E17	Video camera	1	0
E18	Digital Camera	1	0
E19	Washing machine	1	0
E20	Laptop computer	1	0
E21	Desktop computer	1	0

Declaration

I, the undersigned, declare that this thesis is my original work, has not been presented for adegree in this or any other university and that all sources of materials used for the thesis havebeen fully acknowledged.

Name: **MERON WORKU GEBRE**

Signature: ______________________________

Name of the institution: **JIMMA UNIVERSITY**

Date of submission: ---------------------------------------

This thesis has been submitted for examination with my approval as University advisor

Name and signature of first advisor:

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