“TO STUDY THE RELATIONSHIP OF NECK CIRCUMFERENCE AS A PARAMETER IN PREDICTING METABOLIC SYNDROME- A ONE YEAR CROSS SECTIONAL STUDY”

REG NO. BG0110003

Dissertation

Submitted to the
KLE University, Belgaum, Karnataka

In Partial Fulfillment
of the requirements for the degree of

M. D.
in
GENERAL MEDICINE

DEPARTMENT OF MEDICINE,
JAWAHARLAL NEHRU MEDICAL COLLEGE,
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ENDORSEMENT

This is to certify that the dissertation entitled **"TO STUDY THE RELATIONSHIP OF NECK CIRCUMFERENCE AS A PARAMETER IN PREDICTING METABOLIC SYNDROME- A ONE YEAR CROSS SECTIONAL STUDY"** is a bonafide research work done by **THE CANDIDATE REG NO. BG0110003**

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LIST OF ABBREVIATIONS USED

%	– Percentage
AACE	– American Association of Clinical Endocrinologists
AIR	– Acute insulin response
APC	– Asia Pacific Criteria
ATP	– Adult Treatment Panel
BMI	– Body mass index
BP	– Blood pressure
CAD	– Coronary Artery Disease
CI	– Confidence interval
cms	– Centimetres
CNHS	– China Nutrition and Health Survey
CRP	– C-reactive protein
CT	– Computerized tomography
CVD	– Cardiovascular Disease
DBP	– Diastolic blood pressure
DF	– Degree of freedom
DM	– Diabetes Mellitus
DPP	– Diabetes Prevention Programme
DPS	– Diabetes Prevention Study
EGIR	– European Group for the Study of Insulin Resistance
FBS	– Fasting blood glucose
FFA	– Free Fatty acids
FPG	– Fasting plasma glucose
HDL	– High density Lipoprotein

HDL-C – High density Lipoprotein Cholesterol

HOMA IR – Homeostasis model assessment of insulin resistance

Hs-CRP – High sensitivity C-Reactive protein

HTN – Hypertension

IDF – International Diabetes Federation

IFG – Impaired fasting glucose

IGR – Impaired glucose regulation

IGT – Impaired glucose tolerance

IRAS – Insulin Resistance Atherosclerosis Study

ISI – Insulin sensitivity index

kg/m^2 – Kilograms per square metre

LDL – Low density lipoprotein

MCDS – Mexico City Diabetic Study

MetS – Metabolic syndrome

mg – milligrams

mg/dL – Milligrams per deciliter

min – Minute

mm Hg – Millimeters of mercury

mMol/L – Millimoles per litre

MRI – Magnetic resonance imaging

NC – Neck circumference

NCEP – National cholesterol education programme

NPDR – Non proliferative diabetic retinopathy

OGTT – Oral glucose tolerance test

OPD – Out patient department

OR – Odds ratio

OSA – Obstructive sleep apnoea syndrome

PCOS – Polycystic ovarian syndrome

PVD – Peripheral vascular disease

QUICKI – Quantitative insulin sensitivity check index

RENATA – REgistro NAcional de hiperTensión Arterial, National registry of hypertension

SAHS – San Antonio Heart Study

SAT – Subcutaneous abdominal tissue

SBP – Systolic blood pressure

SC – Subcutaneous

SD – standard deviation

T2DM – Type 2 diabetes mellitus

TG – Triglycerides

U.S. – United states

VAT – Visceral adipose tissue

VLDL – Very low density lipoprotein

WC – Waist circumference

WHO – World Health Organization

WHR – Waist hip ratio

µg/min – Microgram per minute

µU/L – Microunit per litre

ABSTRACT

Background and objectives

Upper-body fat distribution has long been recognized as related to increased cardiovascular disease risk, and neck skinfold or NC has been used as an index for such an adverse risk profile. This study was aimed to evaluate the relationship of NC as a parameter in predicting metabolic syndrome.

Methodology

The present study was conducted in the Department of Medicine, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum during the study period from January 2011 to December 2011. Hundred (100) cases of metabolic syndrome were taken based on NCEP ATP III criteria and the various components of metabolic syndrome and the NC were evaluated and compared.

Results

In this study 66% of the patients were males and 34% were females. Most of the patients (45%) were aged between 46 to 60 years. Overall, mean age of the study population was 54.46 ± 14.93 years. 46% of the patients had metabolic syndrome with four components and 31% had five components. The commonest component of metabolic syndrome was hypertension (95%) followed by hypertriglyceridemia (82%). Abnormal NC was observed in 97% patients and mean neck circumference was 38.93±1.95 cms. Waist circumference was abnormal in 74% patients. The mean waist circumference of the study population was 97.9±7.44 cms. Lipid abnormalities of total cholesterol, LDL, triglycerides and HDL were noted in 30%, 18%, 82% and 76% of the patients respectively.

Conclusion and interpretation

Though, majority of the patients with metabolic syndrome presented with abnormal NC, it was not associated with any of the components of metabolic syndrome. However, elevated BMI had associated increased neck circumference and this association was statistically significant.

Keywords

Body mass index; Metabolic syndrome; Neck circumference; Upper body fat; Waist circumference.

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Chapter 1

Introduction

INTRODUCTION

The metabolic syndrome is a cluster of risk factors for cardiovascular disease (CVD), including obesity, hypertension, elevated triglycerides and low levels of HDL Cholesterol. The clinical manifestations of this syndrome include hypertension, hyperglycemia, hypertriglyceridemia, reduced high-density lipoprotein cholesterol (HDL-C), and abdominal obesity.

Approximately one fourth of the adult European population is estimated to have metabolic syndrome, with a similar prevalence in Latin America.[1] Metabolic syndrome is also considered as an emerging epidemic in developing East Asian countries including China, Japan, and Korea. The prevalence of metabolic syndrome may range from 8 to 13% in men and 2 to 18% in women depending on the population and definitions used.[2-4] In Japan, the Ministry of Health, Labor, and Welfare has instituted a screening and interventional program.[5] Metabolic syndrome has been recognized as a highly prevalent problem in many other countries worldwide.[6-11]

In India, studies have reported prevalence varying from 24.9% in northern India to 41% in Southern India using different definitions.[12]

It is accepted that metabolic syndrome increases the relative risk of cardiovascular disease, though it is still debated whether metabolic syndrome adds to global cardiovascular disease risk assessed by traditional risk factors. It is believed that visceral adiposity lies at the root of the cardiometabolic risk with the consequent syndrome of central obesity/insulin resistance. Clinical definitions of metabolic syndrome by National Cholesterol Education Program-ATP-III[13] or

International Diabetes Federation[14] have been of enormous value in the diagnosis, management and research on the cluster of metabolic risk factors. Yet, there is increasing recognition that other atherogenic, pro-thrombotic and inflammatory aspects of this syndrome are not captured by these practical clinical definitions which warrant further investigation, particularly for valuable clinical markers.[15]

Upper-body fat distribution has long been recognized as related to increased cardiovascular disease risk, and neck skinfold[16] or neck circumference (NC)[17,18] has been used as an index for such an adverse risk profile. Free fatty acid release from upper-body subcutaneous fat was reported to be larger than that from lower-body subcutaneous fat.[19]

Although obesity results in metabolic abnormalities, upper body obesity is more strongly associated with glucose intolerance, hyperinsulinemia, diabetes, hypertriglyceridemia, gout and uric calculus disease than lower body obesity. Upper body obesity can be assessed by various techniques such as NC, waist circumference (WC), waist-to-hip ratio, waist-to-thigh ratio, subscapular-to-triceps skinfold ratio and abdominal sagittal diameter.

NC was found to be a simple and time-saving screening measure that could be used to identify overweight and obese individuals. It has been shown that men with a NC of less than 37 cm and women with a NC of less than 34 cm probably have a less chance of developing metabolic syndrome. Patients above these levels require a more comprehensive evaluation of their status as overweight or obese.[20]

Epidemiological population-based studies on the clinical significance of NC in regard to metabolic syndrome are lacking. Disorders in lipid or glucose metabolism and fasting hyperinsulinemia were found to prevail highest in the highest quintile of NC in a study from Finland.[21]

NC was proposed as a screening measure for identifying overweight and obese individuals in 979 Israeli adults visiting a family medicine clinic[22] and sex specific optimal cut-off points were proposed. In a subset of the mentioned group, higher NC was found correlated positively with the factors of the metabolic syndrome.[23] NC was also a good correlate of raised androgens in 107 severely obese premenopausal women.[24]

However, studies on the role of NC in predicting the metabolic syndrome are scarce and so far there are no Indian studies available. Hence the present study was undertaken to evaluate the relationship of NC as a parameter in predicting metabolic syndrome.

Chapter 2

Objectives

OBJECTIVES

To evaluate the relationship of neck circumference as a parameter in predicting metabolic syndrome.

Chapter 3

Review of Literature

REVIEW OF LITERATURE

In 1923 Kylin first described the clustering of hypertension, hyperglycemia, and gout as a syndrome. In 1988 Reaven reintroduced the concept of syndrome X for the clustering of cardiovascular risk factors, including resistance to insulin-stimulated glucose uptake, glucose intolerance, hyperinsulinemia, increased very-low-density lipoprotein (VLDL) triglycerides, decreased high-density lipoprotein (HDL) cholesterol, and hypertension.[25]

Subsequently, several other components to the syndrome, such as obesity and especially its central distribution, microalbuminuria, hyperuricaemia, and abnormalities in haemostatic factors have been added.[26]

However, controversies still exist as to whether or not microalbuminuria is a component of the syndrome. In addition, the syndrome has been given several different names like the deadly quartet, the insulin resistance syndrome, the metabolic cardiovascular syndrome, the insulin resistance-dyslipidaemia syndrome, and plurimetabolic syndrome.[27]

The name “insulin resistance syndrome” has been widely used and refers to insulin resistance as a common denominator of the syndrome. In 1999, the WHO proposed a unifying definition for the syndrome and chose to call it MetS rather than the insulin resistance syndrome.[28]

The reason was mainly that it was not considered established that insulin resistance was the cause of all the components of the syndrome.

Definitions of MetS

Despite abundant research on the subject of MetS, the criteria used for diagnosing MetS are different across studies, causing confusion when assessing prevalence rates across countries. To aid in the clinical practice and research of the syndrome, the WHO,[28] the EGIR,[29] the NCEP,[13] the AACE[30] and the IDF[31] have proposed different definitions.

The new IDF definition emphasizes the importance of central obesity defined by ethnic specific values. WHO,[28] EGIR,[29] NCEP,[13] AACE[30] and IDF[31] definitions of MetS are as below.

WHO definition[28]

Diabetes (fasting plasma glucose ≥7.0 mmol/l and/or 2-hour plasma glucose ≥11.1 mmol/l), or impaired glucose regulation (fasting plasma glucose 6.1-6.9 mmol/l and/or 2-hour plasma glucose 7.8-11.0 mmol/l), and/or insulin resistance (below lowest quartile of glucose uptake in the euglycaemic clamp), and two or more of the following:

- Raised triglycerides (≥1.7 mmol/l or > 150 mg/dL) and/or low HDL-cholesterol (<0.9 mmol/l in men, < 1.0 mmol/l in women).
- Central obesity (waist-to-hip ratio >0.90 in men, >0.85 in women) and/or body mass index (BMI) >30 kg/m^2.
- Raised blood pressure (systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg).

- Microalbuminuria (urinary albumin excretion rate ≥20 μg/min or albumin/creatinine ratio ≥30 mg/g).

EGIR definition for non-diabetic individuals[29]

Hyperinsulinaemia (fasting insulin concentrations in the highest quartile) and at least two of the following:

- Hyperglycaemia (fasting plasma glucose ≥6.1 mmol/l or 110 mg/dL).
- Central obesity (waist circumference ≥94 cm in men, ≥80 cm in women).
- Hypertension (systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg or treated for hypertension).
- Dyslipidaemia (triglycerides >2.0 mmol/l [>178 mg/dL] or low HDL-cholesterol < 1.0 mmol/l [<39 mg/dL] or treated for dyslipidaemia).

NCEP definition[13]

Three or more of the following:

- Abdominal obesity (waist circumference >102 cm in men, >88 cm in women).
- Triglycerides ≥1.7 mmol/l (> 150 mg/dL).
- HDL-cholesterol < 1.03 mmol/l in men (< 40 mg/dL), <1.29 mmol/l in women (< 50 mg/dL).

- Systolic blood pressure ≥130 mmHg and/or diastolic blood pressure ≥85 mmHg.

- Fasting plasma glucose ≥6.1mmol/l (≥ 110 mg/dL).

AACE definition for non-diabetic individuals[30]

Two or more of the following:

- Triglycerides ≥1.7 mmol/l (≥ 150 mg/dL).

- HDL-cholesterol < 1.03 mmol/l (< 40 mg/dL) in men, <1.29 mmol/l (< 50 mg/dL) in women.

- Systolic blood pressure ≥130 mmHg and/or diastolic blood pressure ≥85 mmHg or current use of antihypertensive medications.

- 2-hour plasma glucose 7.8-11.0 mmol/l or fasting plasma glucose 6.1-6.9 mmol/l (IFG) (IFG was added in updated AACE criteria).

IDF definition[31]

Central obesity defined as ethnicity specific values of waist circumference (≥ 90cm for South Asian men and ≥80cm for South Asian women) and at least two of the following:

- Raised triglycerides levels (≥1.7 mmol/l or > 150 mg/dL), or specific treatment for this lipid abnormality.

- Reduced HDL-cholesterol (< 1.03 mmol/l in men, <1.29 mmol/l in women), or specific treatment for this lipid abnormality.

- Raised blood pressure (systolic blood pressure ≥130 mmHg and/or diastolic blood pressure ≥85 mmHg), or treatment of previously diagnosed hypertension.

- Raised fasting plasma glucose (≥5.6 mmol/l), or previously diagnosed type 2 diabetes.

  If above 5.6 mmol/l, OGTT is strongly recommended but is not necessary to define presence of the syndrome.

Epidemiology

Prevalence

Applying the NCEP[13] definition of MetS in a representative U.S. sample of 8,814 men and women aged 20 years and older from the Third National Health and Nutrition Examination Survey (1988-1994), the unadjusted and age-adjusted prevalence of MetS was 21.8% and 23.7%, respectively. The prevalence increased from 6.7% among participants aged 20 through 29 years to 43.5% and 42.0% for participants aged 60 through 69 years and aged at least 70 years, respectively. Mexican Americans had the highest age-adjusted prevalence of MetS (31.9%). The age-adjusted prevalence was similar for men (24.0%) and women (23.4%). However, African American women had a 57% higher prevalence than African American men did, and Mexican American women had a

26% higher prevalence than Mexican American men did. Using 2000 census data, about 47 million U.S. residents have MetS.[32]

The data from eight European studies, which included 8,200 men and 9,363 women, showed that in non-diabetic subjects the frequency of the WHO-defined syndrome[28] varied between 7% and 36% for men aged 40 to 55 years, and for women of the same age, between 5% and 22%; the EGIR-defined syndrome was less frequent than the WHO-defined syndrome (1% to 22% in men, 1% to 14% in women 40-55 years).[33]

In another study based on 11 prospective European cohort studies comprising 6,156 men and 5,356 women without diabetes and aged from 30 to 89 years, the age-standardized prevalence of MetS defined by the modified WHO[28] definition was slightly higher in men (15.7%) than in women (14.2%). The overall prevalence of the WHO defined MetS in non-diabetic adult Europeans is 15%.[34]

In Omani adults aged 20 years and over, living in the city of Nizwa, the age-adjusted prevalence of the NCEP-defined MetS[13] was 21.0% (men: 19.5%, women: 23.0%).[35]

Among 40,698 Korean metropolitan subjects (26,528 men, 14,170 women) aged 20-82 years, the age-adjusted prevalence of the NCEP-defined MetS[13] was 6.8% in total (5.2% male, 9.0% female). Using the Asia-Pacific criteria (APC) for abdominal obesity based on waist circumference (WC) (APC-WC: ≥ 90 cm in men, ≥ 80 cm in women), the prevalence rates of MetS increased to 10.9% (9.8% male, 12.4% female). The subjects over 70 years of age had a 14-

fold increased risk for MetS than those aged 20-29 years, and females had higher prevalence rates than males in age groups older than 50 years.[36]

The 1998 Singapore National Health Survey involving 4,723 men and women of Chinese, Malay, and Asian-Indian ethnicity aged 18-69 years, demonstrated that the age-adjusted prevalence rates of the NCEP-defined MetS[13] were 9.4, 18.7, and 20.4% for Chinese, Malays, and Asian-Indians, respectively. Using the APC criteria, the analogous prevalence rates increased to 14.8, 24.2, and 28.8% for the three ethnic groups, respectively.[37]

The prevalence of the metabolic syndrome depends on age, ethnic background, and gender. It rises linearly from 20 to 50 years and plateaus thereafter. Looking at various studies around the world, which included population samples, aged from 20 to 25 and upwards, the prevalence varies from 8% (India) to 24% (United States) in men and from 7% (France) to 46% (India) in women.[38] Two Indian studies, which differed in their definition of obesity: the first[39] used the obesity criteria suitable for Indians, while the second[40] used the standard ATP III definition of obesity. Both studies used population based samples within the age range but reported prevalence of 13% in Jaipur[40] and 41% in Chennai.[39] Although, the prevalence of obesity in the two study groups was quite similar (31% versus 33%), despite the different definitions used, far larger differences were observed between the two studies for the prevalence of elevated triglycerides (46% vs. 30%), hypertension (55% vs. 39%) and elevated fasting plasma glucose (27% vs. 5%); indicating a far larger impact of these risk factors than obesity alone.

Various Factors contributing to increasing prevalence of metabolic syndrome have been identified:

1. Atherogenic dyslipidemia, Elevated Triglycerides, apolipoprotein B and small low-density lipoprotein, low HDL.
2. Elevated plasma glucose.
3. Elevated blood pressure.
4. Pro-thrombotic state.
5. Pro-inflammatory state

Many studies[41,42,43] have reported that low socio-economic status is associated with a higher mortality rate due to cardiovascular disease. A low education level links cardiovascular disease with risk factors such as smoking, hypertension, impaired glucose tolerance, diabetes mellitus, physical inactivity and overweight associated with other metabolic abnormalities.

Age

The prevalence of metabolic syndrome increases with age, with about 40% of people older than 60 years meeting the criteria.[44] The metabolic syndrome affects 44% of the U.S. population older than age 50. A greater percentage of women older than age 50 have the syndrome than men. The age dependency of the syndrome's prevalence is seen in most populations around the world.

However, metabolic syndrome can no longer be considered a disease of only adult populations. Alarmingly, metabolic syndrome and diabetes mellitus are increasingly prevalent in the pediatric population, again in parallel with a rise

in obesity.[45] In the United States, children are becoming obese at triple the rate compared with the 1960s, making the study and treatment of this problem vital. The epidemic of metabolic syndrome in children and adolescents is an international phenomenon, which lead the International Diabetes Foundation to publish an updated consensus statement to guide diagnosis and further study of the condition.[46,47]

Components of MetS and incident diabetes

There have been many prospective studies on the association between the components of MetS, e.g. IFG, IGT, insulin resistance, overweight/obesity, hypertension, and dyslipidaemia, and incident diabetes. Among these individual risk factors, the most important and consistent are impaired glucose regulation (IGR), obesity, and insulin resistance. However, studies in relation to prediction of other risk factors such as hypertension and dyslipideamia, to incident diabtes showed conflicting results due to differences in covariates or definition of diabetes. Little information is available on whether or not microalbuminuria is an independent predictor of incident diabetes.

Impaired glucose regulation

Although there is evidence that other factors such as age, family history of diabetes, waist-to-hip ratio (WHR), BMI, blood pressure (BP), and lipid levels are independently associated with the development of diabetes, none taken singly is as good at discriminating who will progress to diabetes as measuring glucose levels. IGT had been found to be a strong predictor of incident diabetes before IFG was also created as a new category of abnormal glucose metabolism.[48]

Since the WHO approved new diagnostic criteria for the diagnosis of diabetes in 1999, the Hoorn Study has demonstrated that after adjustment for age, sex, and follow-up duration, the relative risks (RR) of incident diabetes were 10.0 and 10.9 for isolated IFG and isolated IGT, respectively, compared to normal glucose levels, while combined IFG and IGT were associated with a 39.5-fold increased risk of future diabetes.[49]

Furthermore, another study showed that the sensitivity for predicting progression to type 2 diabetes was 26% for IFG and 50% for IGT. Only 26% of subjects that progressed to type 2 diabetes were predicted by their IFG values, but a further 35% could be identified by also considering IGT. The results implicate that IGT identifies more high-risk subjects than IFG.[50]

Obesity

Overweight, obesity, or weight gain has shown to be an important risk factor for the development of type 2 diabetes. In a cohort study of 51,529 U.S. male health professionals aged 40-75 years, a strong positive association between overall obesity as measured by BMI and risk of incident diabetes was observed during the 5-year follow-up.[51] In this study[51] men with a BMI of at least 35 kg/m2 had a multivariate RR of 42.1, compared to men with a BMI of less than 23 kg/m2 (P<0.001). Fat distribution, measured by WHR, was a good predictor of diabetes only among the top 5%, while WC was positively associated with the risk of diabetes among the top 20% of the cohort.

Recently, the Health Professionals Follow-Up Study of 27,270 American men reported that both overall and abdominal adiposity strongly and

independently predicted the risk of type 2 diabetes, and WC was a better predictor than WHR.[52]

In a national cohort of 8,545 U.S. adults from the National Health and Nutrition Examination Survey[53] Epidemiologic Follow-up Study, 5- < 8 kg, 11- < 20 kg and over 20 kg weight gains were associated with a 2.1-fold, 2.6-fold, and 3.9-fold increased risk of incident diabetes during the 9-year follow-up, respectively, compared with participants whose weights remained relatively stable. The authors found no evidence that the results differed by age, sex, or race. They estimated that the population attributated risk was 27% for weight increases of 5 kg or more.

Of an age- and sex-stratified random sample of 1,000 individuals aged 40-79 years, the Bruneck Study confirmed that BMI was a predictor of incident diabetes, independently of other components of MetS such as IFG, IGT, insulin resistance, hypertension, and dyslipidaemia.[54]

Insulin resistance

In a prospective study of Pima Indians the 90th percentile of fasting insulin level was associated with a 15.8-fold increased risk of incident diabetes compared with the 10th percentile adjusted only for gender.[55]

The San Antonio Heart Study[56] (SAHS) of Mexican Americans and non-Hispanic whites reported that after adjustment for age, sex, ethnicity, BMI, and centrality, the top quartile of fasting insulin levels were significantly associated with a 2.3-fold increased risk of the development of diabetes over an 8-year

follow-up. Using combined prospective data from the SAHS, the Mexico City Diabetes Study (MCDS), and the Insulin Resistance Atherosclerosis Study (IRAS), the authors found that in adjusting for age, sex, systolic blood pressure (SBP), HDL-cholesterol and BMI models with all subjects pooled as well as separately glucose tolerance status (NGT versus IGT), study and ethnic group, insulin resistance predicted type 2 diabetes independently of these covariates. However, there were substantial differences between published IR indices in the prediction of diabetes. Among the indices of insulin resistance such as fasting insulin, homeostasis model assessment of insulin resistance (HOMA-IR), quantitative insulin sensitivity check index (QUICKI), insulin sensitivity index (ISI), and 2-h insulin/2-h glucose (I2/G2), Gutt et al.'s ISI at 0 and 120 min (ISI (0,120)) displayed the strongest prediction. After adjustment of age, sex, alcohol, smoking, physical activity, IFG, IGT, BMI, hypertension, and dyslipidaemia, the Bruneck Study also showed that insulin resistance measured as HOMA predicted the development of diabetes independently.

Dyslipidaemia

The results from the Norwegian population-based Finnmark Study showed that HDL cholesterol was inversely related to incident diabetes in women, but not in men, controlling for other risk factors such as BMI, diastolic blood pressure (DBP), glucose and ethnicity. However, triglycerides were positively related to the incidence of diabetes in men and women adjusted for age.[57]

The MONICA (Monitoring of Trends and Determinants in Cardiovascular Disease) Augsburg Cohort Study[58] also displayed an inverse association between HDL-cholesterol and incident diabetes in both genders.

In a prospective study[59] in Swedish women, triglycerides (TG) carried a steeply increased multiple-adjusted (adjusted for age, physical activity, BMI, SBP and total cholesterol) risk for incident diabetes with hazard ratio 3.0 already at TG 1.0-1.4 mmol/l, 3.7 at TG 1.5-1.9 mmol/l and 4.5 at TG >2.0 mmol/l, compared with TG < 1.0 mmol/l (P<0.001).

However, the Bruneck Study[54] did not demonstrate a significant association between dyslipidaemia and incident diabetes in multivariate logistic regression analysis (adjusted for age, sex, alcohol, smoking, physical activity, IFG, IGT, BMI, insulin resistance, and hypertension).

Hypertension

A questionnaire survey in the Netherlands among 5,700 men and women aged 20 to 65 showed that after adjusting for age and BMI, SBP and DBP were still associated with the incidence of diabetes (defined as the current use of oral hypoglycemic drugs and /or insulin) in men. For women, only the relative risk associated with the use of diuretics remained statistically significant.[60] The MONICA Augsburg Cohort Study[58] demonstrated that in multivariate analysis (controlling for age, BMI, HDL cholesterol, uric acid, alcohol intake, physical activity and survey), SBP predicted the development of diabetes in men also.[58]

A study[59] reported that the Swedish women whose SBP was at least 145 mmHg had a risk to diabetes over 2.2 times that of women with a SBP of less than 145 mmHg, after adjusting for age, BMI, physical activity, TG, and total cholesterol.

However, the Bruneck Study[54] displayed that after further control for alcohol, smoking, physical activity, IFG, IGT, BMI, insulin resistance, and dyslipidaemia, there was no association between hypertension and incident diabetes. However, hypertension was associated with a 2.3-fold increased risk of future diabetes adjusted for only age and sex.

Microalbuminuria

Microalbuminuria is a well-established marker for incipient nephropathy in patients with diabetes.[61]

In addition, microalbuminuria is associated with increased CVD in both diabetic and non-diabetic subjects.[62]

Previous studies reported that microalbuminuria in non-diabetic subjects was associated with MetS, and suggested that microalbuminuria might be a feature of MetS.[63]

However, multiple logistic regression analyses in diabetic and non-diabetic subjects separately showed that microalbuminuria was independently associated only with hypertension, diabetes and WHR, but not with other variables of MetS in a Caucasian population. It is therefore likely that

microalbuminuria is a complication of hypertension and diabetes, and not an integral part of MetS.[64]

Thus far, there has been only a Finnish study[65] on the association between the microalbuminuria factor derived from factor analysis and incident diabetes. However, the microalbuminuria factor did not predict incident diabetes in the study.

The WHO-defined or the NCEP-defined MetS and incident diabetes

There have been two prospective studies on association between the WHO-defined or the NCEP defined MetS and incident diabetes.[65,66] These results showed that both the WHO-defined and the NCEP-defined MetS were predictors of incident diabetes. The WHO-defined MetS seemed to be more sensitive for predicting the development of diabetes than the NCEP-defined MetS, except for the inverse results from the SAHS. However, IGT was not included as a component of the WHO defined MetS in the SAHS.

Mechanism of MetS

Although the underlying mechanism of the syndrome is not completely understood, environmental factors such as obesity, physical inactivity, and unbalanced total energy intake, together with still largely unknown genetic triggers, increase susceptibility to the syndrome.[68]

Environmental factors

Birth weight, childhood obesity, smoking, alcohol, coffee, tea, social status and age.

Birth weight

Low birth weight and thinness at birth are correlated with abnormal glucose tolerance, dyslipidaemia and hyperinsulinaemia in later adulthood.[68]

In 34 studies of more than 66,000 people, almost all results showed that an increase in birth weight was associated with a fall in blood pressure, and there was no exception to this in the studies of adults which included total nearly 8,000 men and women.[69]

The odds ratio (OR) for diabetes, after adjusting for current body mass, was 3.8 in men whose birth weights were less than 2.5 kg compared with those who weighed 3.2-3.9 kg.[70]

Of 64-year-old men whose birth weights were 2.95 kg or less, 22% had MetS. Their risk of developing MetS was more than 10 times greater than that of men whose birth weights were more than 4.31 kg.[71]

Childhood obesity

It has been suggested that the origins of adulthood risk of CVD and type 2 diabetes can be related to somatic growth as a child, not necessarily to intrauterine growth. In westernized countries, the relative proportion of underweight newborn children is decreasing; thus, considering the entire

population's low birth weight has lost its theoretical role in the aetiology of type 2 diabetes and CVD.[72]

Conversely, as obesity is known to be increasing in the industrialized countries among all age groups, the association between weight gain in childhood and MetS in adulthood is more than noteworthy. The risk of MetS was lower among obese adults who had not been obese as children compared to obese adults who had also been obese as children.[73]

A population study[72] in Finland found that among obese children at the age of seven (BMI in the highest quartile), the OR for MetS in adulthood was 4.4 (95% CI 2.1-9.5) as compared to the other children (the three other quartiles combined). After adjustment for age, sex and current obesity, the risk of the syndrome still was 2.4 (95% CI 2.1-9.5).

Smoking

The results of 54 published studies displayed that overall, smokers had significantly higher serum concentrations of cholesterol, TG, VLDL cholesterol, and low-density lipoprotein (LDL) cholesterol, and lower serum concentrations of HDL cholesterol and apolipoprotein AI compared with non-smokers.[74]

It was shown that the measures of insulin sensitivity were significantly lower in smokers when the degree of insulin-mediated glucose uptake (insulin sensitivity) was compared in smoking and non-smoking men.[75]

Among those who smoked at least two packs per day at baseline, men had a 45% higher diabetes rate than men who had never smoked; the comparable

increase for women was 74%. Quitting smoking reduced the rate of diabetes to that of non-smokers after five years in women and after ten years in men.[76]

Recently, a study on Koreans reported that smoking (more than 20 pack-years) was associated with a 1.4-fold and 1.9-fold increased risk of high triglycerides and low HDL-cholesterol. The relative risk of developing NCEP-defined MetS in smokers (more than 20 pack-years) was 1.9-fold higher compared with non-smokers although there was no significant difference in blood pressure in the smoking group.[77]

Alcohol

Epidemiological studies have shown an association between light to moderate alcohol consumption and reduced risk of MetS and developing type 2 diabetes. Some of the biological mechanisms reported to explain this observation include an improvement of the lipid profile, especially HDL cholesterol and increasing insulin sensitivity.[78]

Recently, a cross-sectional analysis on data from 8,125 participants in the U.S. showed that after adjustment for age, sex, race/ethnicity, education, income, tobacco use, physical activity, and diet, subjects who consumed 1-19 and >20 drinks of alcohol per month had ORs for the prevalence of the NCEP defined-MetS of 0.65 and 0.34, respectively ($P < 0.05$), compared with current nondrinkers. These findings were particularly noteworthy for beer and wine drinkers. Alcohol consumption was significantly and inversely associated with the prevalence of the following four components of MetS: low serum HDL cholesterol, elevated serum triglycerides, high WC and hyperinsulinemia.[79]

Although alcohol consumption had a significant inverse relation with the OR for low HDL cholesterol in all alcohol groups, and lower alcohol consumption had a favorable effect on MetS, an increasing dose-response relation was found between alcohol consumption and the OR for MetS in a Korean population. In this population, heavy alcohol consumption of at least 30 g per day was associated with significantly higher ORs for high blood pressure, and high triglycerides in men and high fasting blood glucose and high triglycerides in women. ORs for the NCEP-defined MetS and its components tended to increase with increasing alcohol consumption.[80]

Coffee

Intake of coffee is often reported as a cardiovascular risk factor. However, no clear association between coffee and the risk of hypertension, total cholesterol, LDL-C levels, myocardial infarction, or other cardiovascular diseases has been demonstrated.[81] Furthermore, coffee consumption was related to improved insulin sensitivity.[82]

Several studies[83,84] on Dutch, Japanese, American, and Swedish population have shown that coffee consumption was associated with a substantially lower risk of clinical type 2 diabetes, although the reasons for this risk reduction remain unclear.

A Finnish study[85] reported that in 6,974 Finnish men and 7,655 women aged 35 to 64 years during a mean follow-up of 12 years, after adjustment for confounding factors (age, study year, BMI, SBP, education, occupation, commuting, leisure-time physical activity, alcohol and tea consumption, and

smoking), the hazard ratios of diabetes associated with the amount of coffee consumed daily (0-2, 3-4, 5-6, 7-9, >10 cups) were 1.00, 0.71 (95% CI, 0.48-1.05), 0.39 (0.25-0.60), 0.39 (0.20-0.74), and 0.21 (0.06-0.69) in women, and 1.00, 0.73 (0.47-1.13), 0.70 (0.45-1.05), 0.67 (0.40-1.12), and 0.45 (0.25-0.81) in men, respectively. In both sexes combined, the multivariate-adjusted inverse association was significant and persisted when stratified by younger and older than 50 years; smokers and non-smokers; healthy weight, overweight, and obese participants; alcohol drinkers and non-drinkers; and participants drinking filtered and nonfiltered coffee.

Tea

The results of experimental studies[86,87] have shown the protective effect of tea in improving lipid and glucose metabolism and enhancing insulin sensitivity.

A study[88] from Taiwan showed that Oolong tea significantly decreased plasma glucose (from an initial concentration of 229±53.9 to 162.2±29.7 mg/dl), whereas water did not (from 208.7± 61.0 to 232.3±63.1 mg/dl). Fructosamine concentration decreased significantly (from 409.9± 96.1 to 323.3±56.4 µmol/l with the tea treatment) but did not change significantly with water treatment (from 368.4±85.0 to 340.0±76.1 µmol/l). This study supports the concept that Oolong tea is effective in lowering the plasma glucose levels of subjects who have type 2 diabetes.

However, the epidemiological evidence, data released from recent the cohort study[83-85] of diverse countries (the Netherland, the U.S., Sweden and

Finland), failed to show the same association as coffee on the risk of type 2 diabetes.

Diet

Dramatic changes in the prevalence or incidence of type 2 diabetes have been observed in communities where there have been major changes in the type of diet consumed, from a traditional indigenous diet to a typical 'Western' diet, e.g. Pima Indians in Arizona, Micronestans in Nauru and Aborigines in Australia.[89-91]

For the Pima Indians in Arizona, the transition from an agrarian to a modern society was associated with the consumption of increasing amounts of dietary fat, decreasing amounts of dietary carbohydrates, and a deterioration in insulin sensitivity.[92]

Most developing countries have experienced a shift in the overall structure of its dietary pattern with related disease patterns over the last few decades. Major dietary change includes a large increase in the consumption of fat and added sugar in the diet, often a dramatic increase in animal food products contrasted with a fall in total cereal and fiber intake.[93]

The traditional lifestyle of Chinese has changed markedly over two decades with rapid development of its economy. According to 4th CNHS, fat consumption in the diet increased from 28% in 1992 to 35 % of total energy intake in 2002 in urban areas, while carbohydrate consumption decreased from 57% in 1992 to 47% of total energy intake in 2002. In contrast, the analogous

values of fat intake were 19%, 28% (carbohydrate: 72%, 61%), respectively, in rural areas. In developed countries, i.e. in the U.S., a demographic shift toward an overall positive energy balance that has increased over the past few decades has been observed. It has been estimated that Americans consumed an average of 340 kcal/day more in 1994 than in 1984 and 500 kcal/day more than in 1977.[94]

In humans, intakes high in total fat and saturated fat, and intakes low in carbohydrates or starches and fiber, correlated with higher fasting insulin concentrations.[95]

High total fat intake has also been associated with a lower insulin sensitivity index. In both Pima Indians and Caucasians, glucose-mediated glucose disposal, beta-cell function, and glucose tolerance deteriorated in the modern diet (carbohydrate, 30%; fat, 50%; protein, 20%).[96]

A high fat intake has been shown to predict development of IGT in a group of healthy subjects and progression from IGT to type 2 diabetes in a group of subjects with IGT.[97]

Higher proportions of saturated fatty acids in serum lipids/muscle phospholipids have been associated with higher fasting insulin levels, lower insulin sensitivity, and a higher risk of developing type 2 diabetes.[98]

A high intake of trans-fatty acids was also associated a higher risk of diabetes. However, higher vegetable fat (unsaturated fat) and polyunsaturated fatty acids (PUFAs) intake have been associated with a lower risk of type 2 diabetes, as well as lower fasting and 2-hour glucose concentrations.[99]

A whole-grain diet resulted in higher concentrations of insulin sensitivity and lower concentrations of fasting insulin than did a refined-grain diet, while increasing intakes of refined carbohydrates (corn syrup) concomitant with decreasing intakes of fiber paralleled the upward trend in the prevalence of type 2 diabetes.[100]

Physical inactivity

Low levels of physical activity are associated with most components of MetS, especially with an increased risk of obesity. Advances in technology and transportation have reduced the need for physical activity in daily life. Labor-saving devices have eliminated many of back-breaking tasks of agricultural- and industrial-sector occupations and reduced the time it takes to complete them. The appeal of television, electronic games, and computers has increased the time spent in sedentary pursuits among children and adults.[101]

A cohort study (1989 to 1997) from 2,485 adults aged 20 to 45 years from eight provinces in China found that after adjustment of age, work, leisure activity, energy intake, smoking status, alcohol consumption, income, education, household ownership of a computer and TV, and urban residence, the odds of being obese were 70% higher for men and 85% higher for women in households who owned a motorized vehicle compared with those who did not own a vehicle.[102]

Insulin resistance plays a central role in MetS, being associated with most of the other metabolic abnormalities in the syndrome.[103]

Physical training has mostly been shown to improve insulin sensitivity in healthy humans regardless of age, in obese non-diabetic subjects, and in patients with type 2 diabetes.[104] Exercise also has pronounced effects upon the metabolism of glucose because exercising muscle may increase glucose uptake 7- to 20-fold.[105]

The Finnish Diabetes Prevention Study (DPS)[106] and the Diabetes Prevention Program (DPP)[107] in the United States revealed a 58% reduction in the risk of diabetes in high-risk subjects who enhanced physical activity.

The DPS[106] also found that the intervention group had a significant decrease in serum concentrations of 2-h postload insulin and TG, and a marked increase in HDL colesterol levels compared with the control group.

A cross-sectional survey[108] in an urban area of the city of Tianjin, China, found that daily walking or cycling to and from work was inversely associated with serum total cholesterol, LDL cholesterol, and TG concentrations among men, and was positively associated with HDL cholesterol concentrations among women as compared to traveling to and from work by bus.

A meta-analysis[109] of 25 longitudinal studies examining the antihypertensive effect of exercise showed reductions in resting SBP and DBP of 11 and 8 mmHg, respectively. However, the decrement in BP evoked by exercise was not sufficient to produce normotension in many studies.

Obesity

Obesity is becoming increasingly common worldwide due to adoption of a more sedentary lifestyle and an increased intake of energy-rich diets. It is well accepted that obesity, as the core of MetS, promotes glucose intolerance, insulin resistance, hypertension, and dyslipidaemia, and is associated with the development of type 2 diabetes and coronary heart disease.[110]

The 4th CNHS[111] showed that the prevalence of obesity (BMI >30) and overweight (BMI >25) has increased by 97% and doubled, respectively, between 1992 and 2002 in Chinese adults.

Obesity and weight gain are important determinants of clustering of the individual traits of MetS. A study in Hong Kong Chinese men showed, after adjustment for age, smoking, and insulin resistance, increasing BMI and WHR remained closely associated with increased concentrations of TG and apo B, increased ratios between LDL and HDL (LDL/HDL) cholesterol, and between apo B and LDL (apo B/LDL), increased fasting and 2-h plasma glucose and insulin, as well as decreased concentrations of HDL, and apolipoprotein A-I (apo A-I).[112]

The relationship between insulin sensitivity and overall obesity is well established. Furthermore, visceral abdominal tissue (VAT) and subcutaneous abdominal tissue (SAT), which were measured from computed tomography scans performed at the L4/L5 vertebral region, and their joint interactions were each inversely and significantly associated with ISI, adjusting for age, sex, ethnicity, and BMI. SAT, but not VAT, was positively associated with acute insulin

response (AIR). Thus, fat distribution is an important determinant of both insulin resistance and insulin secretion.[113]

The NHANES II (National Health and Nutrition Examination Survey II) study[114] found obese women to be four times more likely to develop diastolic hypertension than non-obese women.

In the Framingham population,[115] weight gain had a stronger relationship with blood pressure in males than in females.

There appears to be a consensus that obesity is an important risk factor of type 2 diabetes.[116]

Prevention of MetS and diabetes

In the Da Qing IGT and Diabetes Study, for subjects assigned to the diet-only intervention, the participants with BMI > 25 kg/m^2 were encouraged to reduce their calorie intake so as to gradually lose weight at a rate of 0.5-1.0 kg per month until they achieved a BMI of 23 kg/m^2. The participants with BMI < 25 kg/m^2 were prescribed a diet containing 25-30 kal/kg body weight, 55-65% carbohydrate, 10-15% protein, and 25-30% fat. For subjects assigned to the exercise-only intervention, the participants were taught and encouraged to increase the amount of their leisure physical activity by at least 1 U/day, i.e., faster walking at least 20 minutes per day and by 2 U/day if possible for those < 50 years of age with no evidence or CVD or arthritis.

For subjects assigned to the diet-plus-exercise intervention, the participants received instruction and counseling for both diet and exercise

interventions that were similar to those for the diet-only and the exercise-only intervention group. The diet-plus-exercise intervention was associated with a 42% reduction in risk of incident diabetes.[117]

In the DPS,[105] 25-47% of the subjects in the intervention group succeeded in achieving the goals of the lifestyle intervention during the first year, which were a reduction in total intake of fat to less than 30% and in the intake of saturated fat to less than 10%, an increase in fiber intake to at least 15 g per 1000 kcal, a weight reduction of at least 5% of initial body weight, and moderate excise for at least 30 minutes per day. As a result, the risk of diabetes was reduced by 58% in the intervention group after four years. In contrast, only 11-26% of the subjects in the control group achieved these goals. The DPP tested a goal of intervention including physical activity of moderate intensity, such as brisk walking for at least 150 minutes per week, a reduction in total intake of average fat to less than 32%, and a weight reduction of at least 7% of initial body weight.

Presentation

History

As with other diseases, careful history taking is important in metabolic syndrome. Even though the condition is diagnosed based on physical and laboratory features, it may be suspected if symptoms of any of the component disorders are present, such as the increased hunger, thirst, or urination that may accompany hyperglycemia. Patients reporting a history of hypertension, dyslipidemia warrant screening for metabolic syndrome. Symptoms suggesting

the rise of cardiovascular and other complications, such as chest pain or shortness of breath, must be investigated carefully. As lifestyle changes can ameliorate the condition, attention should be paid to the patient's dietary habits and exercise routines so that areas for improvement can be identified.

The social history is important for identifying additional risks, such as tobacco use, which may exacerbate the increased cardiovascular complications associated with metabolic syndrome. A family history should be obtained because genetics may play an important role in metabolic syndrome. This feature of the disease is under active investigation; however, currently no gene or group of genes has been implicated consistently, suggesting that the environment exerts substantial influence.[118] Finally, a thorough review of systems may help identify related problems, such as menstrual irregularities that can be seen in polycystic ovarian syndrome.

Physical examination

The physical examination is crucial in patients with metabolic syndrome as the findings of elevated blood pressure and abdominal obesity are 2 of the 5 diagnostic criteria. Measurement and documentation of waist circumference are important routines when screening for metabolic syndrome. Additionally, the examination may reveal findings reflective of the other criteria. For example, patients with insulin resistance and hyperglycemia or diabetes mellitus may have acanthosis nigricans, hirsutism, peripheral neuropathy, and retinopathy. Patients with severe dyslipidemia may have xanthomas or xanthelasmas. The presence of arterial bruits may portend a higher risk of cardiovascular complications.

Diagnosis

Initial laboratory studies in patients suspected of having metabolic syndrome should include standard chemistries to assess for hyperglycemia and renal dysfunction and lipid studies to assess for hypertriglyceridemia or low HDL levels.

If a family history of early coronary or other atherosclerotic disease is present, consider including, in addition to HDL-C and low-density lipoprotein cholesterol (LDL-C), studies of lipoprotein(a), apolipoprotein-B100, high-sensitivity C-reactive protein (CRP), and (if the patient does not already merit the lowest LDL-C target [< 70]), homocysteine and fractionated LDL-C.

In view of the various associations between metabolic syndrome and other conditions discussed, additional helpful blood tests may include thyroid and liver studies, hemoglobin-A1C levels, and uric acid. Hyperuricemia appears to be much more common in patients with metabolic syndrome than in the general population, and this is attributed to the inflammatory effects of metabolic syndrome.[119] Further studies should be pursued as clinical findings dictate.

NECK CIRCUMFERENCE

Body mass Index (BMI) is a traditional measure of obesity, and individuals with values between 25 and 29.9 kg/m2 are considered as being overweight while those with values of 30 kg/m2 or higher as obese. According to WHO, alarming increases in obesity are being observed in Asian countries, including India.[120] Obesity is not just limited to urban and affluent society but also affects the rural places and persons belonging to the lower socio-economic strata. US preventive service task force recommends that all adults must be screened for obesity to prevent morbidity and mortality. And screening must be simple, least cumbersome, noninvasive and easily feasible.[121]

Visceral adipose tissue (VAT) is recognized as a unique, pathogenic fat depot, conferring metabolic risk above and beyond standard anthropometric measures, such as body mass index (BMI) and waist circumference.[122]

Individuals with large amounts of visceral fat are at increased risk of insulin resistance, type 2 diabetes, and atherosclerosis. However, VAT accounts for only modest correlations between cardiometabolic risk factors, suggesting that other mechanisms, or other fat depots, may also contribute to the development of cardiovascular disease (CVD) risk factors.[123]

Upper body SC fat, as estimated by neck circumference, may confer risk above and beyond visceral abdominal fat. Anatomically, upper-body SC fat is a unique fat depot located in a separate compartment compared with VAT. Systemic free fatty acid concentrations are primarily determined by upper-body SC fat, suggesting that this fat depot may play an important role in risk factor

pathogenesis. Elevated free fatty acid concentrations have been associated with insulin resistance, increased very-low-density lipoprotein cholesterol production, and endothelial cell dysfunction.[123]

Recent research has focused extensively on body composition and CVD risk. Emphasis has been placed on whether an individual has an upper-body or lower-body fat distribution or what proportion of fat is stored in visceral *vs.* SC fat depots. Typically, central obesity, particularly high levels of upper-body visceral fat, is associated with adverse metabolic outcomes such as insulin resistance, diabetes, hypertension, and elevated triglycerides, whereas individuals with lower-body obesity tend to have lower levels of these adverse metabolic outcomes.[124]

Upper-body SC fat is a novel, easily measured fat depot, which may be an important predictor of cardiometabolic risk. This fat depot may lead to a better understanding of the differential effects of adiposity in men and women.

Different body morphologies or types of fat distribution are related to the health risks associated with obesity. This was first shown by Jean Vague who himself used a neck skin fold in his index of masculine differentiation to assess upper-body fat distribution.[125] Neck circumference (NC), a measure of upper body obesity has been proposed as a useful indicator in different studies in the past.[20,22,23] These studies have shown that men with NC < 37 cm and women with NC < 34 cm have a low body mass index.[22]

NC measurement potentially has distinct cultural advantages. Due to cultural inhibitions measurement of hip, thigh or waist circumference is

cumbersome in females. The specific research questions for this study are that among in-patients in medical wards, aged 35 years or more a) does a higher neck circumference also reflects a higher BMI or waist circumference; b) do those who are in highest tertile of neck circumference, as compared to those with in lowest tertile, have a higher prevalence of cardiovascular risk factors like hypertension and diabetes.[121]

Some studies[20,22,23] have indicated that neck circumference may be an independent correlate of metabolic risk factors above and beyond BMI and waist circumference. In addition, a small study of men demonstrated that higher levels of upper-body SC fat, as measured by magnetic resonance imaging, were associated with higher LDL and HDL cholesterol levels. However, studies examining the joint impact of neck circumference and VAT have not as yet been reported.[123]

Several previous studies have examined the association between neck circumference and cardiometabolic risk factors. However, none of these previous studies have compared neck circumference directly with VAT with respect to their association with cardiometabolic risk factors.[123]

In a first cross sectional study[22] in 2001 which was done to identify overweight or obese patients solely by measuring the circumference of the neck, it was seen that Men with NC <37 cm and women with NC <34 cm are not to be considered overweight. In this study they used a test sample and a second validation sample included 979 subjects (460 men and 519 women), who visited a family medicine clinic in a southern Israeli urban district for any reason. They

observed that NC >37 cm for men and >34 cm for women were the best cutoff levels for determining the subjects with BMI >25.0 kg/m2 using the receiver output curve analysis. In the validation unrelated group, the test characteristics were excellent with 98% sensitivity, 89% specificity, and 94% accuracy for men, and 100% sensitivity, 98% specificity, and 99% accuracy for women. In this study they also observed same characteristics as NC 38 cm for men and 34.7 cm for women identified subjects with BMI >25.0 kg/m2 with 75% to 86% sensitivity for men and 63% to 93% for women, 80% to 90% specificity for men and 80% to 100% for women.

The author[126] once again in 2004 observed relationship between changes in neck circumference and changes in blood pressure. In this longitudinal cohort study the study group was comprised of 364 subjects (155 men and 209 women) with no known major medical conditions who were not receiving any medication therapy. They found that changes in systolic BP and diastolic BP correlated positively with changes in NC and other components of the metabolic syndrome.

In a cross-sectional study of 43,595 women participating in the Take Off Pounds Sensibly (TOPS) Club, those with a self-reported neck circumference in the top tertile were found to have a 2-fold increased risk of diabetes relative to those in the bottom tertile, even after adjustment for multiple other measures of adiposity.[127]

In a cross-sectional analysis of 541 Finnish individuals, neck circumference in the highest quintile was associated with nearly a 5-fold

increased risk of impaired fasting glucose in women after adjustment for BMI.[128] No association was seen for men.

Additionally, neck circumference was associated with approximately a 3-fold increased OR of hypertension, after adjustment for BMI, in both men and women. Although neck circumference is a proxy measure for upper-body SC fat, only one study has examined the association of upper-body SC fat as measured by MRI.[123]

Among 258 men from the control group of the Fat Redistribution and Metabolic Change in HIV Infection study, upper-body SC fat was shown to be independently associated with insulin resistance even after adjustment for VAT.[129]

Additional analyses of 145 control participants from the Fat Redistribution and Metabolic study showed that increased levels of upper-body SC fat were positively associated with LDL cholesterol and inversely associated with HDL cholesterol levels, after adjustment for demographic and lifestyle factors.[130]

One interesting finding from a study was a greater association of neck circumference with cardiometabolic risk factors in women compared with men. This differential effect of neck circumference by sex has previously been observed.[23]

Previous analyses in the Framingham Heart Study have also shown that fat depots, especially VAT, are more strongly associated with an adverse risk factor profile in women compared with men.[122]

The mechanisms by which there is a stronger adverse effect associated with increased body fat in women are unknown. However, it has been suggested that in women, there is a greater proportion of free fatty acid delivery to the liver from VAT than in men.[123]

Obesity and elevated levels of plasma free fatty acids are associated with insulin resistance and increased very-low-density lipoprotein triglyceride production. Increased levels of free fatty acids have also been correlated with markers of oxidative stress and vascular injury and are associated with the development of hypertension. Much of the literature has focused on the adverse effects of visceral fat; however, whereas visceral fat may be a marker for excess free fatty acids, it is not the primary source of circulating levels. It has been demonstrated that upper-body SC fat is responsible for a much larger proportion of systemic free fatty acid release than visceral fat, particularly in obese individuals.[123]

Obese men and women have a 2- to 3-fold larger fraction of fatty acids stored in SC fat compared with normal-weight men and women.[123] The excess free fatty acid release associated with upper-body SC fat may be one mechanism to explain the association between neck circumference and cardiometabolic risk. Although free fatty acid release from upper-body SC fat is the primary contributor of abnormal free fatty acid metabolism in obese individuals, lipolysis

of VAT is also an important contributor to hepatic free fatty acid delivery, which may explain why there is an interaction between neck circumference and VAT.[123]

Differences in free fatty acid metabolism between men and women may explain the sex differences observed in the relationship between neck circumference and cardiometabolic risk factors. It has been shown that women store a much larger proportion of free fatty acids in SC tissue than do men.[123]

This difference in free fatty acid storage between men and women may account for the stronger association found between neck circumference and cardiometabolic risk factors among women.[123]

A study[121] from India hypothesized that NC (primary outcome measure) could be a predictor of obesity and overweight in rural Indian population and that higher tertile of neck circumference may be associated with higher prevalence of cardiovascular risk factors like hypertension and diabetes (secondary outcome measure). After adjustment for age, weight and height, significant association was found between NC and conventional overweight and obesity indexes. Authors also found that higher tertile of NC correlated positively with the presence of cardiovascular risk factors like hypertension and diabetes. A study concluded that, NC may be used as a simple and time-saving screening measure to identify overweight and obese patients. Men with NC <36.6 cm and women with NC <32.1 cm are not to be considered overweight. Patients with NC >36.6 cm for men and >32.1 cm for women require additional evaluation of overweight or obesity status.

In a study[121] from India significant negative correlation was found between NC and height among women, but not in men. This finding can be explained by differences in bodily structures between men and women especially in rural area of India. It seems, therefore, that with an increase in NC, the likelihood of risk factors for cardiovascular disease also increases.

These observations indicate that NC as an index of upper body fat distribution can be used to identify overweight and obese patients. Results of these studies, performed by various set of investigators, have not been externally validated. In India study of neck circumference as a measure of obesity and metabolic syndrome has not been done. NC measurement potentially has distinct cultural advantages. Due to cultural inhibitions measurement of hip, thigh or waist circumference is cumbersome in females. In contrast measurement of NC is a simple, time saving, and least invasive measurement tool.

Chapter 4

Methodology

METHODOLOGY

The present study was conducted in the Department of Medicine, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum on patients with metabolic syndrome during the period of January 2011 to December 2011.

Study design

The study design was one year cross sectional study.

Study period and duration

The present one year study was conducted during the period of January 2011 to December 2011.

Method of collection of data

Source of Data

Patients admitted in the wards of Medicine Department or attending the Medicine OPD/executive health check-up schemes on Mondays, Wednesdays and Fridays at KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum were studied.

Sample size

Hundred (100) patients with metabolic syndrome were selected for the study.

Sampling procedure

The sample size was calculated based on the formula as mentioned below.

$n = 4 X p X q / d^2$

Where, p = Prevalence (The prevalence of metabolic syndrome in India is 45%).

q = 100 – p

d = Absolute error taken as 10%

Therefore, $n = 4 X 45 X 55 / 10^2$

n = 99

Sampling method

Every third patient fulfilling the inclusion criteria will be included in the study.

Selection criteria

Inclusion Criteria

- Age above 18 years.
- Patients with metabolic syndrome based on National Cholesterol Education Program-ATP-III criteria

Exclusion Criteria

- Patients with spine deformities.
- Patients with neck swellings like goiter.
- Patients who have been diagnosed with turners syndrome.

- Patients who had undergone surgeries in neck.
- Patients with cervical lymphadenopathies and secondaries in the neck.
- Surgical emphysema in the neck.
- Cellulitis of neck

National Cholesterol Education Program-ATP-III criteria for metabolic syndrome[13]

Three or more of the following:

- Abdominal obesity (waist circumference >102 cm in men, >88 cm in women).
- Triglycerides ≥ 150 mg/dL.
- HDL-cholesterol < 40 mg/dL in men, < 50 mg/dL in women.
- Systolic blood pressure ≥130 mmHg and/or diastolic blood pressure ≥85 mm Hg.
- Fasting plasma glucose ≥ 110 mg/dL.

Ethical clearance

The study was approved by the Institutional Ethics Committee of Jawaharlal Nehru Medical College, Belgaum.

Informed consent

Patients admitted in the wards of Medicine Department or attending the Medicine OPD/executive health check-up schemes on Mondays, Wednesdays and Fridays at KLES Dr. Prabhakar Kore Hospital and Medical Research Centre,

Belgaum were evaluated based on selection criteria. The selected patients were briefed about the nature of the study and a written informed consent was obtained (Annexure–I).

Data collection

Demographic data like gender and age were collected along with relevant history and recorded on predesigned and pretested proforma (Annexure-II). A thorough clinical examination was conducted and the findings were also recorded.

Body mass index was calculated based on formula;

$$\text{Body Mass Index} = \frac{\text{Weight (Kg)}}{\text{Height}^2 \text{ (m)}}$$

Body mass index in the range of less than 18.5 kg/m^2 were considered as underweight, 18.5 to 24.9 kg/m^2 were considered as normal, 25.0 to 29.9 kg/m^2 were considered as overweight and more than 30 kg/m^2 were considered as obese.[131-133]

The waist circumference was measured using a standard measuring tape in cms. Waist circumference of > 102 cms in males and > 88 cms in females was considered abnormal.

Neck circumference was measured to the nearest 0.1 centimeter just below the laryngeal prominence (Adam's apple) perpendicular to the long axis of neck in both sexes with the subjects standing upright, with shoulders relaxed

using flexible measuring tapes. Neck circumference of ≥ 37 cms in males and ≥ 34 cms in females was considered abnormal.

Blood pressure was recorded in the sitting position after five minutes of rest using standard mercury manometer. Three readings were taken at an interval of one minute and mean BP was calculated.

Fasting blood samples were drawn for investigations such as FBS and lipid profile (total cholesterol, triglycerides, HDL and LDL)

Statistical analysis

The data obtained was tabulated on Microsoft Excel spreadsheet. Categorical data was expressed as rates, ratios and percentages. Fisher exact test was used to assess the level of significance between NC and components of metabolic syndrome. Continuous data was expressed as mean ± standard deviation (SD) and the comparison was done using student unpaired 't' test. Correlation coefficient (*r*) was used to assess the correlation between NC and components of metabolic syndrome. SPSS 18 trial version software was used for analysis. A probability value ('p' value) of less than or equal to 0.050 was considered as statistically significant.

Chapter 5

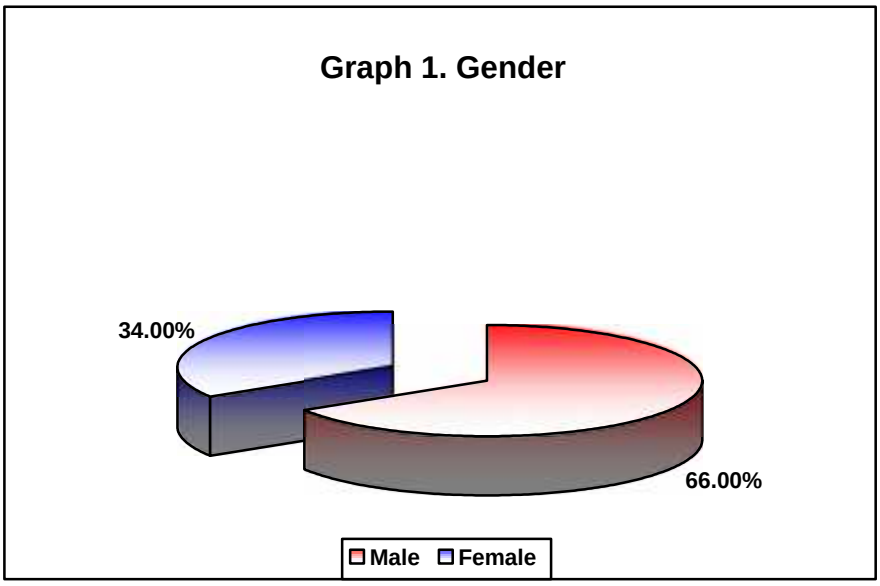
Results

RESULTS

The present study was conducted in the Department of Medicine, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum during the study period from January 2011 to December 2011. Hundred (100) cases of metabolic syndrome (based on NCEP ATP III criteria) were studied and the findings obtained are tabulated as below.

Table 1. Gender

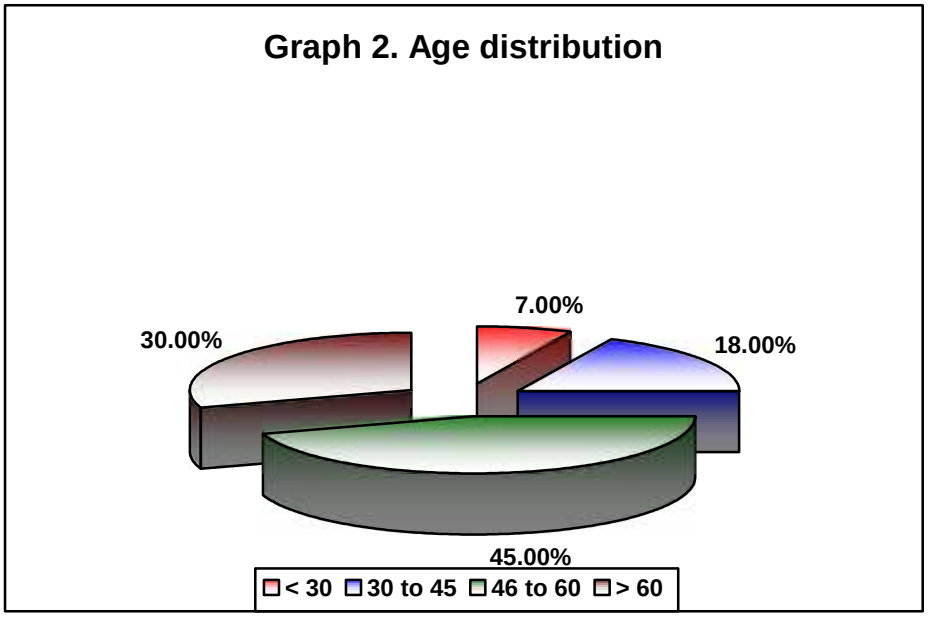
Gender	Distribution (n=100)	
	Number	Percentage
Male	66	66.00
Female	34	34.00
Total	**100**	**100.00**



In the present study, males accounted for 66 % (n=66), whereas females accounted for 34% (n=34).

Table 2. Age distribution

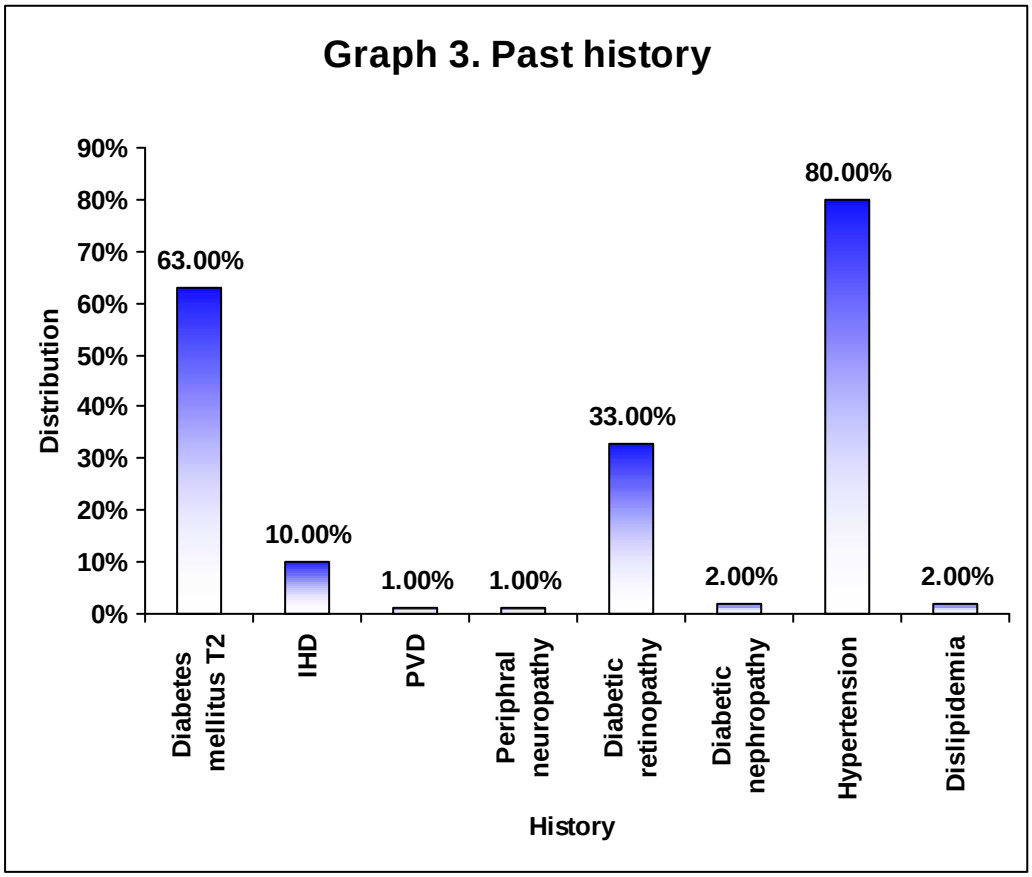
Age group (Years)	Distribution (n=100)	
	Number	**Percentage**
< 30	7	7.00
30 to 45	18	18.00
46 to 60	45	45.00
> 60	30	30.00
Total	**100**	**100.00**



The above table, shows the distribution of subjects according to age. Majority of the subjects were between 46 to 60 years accounting for 45% (n=45), with 30 subjects in the age group > 60. 18 subjects were in the group 30 to 45. Only a small number were below 30 years. Overall, the mean age for the study population was 54.46 ± 14.93 years.

Table 3. Past history

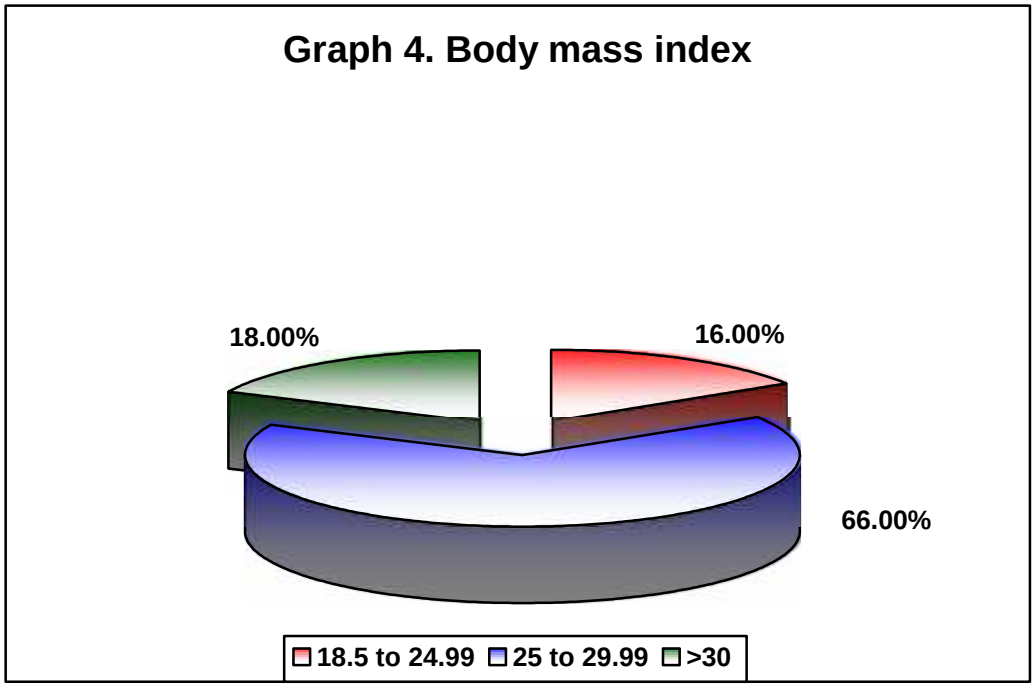
History	Distribution (n=100)	
	Number	Percentage
Diabetes mellitus T2	63	63.00
IHD	10	10.00
PVD	1	1.00
Peripheral neuropathy	1	1.00
Diabetic retinopathy	33	33.00
Diabetic nephropathy	2	2.00
Hypertension	80	80.00
Dislipidemia	2	2.00



Past history was taken regarding diabetes, hypertension, dyslipidemia and complications like cerebrovascular accidents, ischaemic heart disease, peripheral vascular disease, peripheral neuropathy, diabetic retinopathy and diabetic nephropathy. Diabetes accounted for 63 subjects (63%); whereas 80% (n=80) were hypertensive. Three patients reported a history of cerebrovascular accident and 10 had a significant past history suggestive of ischaemic heart disease. Of the 63 diabetic patients, 33 of them had diabetic retinopathy and only 2 had diabetic nephropathy. History suggestive of peripheral vascular disease and peripheral neuropathy was found in one patient each.

Table 4. Body Mass Index

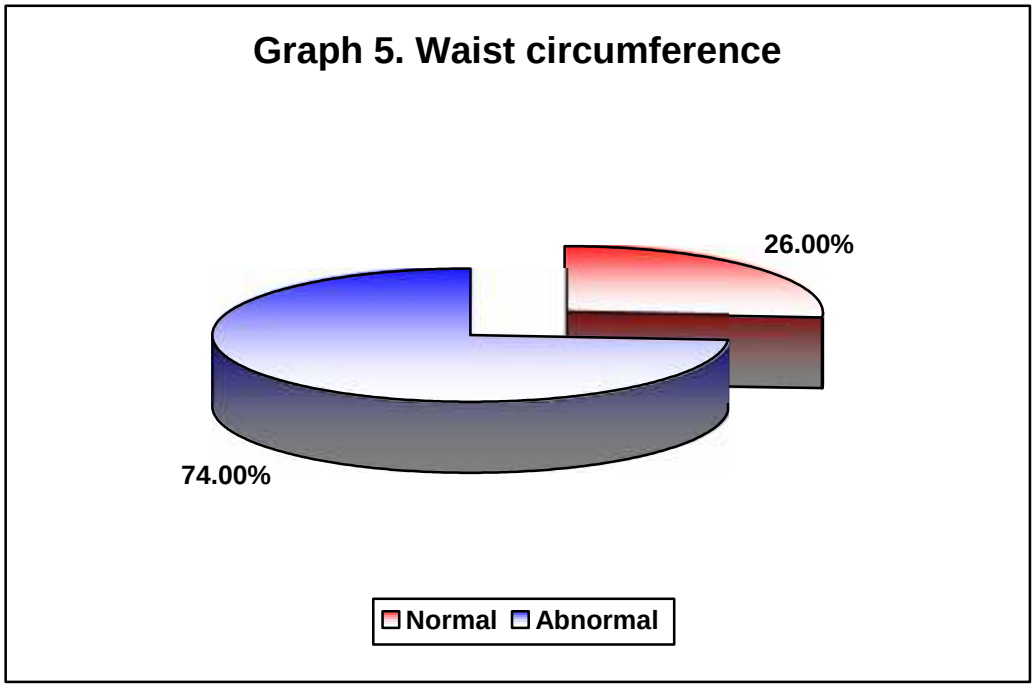
Body mass index (Kg/m2)	Distribution (n=100)	
	Number	Percentage
18.5 - 24.99	16	16.00
25 - 29.99	66	66.00
> 30	18	18.00
Total	**100**	**100.00**



In the present study, 66 subjects were in the pre-obese group with a BMI between 25 to 29.99 kg/m^2 and 18 patients were obese with a BMI of > 30 kg/m^2. 16 patients had a normal BMI between 18.5-24.99 kg/m^2. The mean BMI of the study population was 27.8 ± 2.99 Kg/m^2.

Table 5. Waist circumference

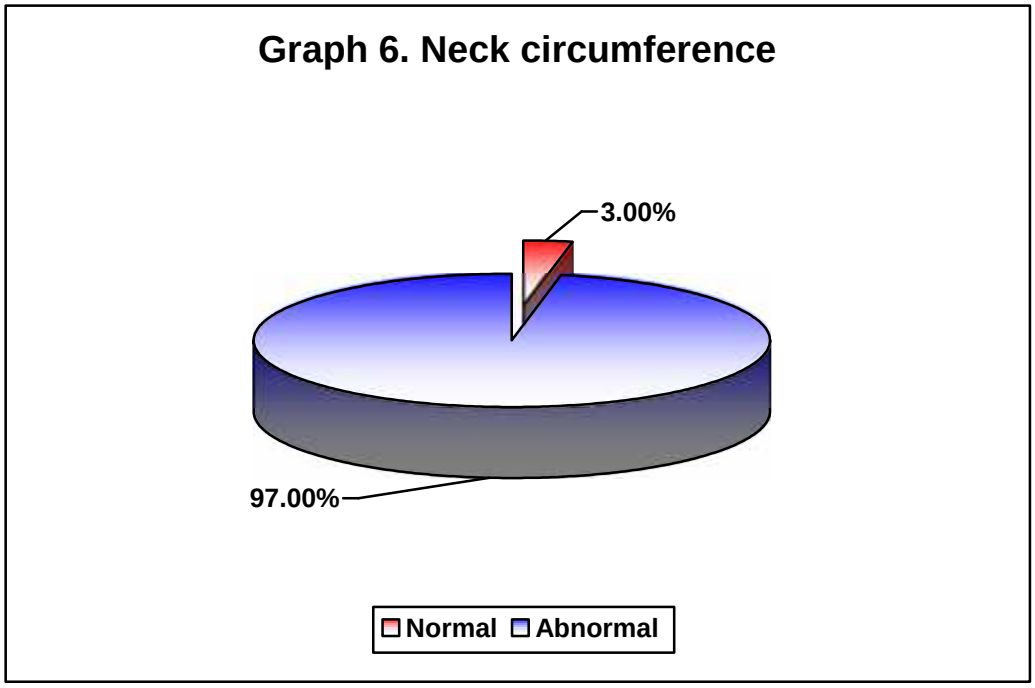
Waist circumference	Distribution (n=100)	
	Number	**Percentage**
Normal	26	26.00
Abnormal	74	74.00
Total	**100**	**100.00**



In accordance with the NCEP-ATP III criteria, waist circumference of >102 cms in males and > 88 cms in females was regarded as abnormal. 74 (74%) patients had abnormal waist circumference whereas in 26 (26%) patients waist circumference was within the normal range. The mean waist circumference for the study population was found to be 97.9 ± 7.44 cms. Males had a mean waist circumference of 101.30 ± 6.18 cms and females had a mean waist circumference of 91.18 ± 4.60 cms.

Table 6. Neck circumference

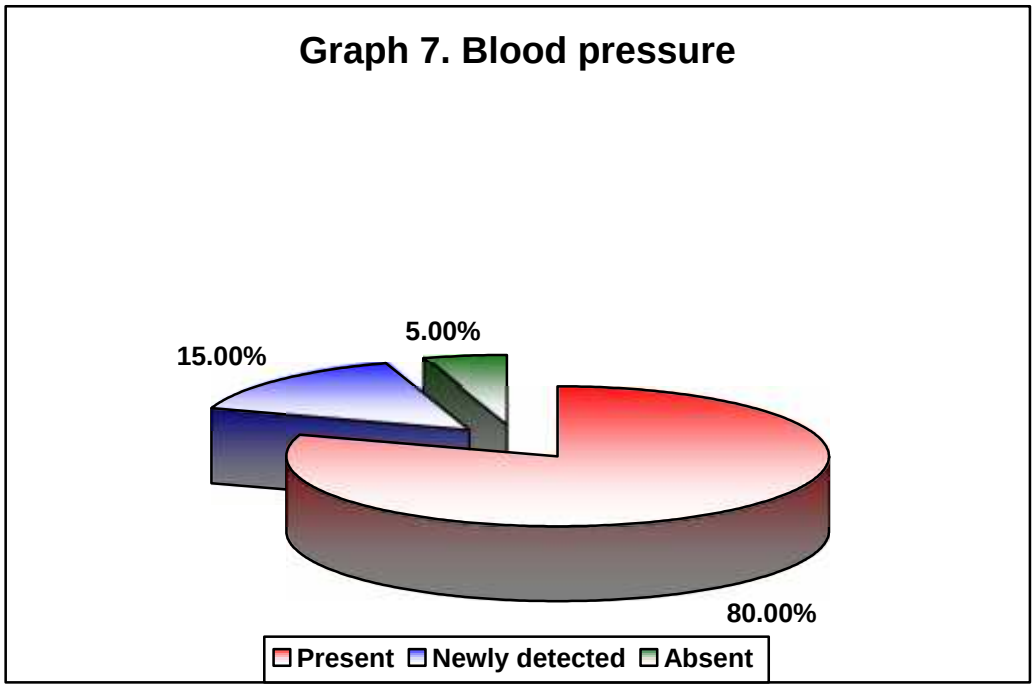
Neck circumference	Distribution (n=100)	
	Number	**Percentage**
Normal	3	3.00
Abnormal	97	97.00
Total	**100**	**100.00**



Neck circumference of ≥ 37 cms in males and ≥ 34 cms in females was considered abnormal. In the present study 97 subjects had abnormal neck circumference. The mean neck circumference was 38.93 ± 1.95 cms. The mean neck circumference in males was 39.83 ± 1.68 cms. The mean neck circumference in females was 37.17 ± 1.00 cms.

Table 7. Blood pressure

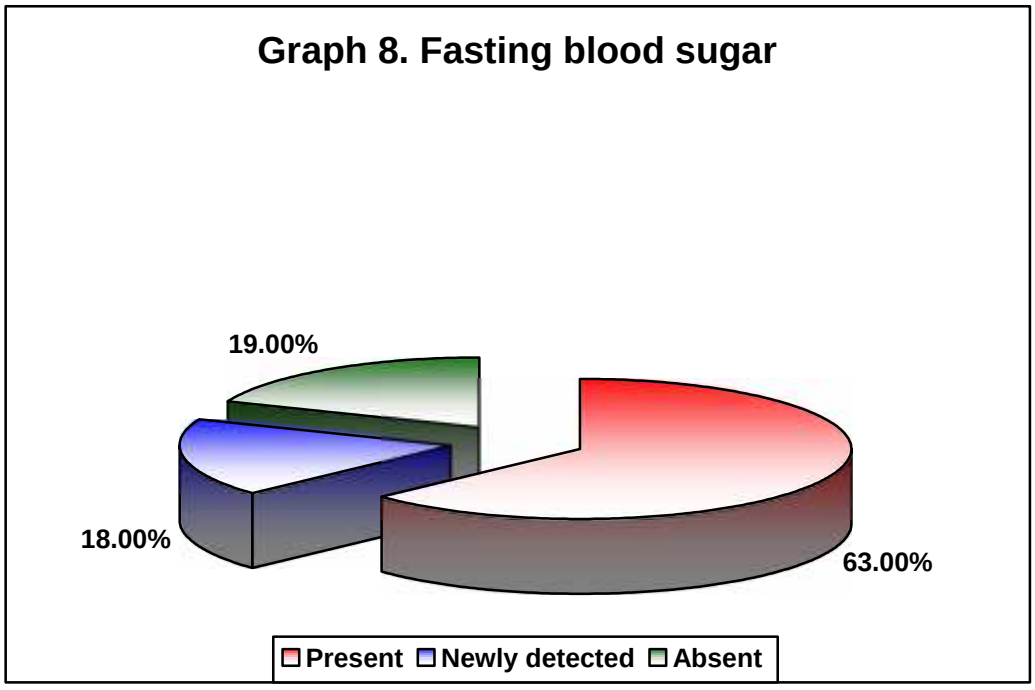
Hypertension	Distribution (n=100)	
	Mean	**SD**
Present (Presented with HTN)	80	80.00
Newly detected	15	15.00
Absent	5	5.00
Total	**100**	**20.00**



80% of the patients were known hypertensive, 15% were newly detected, 5% of the patients were with normal blood pressure.

Table 8. Fasting blood sugar

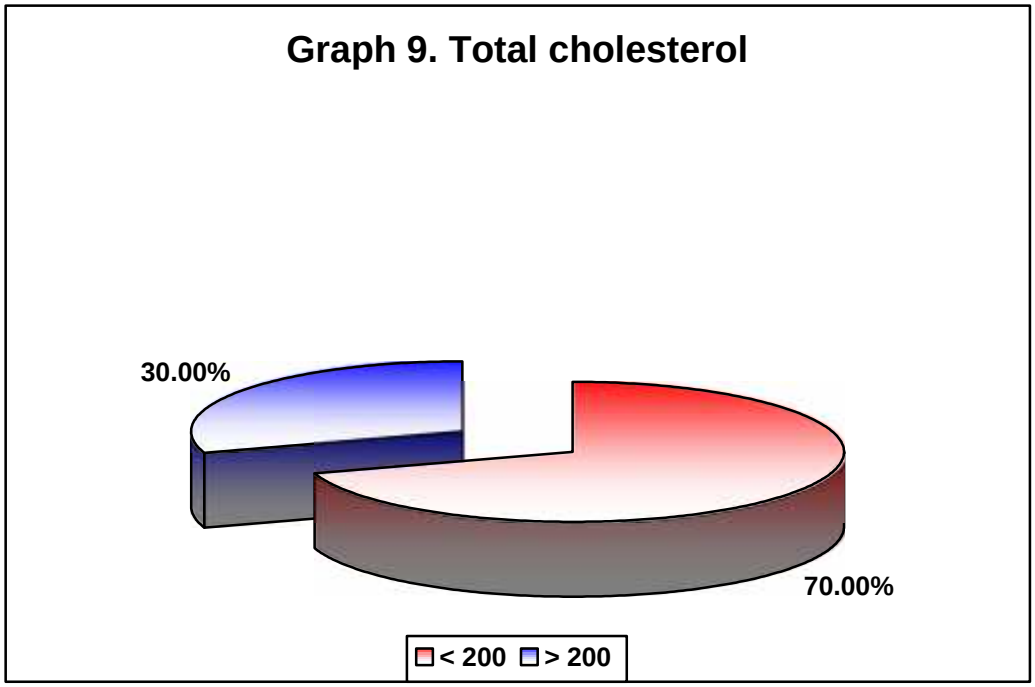
Fasting blood sugar (mg/dL)	Distribution (n=100)	
	Number	**Percentage**
Present (Presented with DM)	63	63.00
Newly detected	18	18.00
Absent	19	19.00
Total	**100**	**37.00**



63% of the patients were known diabetic, 18% of patients had abnormal FBS, 19% had normal FBS.

Table 9. Total cholesterol

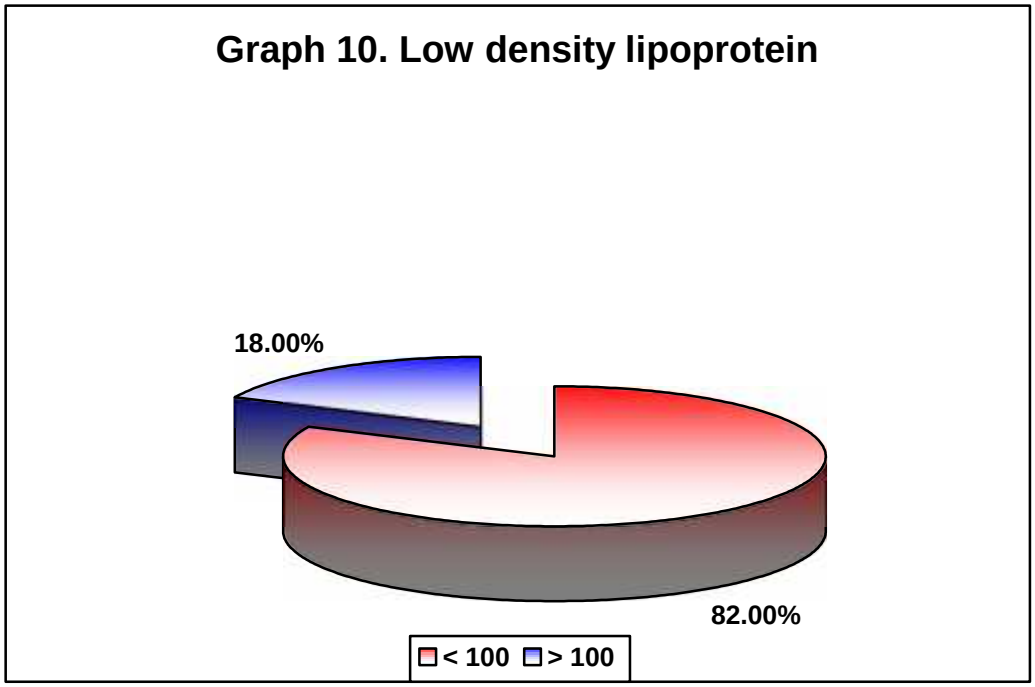
Total cholesterol levels (mg/dL)	Distribution (n=100)	
	Number	Percentage
< 200	70	70.00
> 200	30	30.00
Total	**100**	**100.00**



30% of the patients had a total cholesterol level of > 200 mg/dl and in 70% it was <200 mg/dl.

Table 10. Low density lipoprotein (LDL)

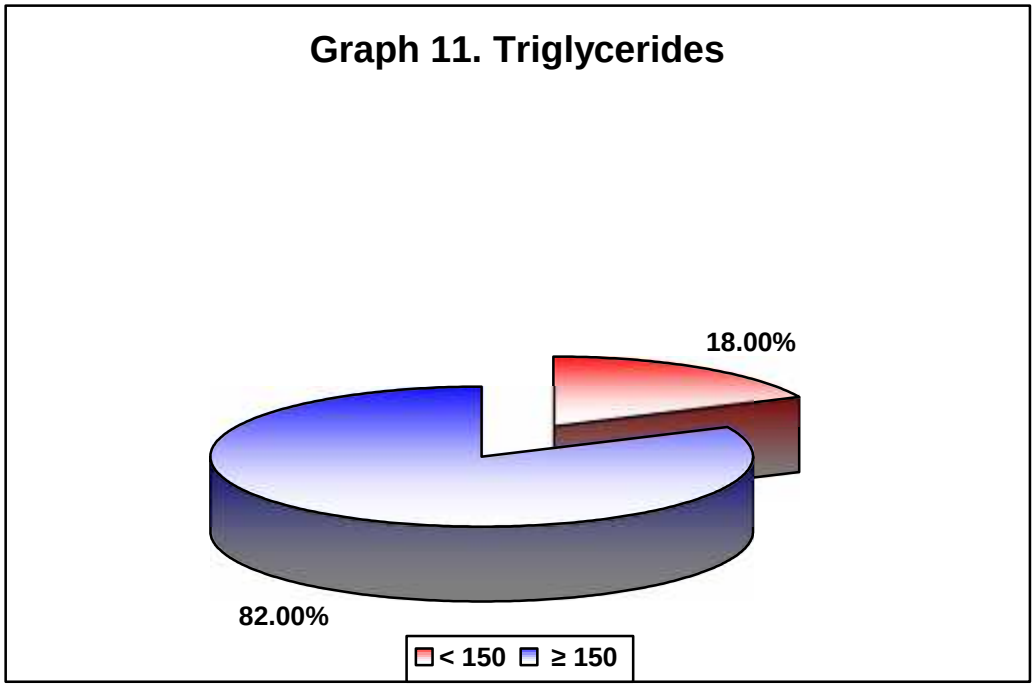
Low density lipoprotein (mg/dL)	Distribution (n=100)	
	Number	Percentage
< 100	82	82.00
> 100	18	18.00
Total	**100**	**100.00**



In majority of patients (82%) LDL was below 100mg/dl and in only 18% it was >100 mg/dl.

Table 11. Triglycerides

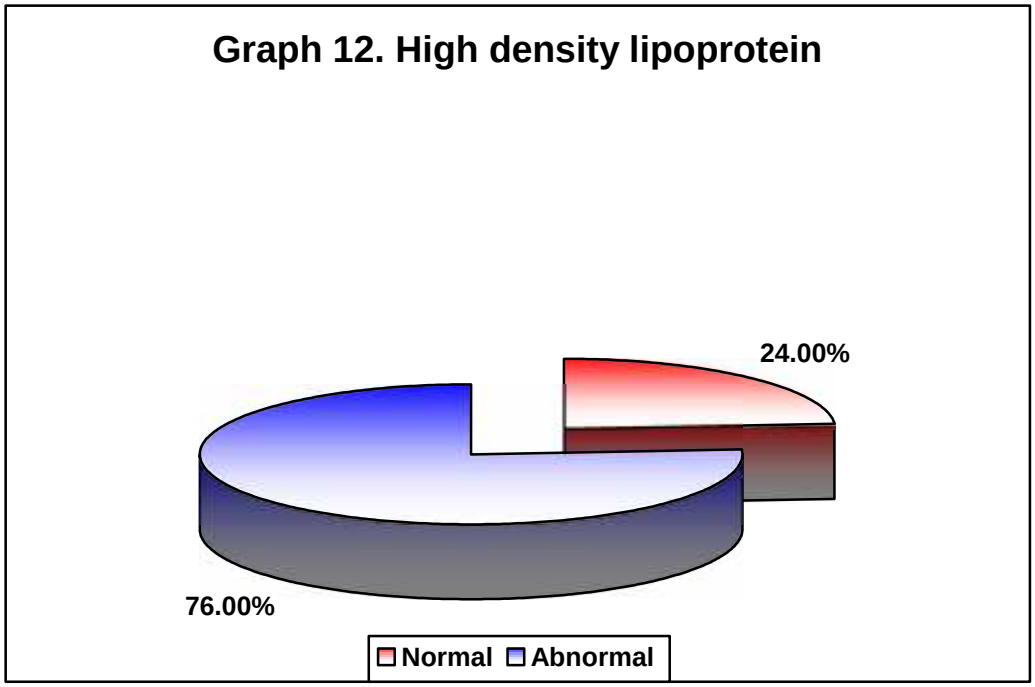
Triglyceride levels (mg/dL)	Distribution (n=100)	
	Number	**Percentage**
< 150	18	18.00
≥ 150	82	82.00
Total	**100**	**100.00**



Majority of patients (82%) had abnormal triglycerides levels. 18% had normal triglyceride levels.

Table 12. High density lipoprotein (HDL)

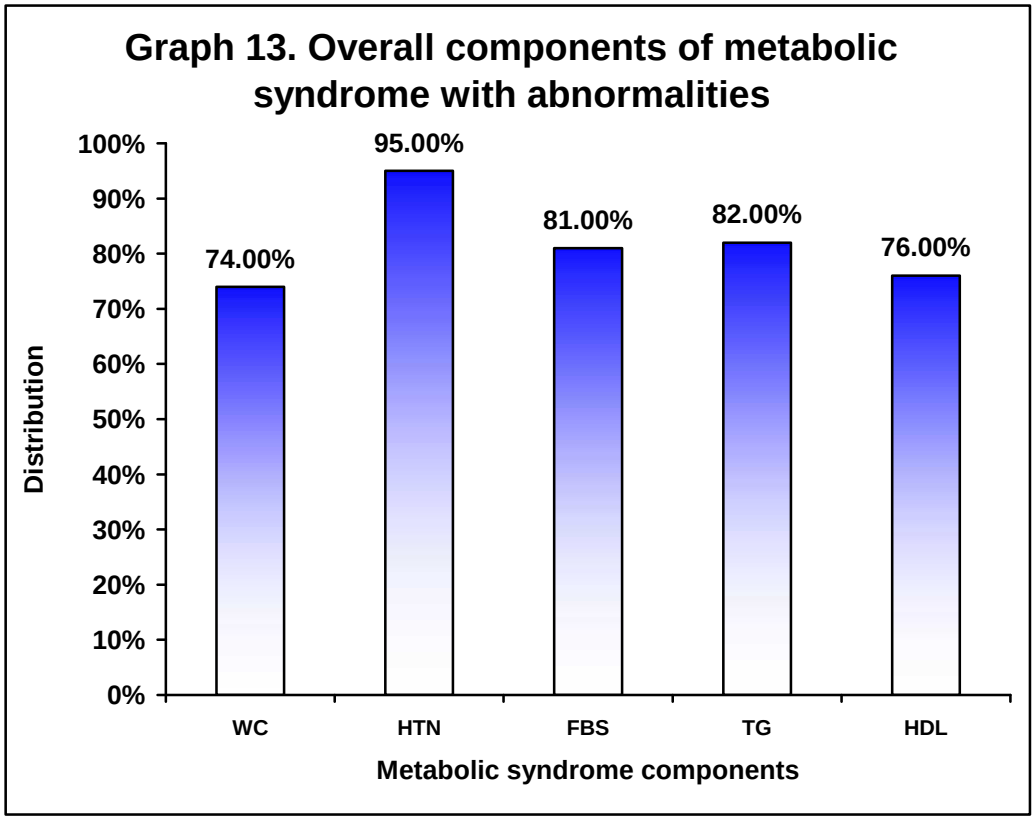
HDL Levels (mg/dL)	Distribution (n=100)	
	Number	**Percentage**
Normal	24	24.00
Abnormal	76	76.00
Total	**100**	**100.00**



In this study, 76% of the patients had abnormal and 24% had normal HDL.

Table 13. Overall components of metabolic syndrome with abnormalities

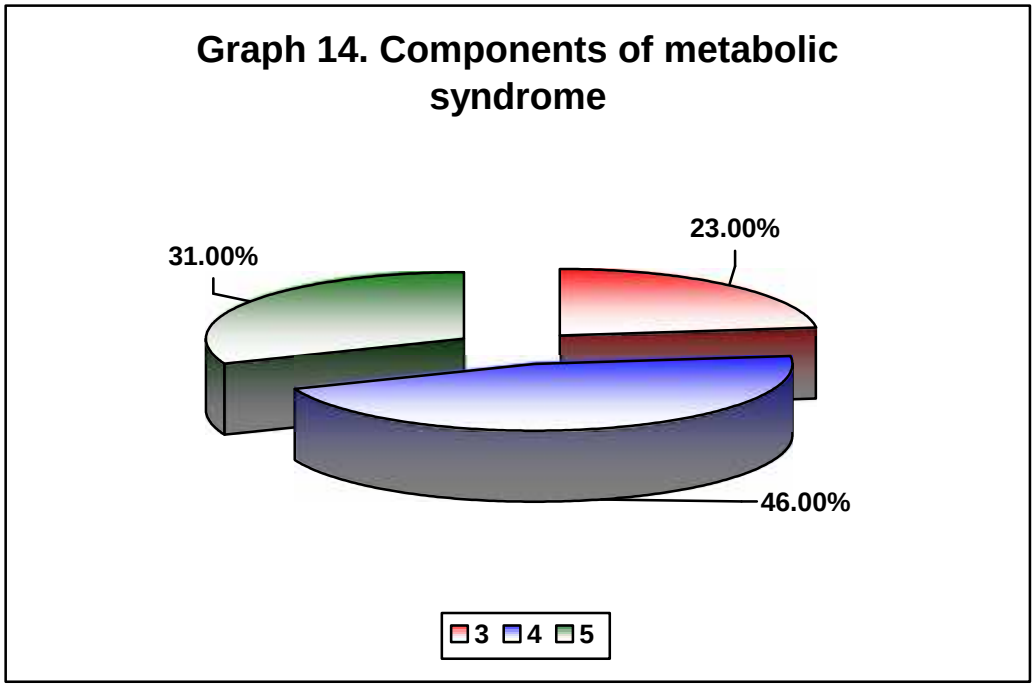
Metabolic syndrome components	Distribution (n=100)	
	Number	Percentage
Waist circumference	74	74.00
Hypertension	95	95.00
Fasting blood sugar	81	81.00
Triglycerides	82	82.00
HDL	76	76.00



The commonest component of metabolic syndrome was hypertension 95%, followed by hypertriglyceridemia 82%, elevated fasting blood sugar 81%, low HDL 76% and abnormal waist circumference 74%.

Table 14. Components of metabolic syndrome

Components	Distribution (n=100)	
	Number	**Percentage**
3	23	23.00
4	46	46.00
5	31	31.00
Total	**100**	**100.00**

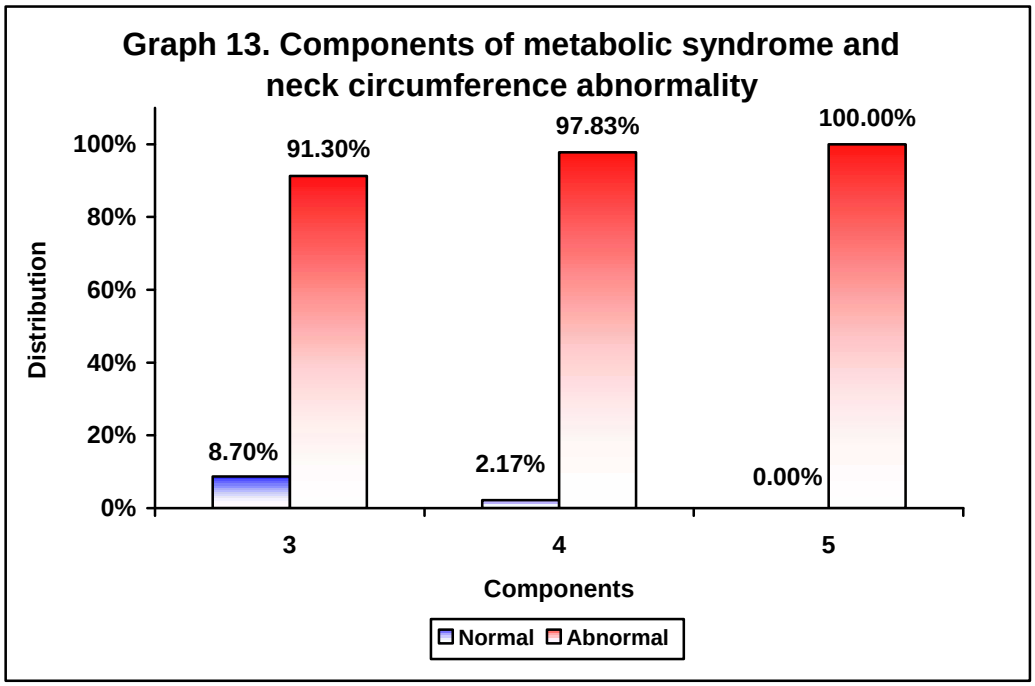


In the present study 46% patients had metabolic syndrome with four components and 31% had five components. However 23% of the patients were noted with three components of metabolic syndrome.

Table 15. Components of metabolic syndrome and neck circumference abnormality

Components	Neck circumference				Total (n=100)	
	Normal (n=3)		Abnormal (n=97)			
	No.	%	No.	%	No.	%
3	2	8.70	21	91.30	23	23.00
4	1	2.17	45	97.83	46	46.00
5	0	0.00	31	100.00	31	31.00

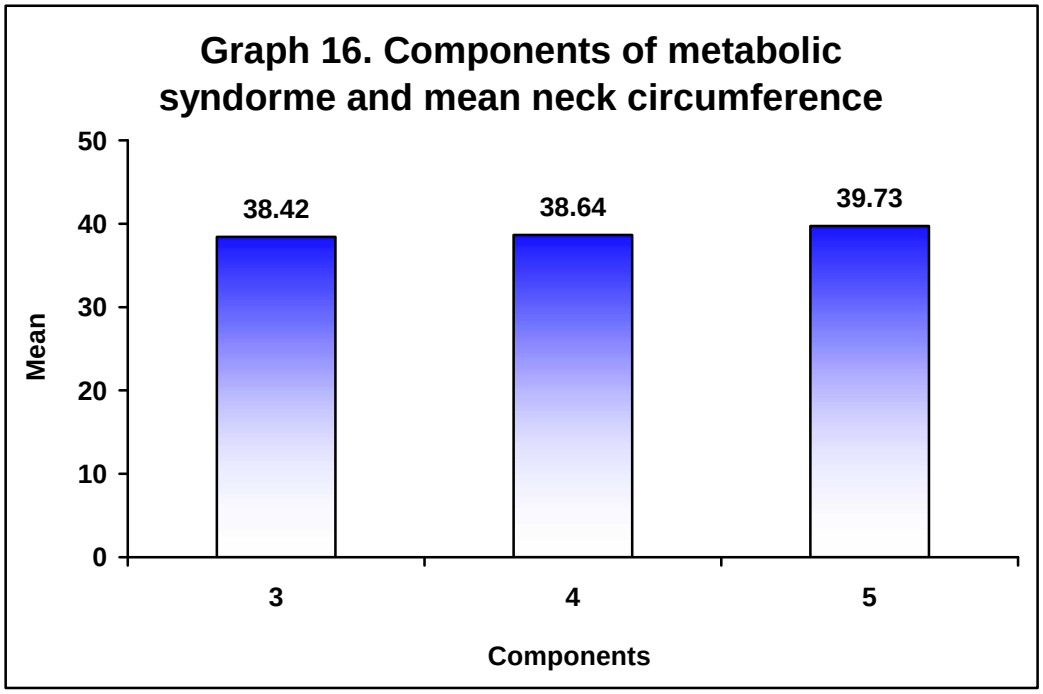
p= 0.083 (Fisher exact test)



In patients with 3 components of metabolic syndrome (n=23), abnormal NC was found in 21 patients (91.3%) whereas 2 patients (8.7%) had normal neck circumference. In patients with 4 components of metabolic syndrome (n=46), abnormal NC was found in 45 patients (97.83%) whereas one patient (2.17%) had normal neck circumference. All the patients with 5 components of metabolic syndrome (n=31), had abnormal NC.

Table 16. Components of metabolic syndrome and mean neck circumference

Components	Distribution (n=100)	
	Mean (cms)	SD
3	38.42	1.33
4	38.64	1.85
5	39.73	2.25

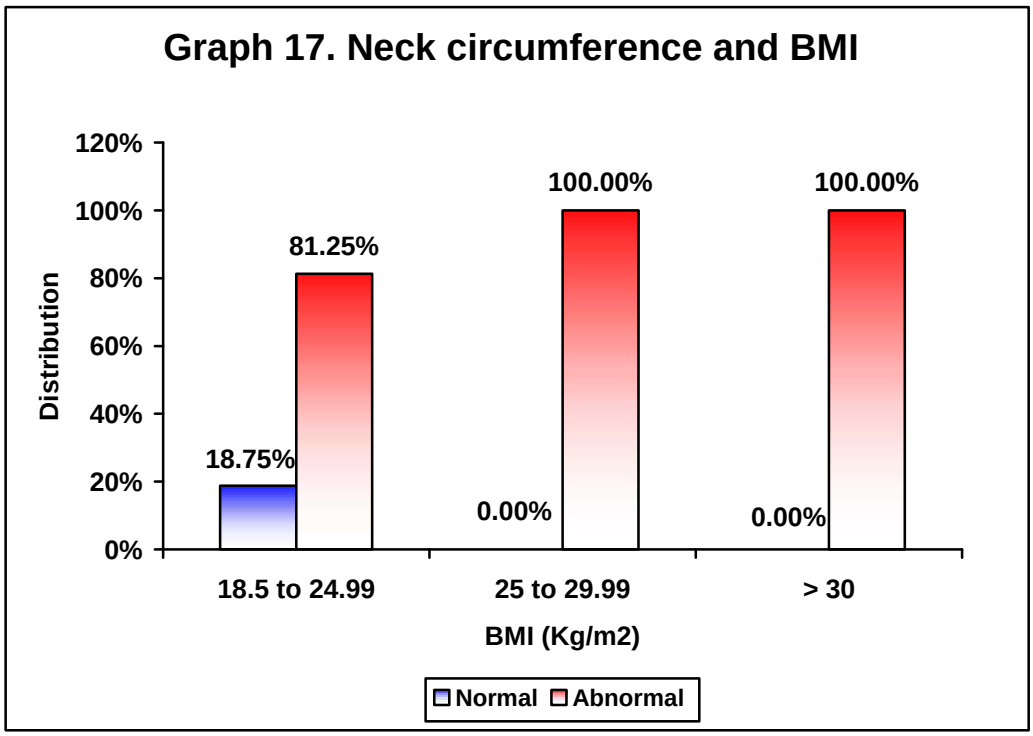


In patients with 3 components of metabolic syndrome, the mean NC was 38.42 ± 1.33 whereas in patients with 4 components of metabolic syndrome the mean NC was 38.64 ± 1.85. The mean NC was maximum in patients with 5 components of metabolic syndrome which was found to be 39.73 ± 2.25.

Table 17. Neck circumference and BMI

Body mass index (Kg/m2)	Neck circumference				Total (n=100)	
	Normal (n=3)		Abnormal (n=97)			
	No.	%	No.	%	No.	%
18.5 - 24.99	3	18.75	13	81.25	16	16.00
25 - 29.99	0	0.00	66	100.00	66	66.00
> 30	0	0.00	18	100.00	18	18.00

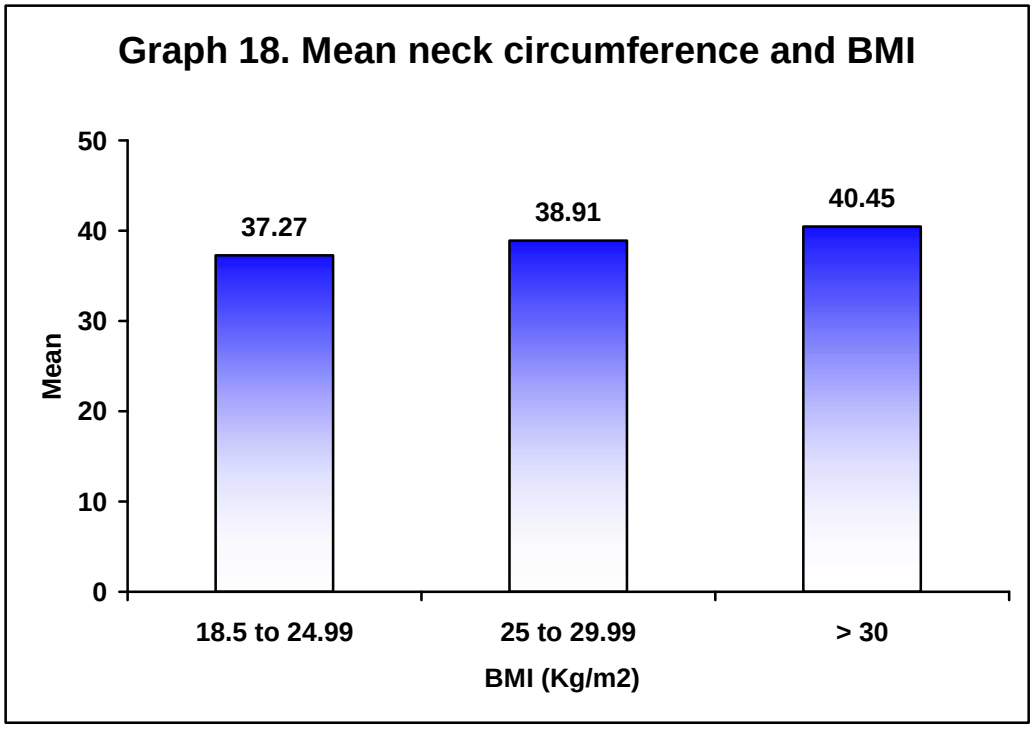
p= 0.003 (Fisher exact test)



In the present study the abnormal neck circumference was noted among all the (100%) ovrweight (BMI 25.00 to 29.99 Kg/m^2) and obese (BMI > 30.00 Kg/m^2) patients and this difference was statistically significant (p=0.003).

Table 18. Mean neck circumference and BMI

BMI (Kg/m2)	Distribution (n=100)	
	Mean (cms)	SD
18.5 - 24.99	37.27	1.98
25 - 29.99	38.91	1.53
> 30	40.45	2.15

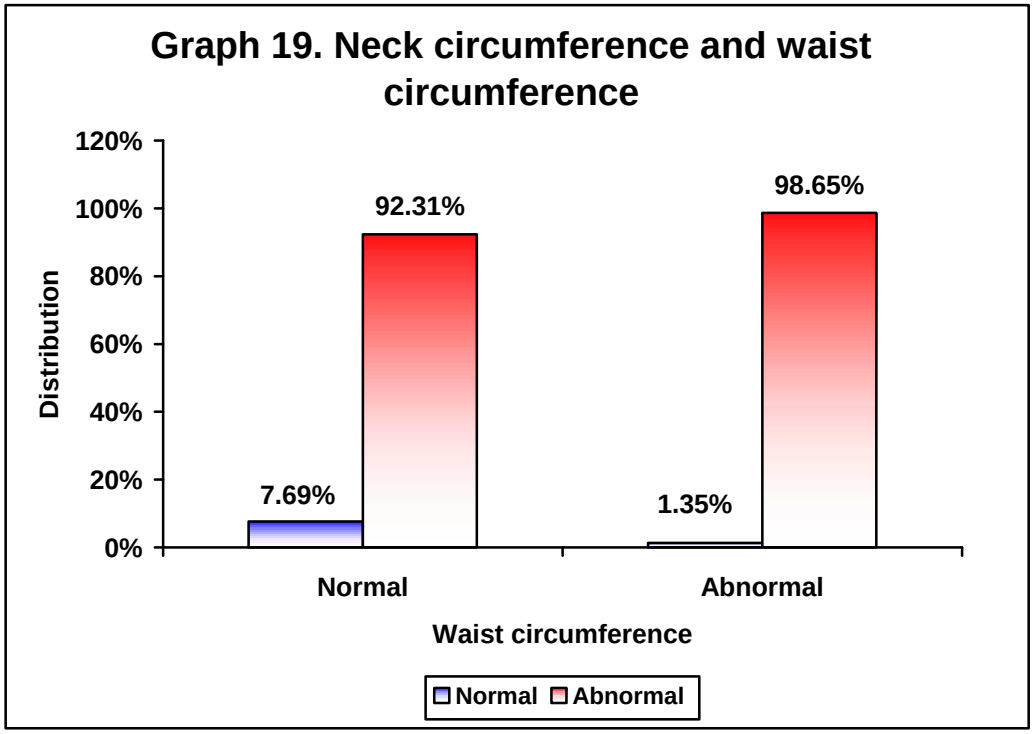


The mean neck circumference among normal, overweight and obese were in the increasing trend (37.27 ± 1.98, 38.91 ± 1.53 and 40.45 ± 2.15 respectively).

Table 19. Neck circumference and waist circumference

Waist circumference	Neck circumference				Total (n=100)	
	Normal (n=3)		Abnormal (n=97)			
	No.	%	No.	%	No.	%
Normal	2	7.69	24	92.31	26	26.00
Abnormal	1	1.35	73	98.65	74	74.00

p= 0.165 (Fisher exact test)

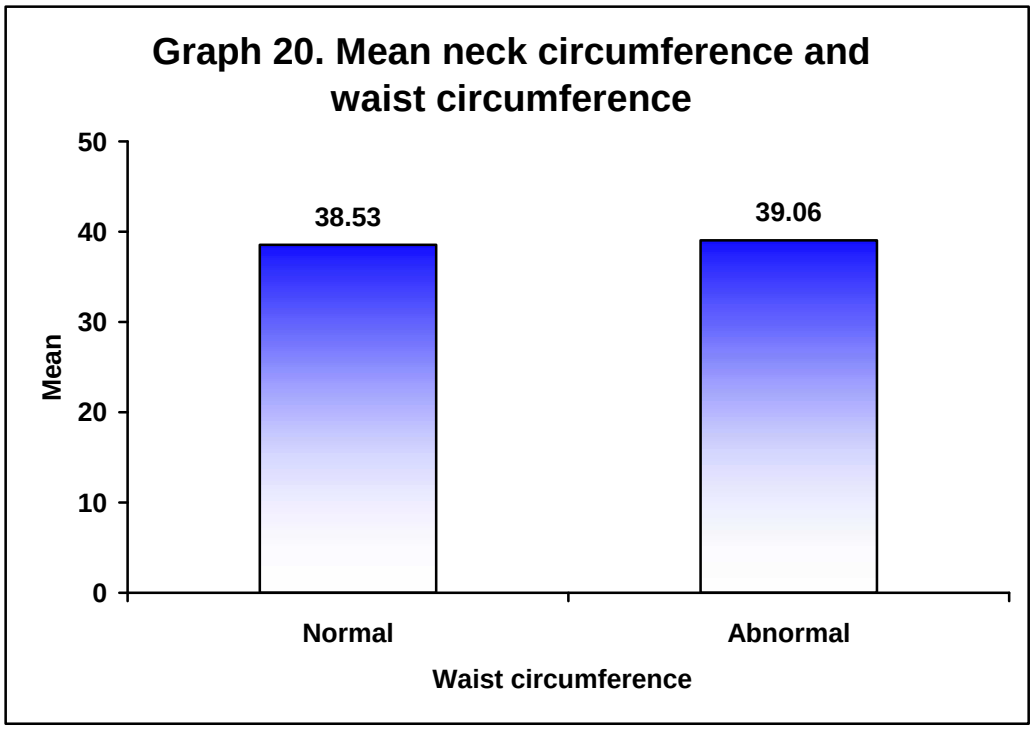


Of the 74 (74%) patients with abnormal waist circumference, NC was increased in 73 (98.65%) and was normal in 1 patient (1.35%).

Table 20. Mean neck circumference and waist circumference

Waist circumference	Distribution (n=100)	
	Mean (cms)	**SD**
Normal	38.53	1.37
Abnormal	39.06	2.10

t=0.014 **DF=98** **p=0.884**

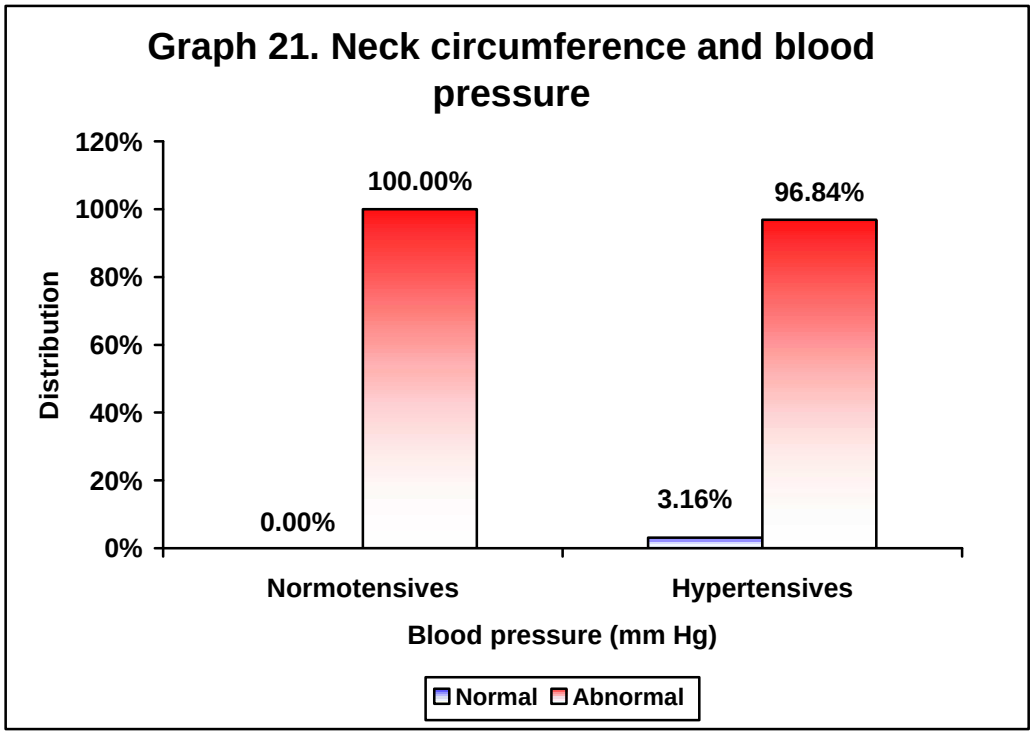


The mean NC in patients with normal and abnormal waist circumferences were 38.53 ± 1.37 and 39.06 ± 2.1 respectively which did not vary significantly.

Table 21. Neck circumference and blood pressure

Blood pressure (mm Hg)	Neck circumference				Total (n=100)	
	Normal (n=3)		Abnormal (n=97)			
	No.	%	No.	%	No.	%
Normotensives	0	0.00	5	100.00	5	5.00
Hypertensives	3	3.16	92	96.84	95	95.00

p= 1.000 (Fisher exact test)

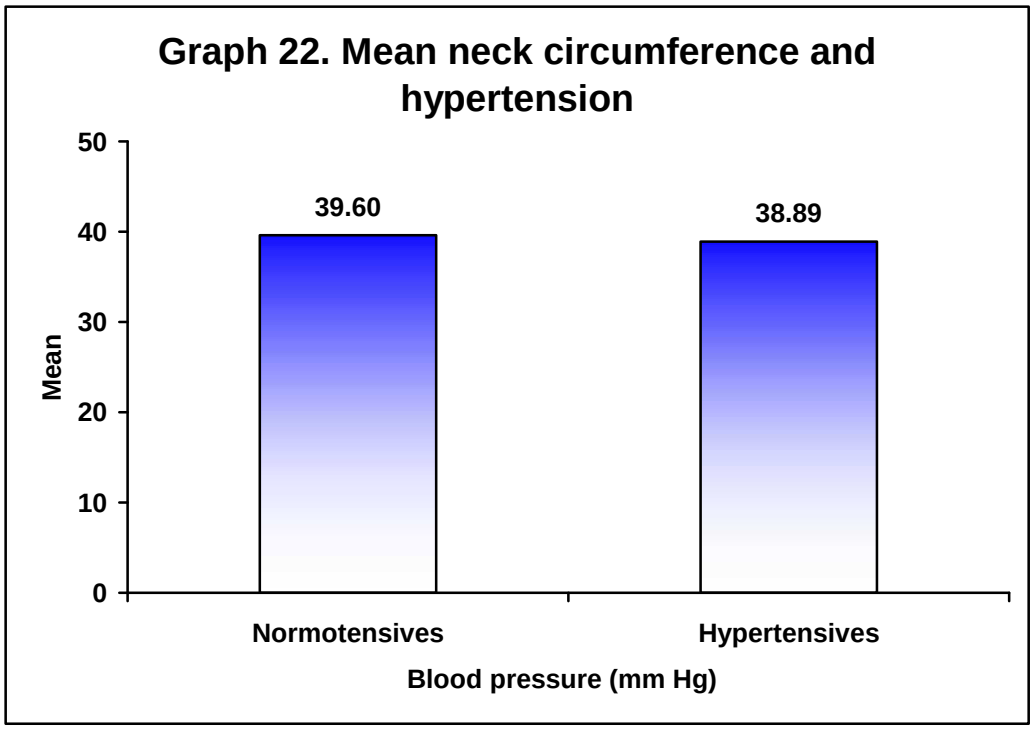


In patients with hypertension 95 (95%), NC was elevated in 92 (96.84 %).

Table 22. Mean neck circumference and hypertension

Blood pressure (mm Hg)	Distribution (n=100)	
	Mean (cms)	SD
Normotensives	39.60	1.18
Hypertensives	38.89	1.98

t=0.081 **DF=98** **p=0.934**

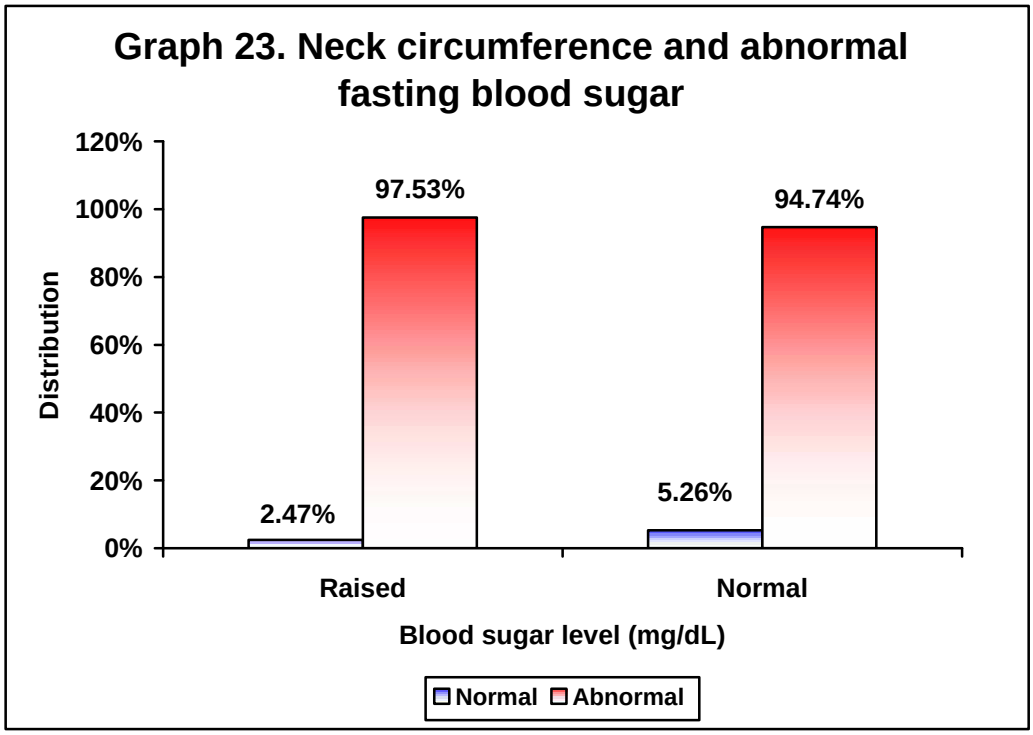


The mean NC in normotensives and hypertensives were 39.60 ±1.18 and 38.89 ± 1.98 respectively.

Table 23. Neck circumference and abnormal fasting blood sugar

Blood sugar level (mg/dL)	Neck circumference				Total (n=100)	
	Normal (n=3)		Abnormal (n=97)			
	No.	%	No.	%	No.	%
Raised	2	2.47	79	97.53	81	81.00
Normal	1	5.26	18	94.74	19	19.00

p= 0.472 (Fisher exact test)

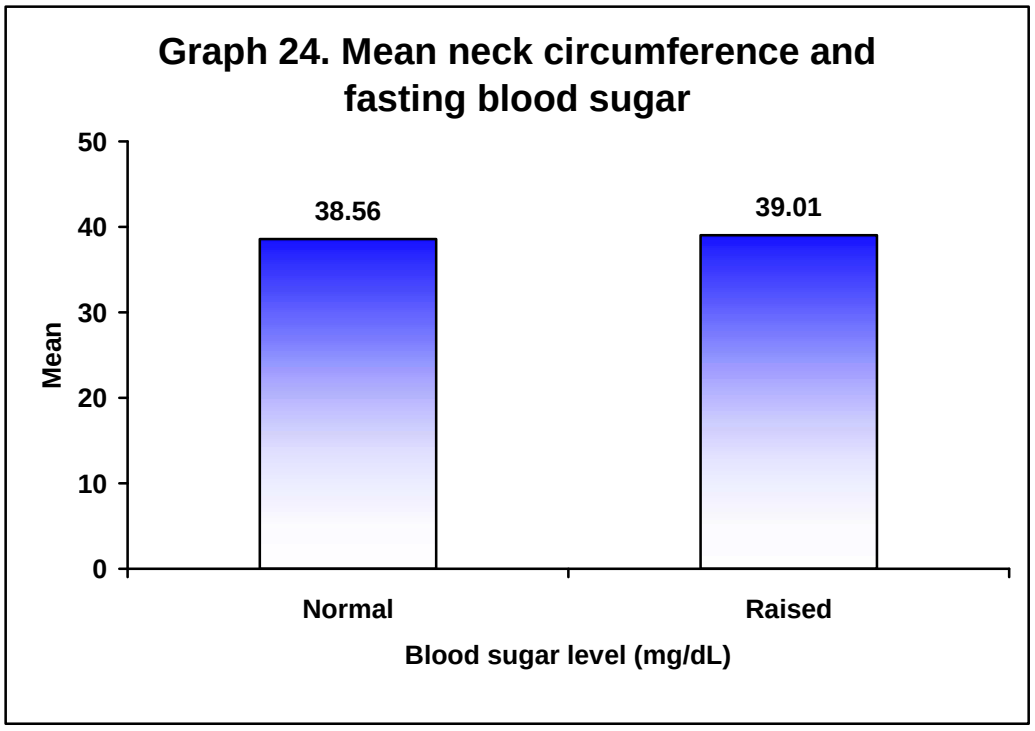


Of the 81 (81%) patients with abnormal FBS, 79 (97.53%) had elevated NC.

Table 24. Mean neck circumference and fasting blood sugar

Blood sugar level (mg/dL)	Distribution (n=100)	
	Mean (cms)	SD
Normal	38.56	1.89
Raised	39.01	1.96

t=0.111 **DF=98** **p=0.911**

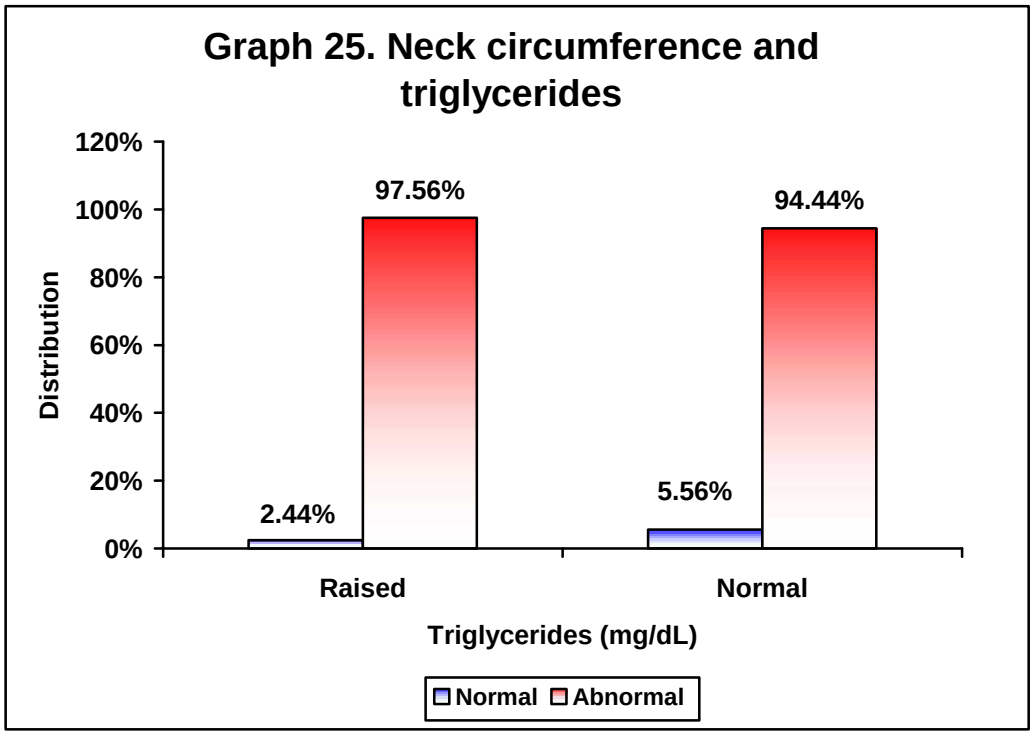


The mean NC in patients with normal and abnormal fasting blood sugars were 38.53 ± 1.89 and 39.01 ± 1.96 respectively.

Table 25. Neck circumference and triglycerides

Triglycerides (mg/dL)	Neck circumference				Total (n=100)	
	Normal (n=3)		Abnormal (n=97)			
	No.	%	No.	%	No.	%
Raised	2	2.44	80	97.56	82	82.00
Normal	1	5.56	17	94.44	18	18.00

p= 0.452 (Fisher exact test)

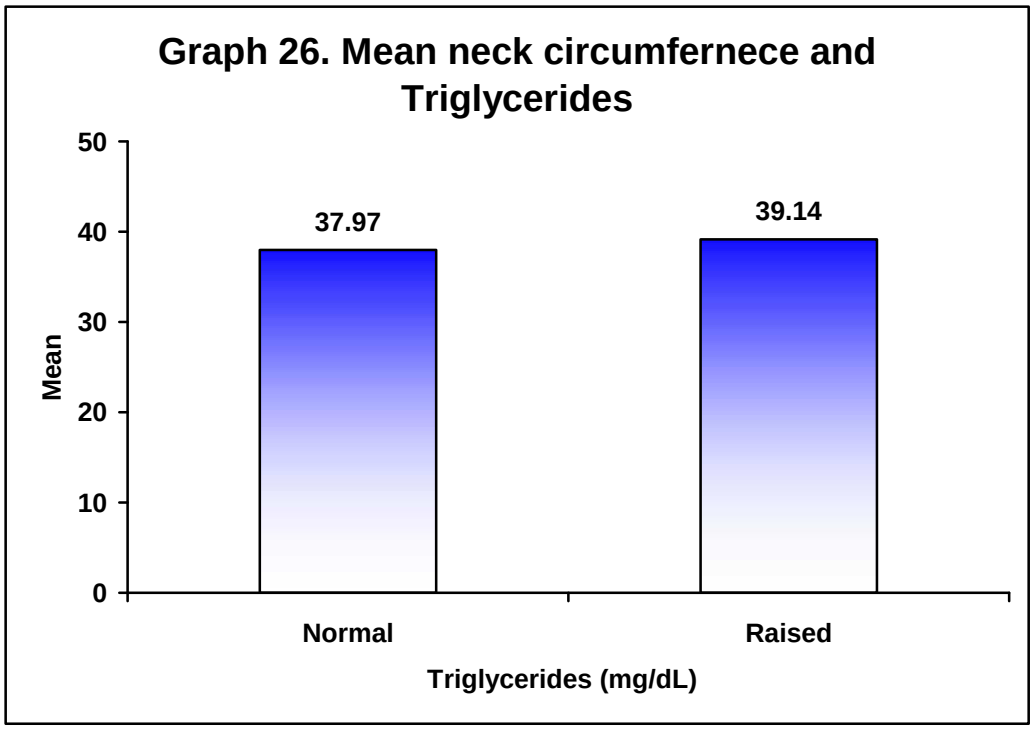


Of the 82 (82%) patients with hypertriglyceridemia 80 (97.56%) had elevated NC.

Table 26. Mean neck circumference and TG

Triglycerides (mg/dL)	Distribution (n=100)	
	Mean (cms)	SD
Normal	37.97	1.46
Raised	39.14	1.98

t=0.254 **DF=98** **p=0.799**

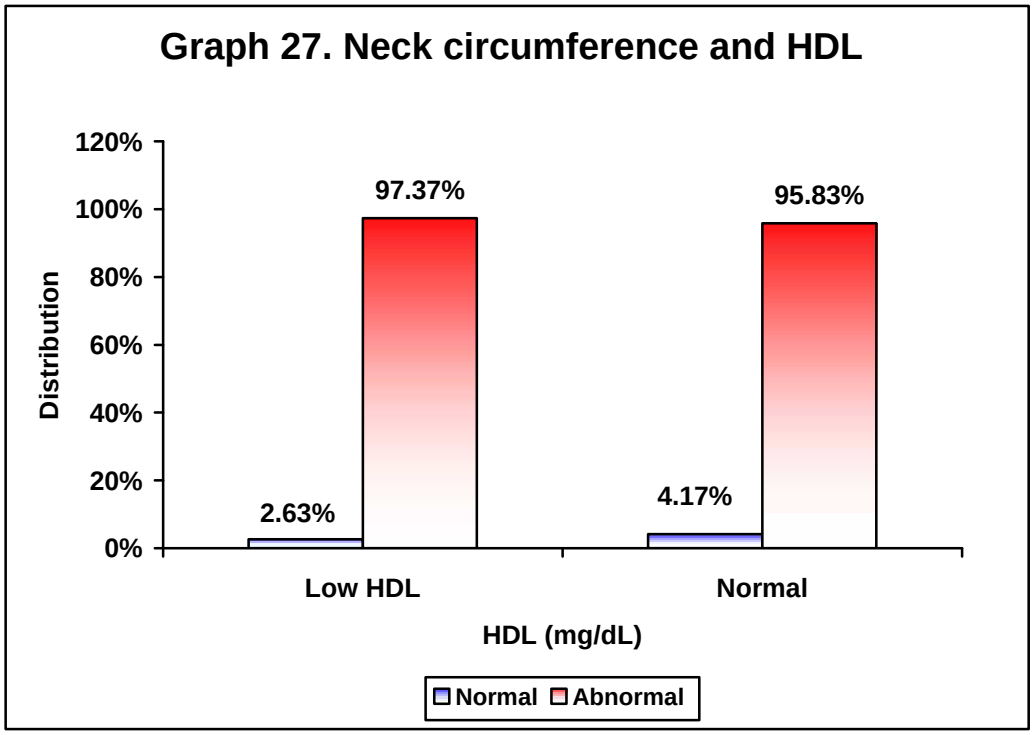


The mean NC in patients with hypertriglyceridemia was 39.14 ± 1.98. Among patients with normal triglyceride levels the mean NC was 37.97 ± 1.46.

Table 27. Neck circumference and HDL

HDL (mg/dL)	Neck circumference				Total (n=100)	
	Normal (n=3)		Abnormal (n=97)			
	No.	%	No.	%	No.	%
Low HDL	2	2.63	74	97.37	76	76.00
Normal	1	4.17	23	95.83	24	24.00

p= 0.565 (Fisher exact test)

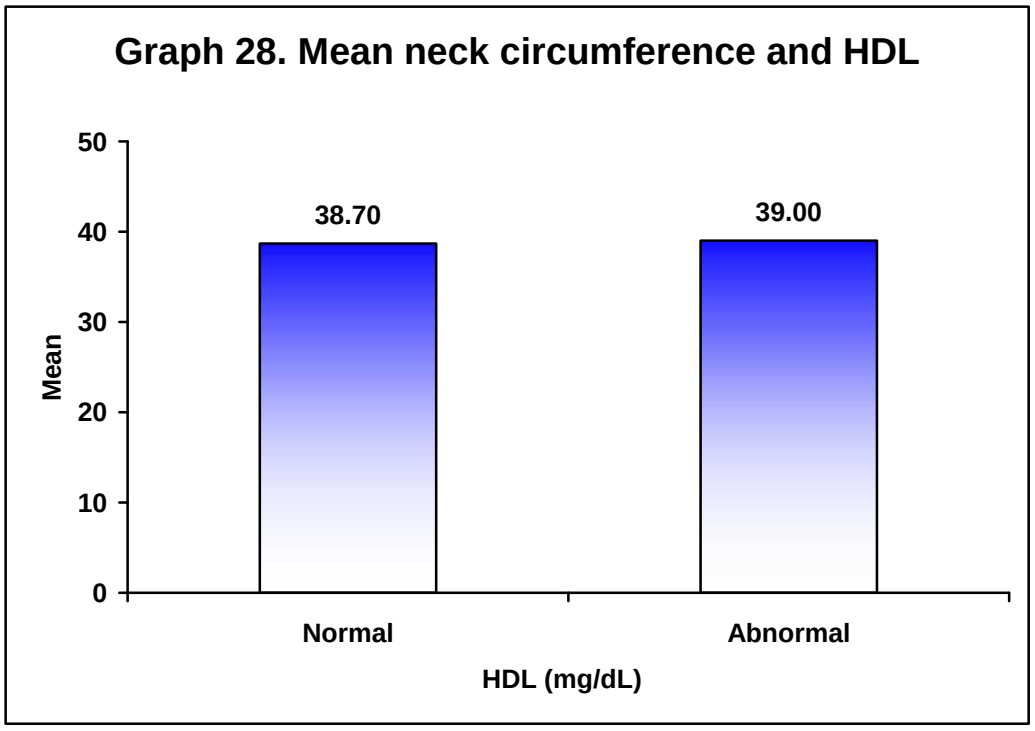


Among patients with abnormal HDL levels 76 (76%), NC was elevated in 74 (97.37%) patients.

Table 28. Mean neck circumference and HDL

HDL (mg/dL)	Distribution (n=100)	
	Mean (cms)	SD
Normal	38.70	1.74
Abnormal	39.00	2.01

t=0.090 **DF=98** **p=0.927**



The mean NC among patients with normal and abnormal HDL levels were 38.7 ± 1.74 and 39.0 ± 2.01 respectively.

Table 29. Correlation co-efficient between neck circumference and components of metabolic syndrome

Components	*'r'* value	't' value	'p' value
Systolic BP	-0.008	0.000	1.000
Diastolic BP	-0.115	1.146	> 0.005
Fasting blood sugar	0.128	1.277	> 0.005
Triglycerides	0.308	3.206	< 0.005
High density lipoprotein	-0.289	2.989	< 0.010
Body mass index	0.431	4.730	< 0.001
Waist circumference	0.654	8.558	< 0.001

In this study statistically significant correlation was found between neck circumference and metabolic components such as triglycerides, high density lipoprotein, body mass index and waist circumference whereas no correlation was found between neck circumference and components like blood pressure (systolic and diastolic) and fasting blood sugar.

Chapter 6

Discussion

DISCUSSION

Measurement of NC has recently been used to identify overweight and obesity and is observed to have good correlation with age, weight, waist and hip circumferences, waist-to-hip ratio, and BMI for both genders. Besides, NC is considered an index of upper body obesity and correlates positively with changes in systolic and diastolic blood pressure and other components of the metabolic syndrome. NC measurements are an alternative and innovative approach for determining body fat distribution.[134]

Neck circumference as an index for upper-body subcutaneous adipose tissue distribution has been evaluated in relation to cardiovascular risk factors, insulin resistance, and biochemical components of metabolic syndrome.[135] However, studies on role of NC in predicting the metabolic syndrome are scarce and so far there are no Indian studies available. Hence the present study was undertaken to evaluate the relationship of NC as a parameter in predicting metabolic syndrome.

The present study was conducted in the Department of Medicine, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum during the study period from January 2011 to December 2011. Hundred (100) cases of metabolic syndrome (based on NCEP ATP III criteria) were taken and the various components of metabolic syndrome and the NC were evaluated and compared. The NC was measured at a level just below the laryngeal prominence perpendicular to the long axis of neck.

In the present study, males accounted for 66% (n=66), whereas females accounted for 34% (n=34).

In a study[136] done in Perth, (Australia) 60.7% were males in the cohort of subjects with metabolic syndrome as diagnosed by the NCEP-ATP III criteria.

This is in sharp contrast with one study[134] done in Andhra Pradesh which showed metabolic syndrome rates were significantly higher among females. Females accounted for 52.2% (n=307) whereas males were only 34.2% (n=202).

This difference could be because of number of males and females patients studied (total of 509).

Majority of the subjects were between 46 to 60 years accounting for 45%, with 30 subjects in the age group > 60. Overall, the mean age for the study population was 54.46 ± 14.93 years.

In an Indian study,[137] significantly higher rates of metabolic syndrome was observed in older age groups. The incidence of metabolic syndrome increased with increasing age in such a way that the incidence was around 6% in the age group of 20 -29 years peaking to around 65 % in the age group of 60-69 years.

In a study[136] done in Australia in 2005, the mean age for the cohort of patients with metabolic syndrome was 57.1 (55.3–58.9)

In this study past history of diabetes was present in 63 patients and hypertension in 80 patients. Three patients reported a history of cerebrovascular

accident and 10 patients had ischaemic heart disease. Of the 63 diabetic patients, 33 of them had diabetic retinopathy and only 2 had diabetic nephropathy. History suggestive of peripheral vascular disease and peripheral neuropathy was found in one patient each.

In a study[138] done in the University of Oslo, among patients with metabolic syndrome, 40% had hypertension and 28% had previous cardiovascular disease.

A study[137] of metabolic syndrome in Asian Indians, all the individual components of metabolic syndrome increased significantly with age. Elevated blood pressure (63.1%) was the commonest abnormality observed.

In a study[138] done in the University of Oslo, among patients with metabolic syndrome, 29% had diabetes. On the other hand, in a prevalence study of metabolic syndrome and its components in urban India, diabetes was found in 82.01% of patients.

An Indian study[137] have shown that Diabetes and Hypertension are found more widely prevalent in South Asians, thus conferring a large and very real risk of adverse cardiovascular events and other attending complications. The possible explanations for this inordinately high prevalence can be attributed to a high prevalence of obesity, insulin resistance and a body fat structure that favours the development of metabolic syndrome, Diabetes and Hypertension.[139,140]

In the present study, 66% of the patients were in the overweight group (BMI between 25 to 29.99 kg/m^2) and 18% of the patients were obese (BMI of >

30 kg/m^2). However, 16% patients had a normal BMI (between 18.5-24.99 kg/m^2). Overall the mean BMI of the study population was 27.8 ± 2.99 Kg/m^2.

In a study[141] done in Norway, the mean BMI in patients with metabolic syndrome was found to be 28.4 kg/m^2 (26.6-30.6).

In the National health statistics report[142] of 2009, 29.8% of subjects were overweight and 65% of subjects were obese. In a study of urban Indian population, they found that 79.01% of the subjects had a BMI of > 24.9 Kg/m^2.

An Indian study[137] showed that metabolic syndrome and cardiovascular risk in Asian Indians/South Asians are heightened by their relative increase in body fat mass, truncal subcutaneous fat mass, intra-abdominal fat mass, and also by ectopic fat deposition. South Asians also seem to have a peculiar body phenotype known as South Asian Phenotype, characterized by increased waist circumference, increased waist hip ratio and excessive body fat mass.

In this study, 74% of the patients had abnormal waist circumference whereas in 26% waist circumference was within the normal range. Overall, the mean waist circumference for the study population was found to be 97.9 ± 7.44 cms. Among males the mean waist circumference was 101.30 ± 6.18 cms and in females it was 91.18 ± 4.60 cms.

Another study[143] done in Taiwan according to the National Cholesterol Education Program Adult Treatment Panel III criteria, waist circumference abnormality was seen in 40% in 11411 adults.

This sharp contrast in our study and the study reported by Taiwan group may be because of the number of patients in the study group.

A study done[144] in China showed that waist circumference (WC) and body mass index (BMI) were good markers for MetS. WC was a good marker for T2 DM and dyslipidemia, and BMI was a good marker for hypertension. The optimal BMI cut-off value of MetS was 24 kg/m², and the optimal WC cut-offs were 86 cm and 78 cm in men and women, respectively.

In the present study 97% of the patients had abnormal neck circumference. Overall, the mean neck circumference was 38.93±1.95 cms. Among the males the mean neck circumference was 39.83 ± 1.68 cms and in females it was 37.17 ± 1.00 cms.

In a similar study[145] done in the Istanbul University, Istanbul, Turkey, the mean NC measured among patients with metabolic syndrome was 36.7 cm in the total sample. With a mean of 38.8 cm in men, it was 4 cm wider than in women (34.8 cm).

In this study, overall 95 (95%) patients had hypertension of which, 80 (80%) were known hypertensives and 15 (15%) were newly detected. However, in 5% normal blood pressure was recorded.

In the present study 81% of patients were diabetics. Among these, 63 (63%) patients were known diabetics and 18 (18%) were detected with abnormal FBS. However, 19% patients had normal FBS levels.

In this study, the lipid profile revealed majority of the patients with abnormal triglycerides (82%) and HDL (76%) levels whereas elevated total cholesterol levels were noted in 30% of patients. Abnormal LDL was noted in only 18% of the patients.

In a survey[142] done by the US Department of Health and Human services, Triglyceride levels and HDL levels were found to be abnormal in 31.4% and 24.7% respectively.

In another study[146] done in New Delhi, India, the age-adjusted HDL levels were found to be low in 64.91% of subjects.

In a study done on Asian-Indians (Chennai), abnormal TG and HDL levels were seen in 76% and >90% of the study population. Asian Indians were found not only to have low HDL, but also have a preponderance of small, dense, dysfunctional HDL particles that are associated with less efficient reverse cholesterol transport and less protection against CAD.[138] In a sub-study of the Chennai rural epidemiology study, abnormal Triglycerides and HDL were found in 25.2% and 63.5% of the patients respectively.[147] However, in a study[148] done only on urban south Indian men, abnormal TG was seen in 45.2%, whereas abnormal HDL was seen in 70.3% of subjects.

In the present study the most common component of metabolic syndrome was hypertension 95%, followed by hypertriglyceridemia 82%, elevated fasting blood sugar 81%, low HDL 76% and abnormal waist circumference 74%.

In the present study 46% patients had metabolic syndrome with four components and 31% had five components. However 23% of the patients were noted with three components of metabolic syndrome. In patients with 3 components of metabolic syndrome (n=23), abnormal NC was found in 21 patients (91.3%) whereas 2 patients (8.7%) had normal neck circumference. In patients with 4 components of metabolic syndrome (n=46), abnormal NC was found in 45 patients (97.83%) whereas one patient (2.17%) had normal neck circumference. All the patients with five components of metabolic syndrome (n=31), had abnormal NC.

In this study the mean neck circumference among patients with five components was slightly higher (39.73 ± 2.25) compared to patients with three (38.42 ± 1.33) and four (38.64 ± 1.85) but, this difference was statistically not significant.

In the present study, among all the overweight (BMI 25.00 to 29.99 Kg/m^2) and obese (BMI > 30.00 Kg/m^2) patients the NC was abnormal (100%) and this difference was statistically significant (p=0.003). The mean neck circumference among normal, overweight and obese showed an increasing trend (37.27 ± 1.98, 38.91 ± 1.53 and 40.45 ± 2.15 respectively).

In this study among the 74 patients with abnormal waist circumference NC was abnormal in 98.65% and normal in 1.35% suggesting most of the patients with abnormal waist circumference had elevated NC. The mean NC in patients with normal and abnormal waist circumference was 38.53 ± 1.37 and

39.06 ± 2.1 respectively. However these findings were statistically not significant.

In the present study, of the 95 patients with hypertension, NC was elevated in 96.84% which was not statistically significant. The mean NC did not vary significantly in normotensive and hypertensive patients.

In the RENATA study[149] done in Argentina hypertension was found in 57.4% of the patients with abdominal and neck obesity.

In our study, of the 81 patients with abnormal FBS, 79 (97.53%) had elevated NC but this difference was not statistically significant. The mean NC did not vary significantly among normoglycemics and hyperglycemics.

In the present study, of the 82 patients with hypertriglyceridemia, 97.56% had elevated NC. The mean NC in patients with hypertriglyceridemia was 39.14 ± 1.98 and in those with normal triglyceride levels it was 37.97 ± 1.46 cms. However these differences were statistically not significant.

In our study among the 76 patients with abnormal HDL levels, NC was elevated in 97.37% patients but no statistically significant association was found between abnormal HDL and NC. The mean NC levels were 38.7 ± 1.74 cms and 39.0 ± 2.01 cms in patients with normal and abnormal HDL levels respectively.

In this study statistically significant correlation was found between neck circumference and metabolic components such as triglycerides, high density lipoprotein, body mass index and waist circumference whereas no correlation was

found between neck circumference and components like blood pressure (systolic and diastolic) and fasting blood sugar.

In a similar study[145] done in the Istanbul University, Turkey, correlation coefficients were high between NC and waist hip ratio, but were particularly high with waist circumference and BMI, exhibiting *r* value of 0.6 or over.

In the Framingham Heart Study[123] it was found that neck circumference was correlated with all cardiometabolic risk factors, with the exception of total and LDL cholesterol.

Another study[23] done in Israel indicated a strong correlation between NC and BMI (total adiposity index), as well as between NC and WC and waist-to-hip ratio (upper-body obesity indexes). NC was also strongly correlated with SBP, DBP, total cholesterol, LDL-cholesterol, triglycerides, fasting glucose, and uric acid levels. No significant correlation was found between NC and HDL-cholesterol levels.

This difference in our study and other studies may be because of number of patients in the study group. As a main finding in this cross-sectional analysis of data among patients with metabolic syndrome, we found NC as an indicator of central obesity and metabolic syndrome. This novel finding presumably reflects fat deposition in an ectopic site, such as observed in fatty liver or in the thoracic visceral adipose tissue that may include (basal areas of) the neck and palate.

A study[150] in 166 patients with and without MetS demonstrated a clear relationship between epicardial fat, assessed by echocardiography and activity of

hepatic serum alanine and aspartate aminotransferases in subjects with increased visceral adiposity, an association which seemed to be independent of BMI.

Furthermore, threshold values of echocardiographic epicardial fat measurements were proposed for men and women which could be of help for cardiometabolic risk stratification.[151] Newly, evidence was provided that peri-coronary epicardial adipose tissue was associated with CT-assessed coronary artery calcification in 573 healthy post-menopausal women suggesting the possibility that local fat may drive the development of atherosclerosis.[152]

Limitations

The present study's cross-sectional nature limits to some extent its interpretation as to causality of associations. Evaluation of NC based on single measurements might be considered a minor limitation.

Conclusions reached may not be fully applicable to a population because of the relative small sample size of the present study. Further studies with larger sample sizes are needed to identify the relationship of NC with central obesity and MS in general population.

Chapter 7

Conclusion

CONCLUSION

In this study majority of the patients with metabolic syndrome presented with abnormal NC. But, abnormal neck circumference was not associated with any of the components of metabolic syndrome. Patients with elevated BMI had associated increased neck circumference and this association was statistically significant. Correlation test revealed that neck circumference was significantly correlating with triglycerides, high density lipoprotein and waist circumference. However, no correlation was seen between neck circumference and blood pressure (both systolic and diastolic) and fasting blood sugar.

Chapter 8

Summary

SUMMARY

Upper-body fat distribution has long been recognized as related to increased cardiovascular disease risk, and neck skinfold or NC has been used as an index for such an adverse risk profile. The objective of the present study was to evaluate the relationship of NC as a parameter in predicting metabolic syndrome.

The present study was conducted in the Department of Medicine, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum during the study period from January 2011 to December 2011. Hundred (100) cases of metabolic syndrome were taken based on NCEP ATP III criteria and the various components of metabolic syndrome and the NC were evaluated and compared.

In this study 66% of the patients were males and 34% were females. Most of the patients (45%) were aged between 46 to 60 years. Overall, mean age of the study population was 54.46 ± 14.93 years. 46% of the patients had metabolic syndrome with four components and 31% had five components. The commonest component of metabolic syndrome was hypertension (95%) followed by hypertriglyceridemia (82%). Abnormal NC was observed in 97% patients and mean neck circumference was 38.93 ± 1.95 cms. Waist circumference was abnormal in 74% patients. The mean waist circumference of the study population was 97.9 ± 7.44 cms. Lipid abnormalities of total cholesterol, LDL, triglycerides and HDL were noted in 30%, 18%, 82% and 76% of the patients respectively.

In this study majority of the patients with metabolic syndrome presented with abnormal NC. But, abnormal neck circumference was not associated with

any of the components of metabolic syndrome. Patients with elevated BMI had associated increased neck circumference and this association was statistically significant. Correlation test revealed that neck circumference was significantly correlating with triglycerides, high density lipoprotein and waist circumference. However, no correlation was seen between neck circumference and blood pressure (both systolic and diastolic) and fasting blood sugar.

Chapter 9

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Annexures

Annexure I

ANNEXURE I – CONSENT FORM

"TO STUDY THE RELATIONSHIP OF NECK CIRCUMFERENCE AS A PARAMETER IN PREDICTING METABOLIC SYNDROME- A ONE YEAR CROSS SECTIONAL STUDY"

Objective and purpose of the study:

This research is intended to study the relationship between neck circumference and metabolic syndrome. The principal investigator of the study is Dr. ****** ****** under the guidance of Dr. **** *****. My co-operation will be of great help to patients with metabolic syndrome and those with increased risk of developing metabolic syndrome.

Procedure:

If you agree to be part of the research study you will be asked the relevant history and will be subjected to relevant clinical examination and investigations. You will also have to give blood and urine samples for the necessary investigations

Risk and Benefits:

The only risk and possible discomfort you might get is while taking blood from your arm for the investigations. It may cause swelling, pain, redness, bruising or infection (rarely happens) at the site from where the blood is drawn.

Alternatives

Taking part in this study is voluntary. You may choose not to take part in this study, or if you decide to take part now, you can later change your mind and withdraw from the study. Your decision will not change the present or future health care or other services that you receive. If you choose not to take part in the study you will receive the standard treatment for patients with your condition.

Privacy and Confidentiality

All information collected about you during the course of this study will be kept confidential to the extent permitted by law. The code numbers will identify you in this research record. Information from this study may be published but your identity will be confidential in any publication.

Institution / Sponsor's policy

Does not apply to this research

Financial incentives for participation

You will not be paid / offered any gifts /incentives for participating in the study.

Authorization to publish the results

The results of the study would be forwarded to the KLE University, Belgaum as part of requirement towards the completion of MD degree, review and publishing.

If I have any questions about your rights as a participant you may call Principal and Chairman, J.N.M.C Ethical Committee for Human Research phone number ***** ******.

Consent Statement

I voluntarily agree to take part in this study by signing below. I may withdraw at any time. I am not giving up any of my legal rights by signing this form. My signature below indicates that I have read, or it has been read to me, this entire consent form, and have had all my questions answered.

In case of the queries during study or in future you may contact following person

Principal investigator : Dr. ****** *******

Guide : Dr. ****** *******

Name of the Participant: _____ Signature/Thumb print _____

Name of the Witness _____ Signature _____

Name of the investigator _____ Signature _____

Date: Place:

Annexures

Annexure II

ANNEXURE II – PROFORMA

Case no:

Name: Age/sex:

IP No. Address:

Occupation:

Complaints at presentation:

History pertaining to metabolic syndrome:

k/c/o Type 2 diabetes mellitus yes ☐ no ☐

If yes,

Duration of illness -

Details of treatment –

Past history of cerebrovascular events –

Past history of angina/Myocardial infarction/ Ischaemic heart disease or on any specific medication.

H/o peripheral neuropathy - yes ☐ no ☐

Documented Diabetic retinopathy/surgical management of retinopathy in the past

Diabetic nephropathy yes ☐ no ☐

Diabetic foot yes ☐ no ☐

Autonomic neuropathy yes ☐ no ☐

K/c/o Hypertension or on specific yes ☐ no ☐

anti-hypertensive medication

H/o Peripheral vascular disease/ yes ☐ no ☐

past h/o treatment for the same

K/c/o of dyslipidemia or on any specific medication — yes ☐ no ☐

On examination

- Nutrition :

  Height :

  Weight:

  Waist circumference:

  Neck circumference:

- Blood pressure :

BMI :

INVESTIGATIONS :

- FBS
- Fasting lipid profile

  Total cholesterol,

  Triglycerides,

  HDL

  LDL

ANNEXURE III - MASTER CHART

				History												Clinical examination							Investigations				
				T2 DM			Cardio vascular events														BP (mm Hg)						
Serial Number	In Patient Number	Sex	Age (Years)	History	Duration (Years)	Cerebrovascular events	Angina	Myocardial Infarction	Ischeamic heart disease	Peripheral vascular disease	Peripheral neuropathy	Diabetic retinopathy	Diabetic nephropathy	Hypertension	Dislipidemia	Height (Cms)	Weight (Kg)	BMI (Kg/m2)	Waist Circumference (Cms)	Neck Circumference (Cms)	Systolic	Diastolic	Fasting blood sugar (mg/dL)	Total triglycerides	Total HDL	Total CHL	Estimated LDL
1	421610	F	58	Y	10	N	N	N	N	N	N	N	N	Y	Y	143	76	37.17	108.0	37.0	140	90	134	112	37	226	167
2	488102	M	31	N	-	N	N	N	N	N	N	N	N	Y	N	168	93	32.95	110.0	41.8	130	90	80	324	28	154	61
3	488081	M	27	N	-	N	N	N	N	N	N	N	N	N	N	174	98	32.37	106.0	43.0	150	90	100	193	17	202	146
4	2142918	M	64	Y	4	N	N	N	N	N	N	N	N	Y	N	162	71	27.05	96.0	39.0	146	96	136	209	31	208	135
5	471031	M	46	Y	10	N	N	N	N	N	N	N	N	Y	N	170	80	27.68	96.0	39.0	140	86	174	176	25	164	104
6	480353	M	44	N	-	N	N	N	N	N	N	N	N	N	N	170	80	27.68	92.0	40.5	150	94	223	358	40	122	46
7	484459	M	26	N	-	N	N	N	N	N	N	N	N	N	N	167	89	31.91	108.0	43.5	150	100	204	463	20	149	36
8	484645	M	44	N	-	N	N	N	N	N	N	N	N	N	N	170	90	31.14	106.0	42.0	140	94	144	241	26	278	204
9	467234	M	49	Y	1	N	N	N	N	N	N	N	N	Y	Y	162	76	28.96	104.0	41.5	150	90	108	364	30	198	95
10	465846	M	66	Y	2	N	N	N	N	N	N	N	N	Y	N	164	82	30.49	106.0	39.5	146	92	146	104	39	246	186
11	468085	M	80	Y	8	N	N	N	N	N	N	N	N	Y	N	170	86	29.76	100.0	40.0	160	90	125	130	32	211	153
12	468820	M	54	Y	4	N	N	N	N	N	N	N	N	Y	N	157	68	27.59	86.0	40.0	150	90	141	113	30	220	167
13	2215979	M	35	N	-	N	N	N	N	N	N	N	N	Y	N	170	92	31.83	106.0	39.5	144	94	98	237	33	162	82
14	468990	F	54	N	-	N	N	N	N	N	N	N	N	Y	N	154	80	33.73	96.0	40.0	150	90	140	529	25	117	39
15	1012174	F	60	Y	10	N	N	N	N	N	N	N	N	Y	N	156	84	34.52	96.0	36.0	144	94	118	204	28	234	165
16	413786	M	60	Y	6	N	N	N	N	N	N	N	N	Y	N	166	60	21.77	84.0	37.0	140	100	186	226	32	139	62
17	414534	M	68	Y	10	N	N	N	N	N	N	N	Y	Y	N	169	65	22.76	92.0	36.0	130	90	126	182	48	136	49
18	414523	M	47	Y	6	N	Y	Y	Y	N	N	N	N	N	N	165	63	23.14	102.0	39.5	140	90	113	136	36	139	79
19	414279	F	58	Y	10	Y	N	N	N	N	N	Y	N	Y	N	167	80	28.69	96.0	37.5	140	90	146	180	30	148	78
20	414523	M	47	Y	6	N	Y	N	N	N	N	N	N	N	N	165	63	23.14	102.0	36.0	140	90	113	136	36	139	79
21	414464	M	72	Y	10	N	N	N	N	N	N	N	N	Y	N	168	79	27.99	106.0	40.5	120	70	295	245	36	169	88
22	411869	M	60	Y	0.2	N	N	N	N	N	N	N	N	Y	N	156	67	27.53	104.0	41.5	120	70	112	304	31	237	127
23	413196	F	89	Y	15	N	N	N	N	N	N	Y	N	Y	N	160	62	24.22	94.0	35.6	140	90	130	120	48	135	63
24	412604	F	74	Y	12	N	N	N	N	N	N	N	N	Y	N	166	65	23.59	90.0	35.7	130	90	125	115	48	168	97
25	414226	M	45	Y	6	N	N	N	N	N	N	N	N	N	N	169	98	34.31	130.0	41.0	130	90	125	159	32	290	130
26	402639	F	65	Y	12	N	N	N	N	N	N	Y	N	Y	N	166	72	26.13	89.0	38.2	160	80	136	264	34	190	58
27	465996	F	50	Y	4	N	N	N	N	N	N	Y	N	Y	N	166	65	23.59	96.0	38.8	140	90	120	263	34	203	58
28	467848	M	33	Y	6	N	N	N	N	N	N	N	N	Y	N	178	88	27.77	103.0	39.0	150	90	136	146	18	165	36
29	469539	M	25	N	-	N	N	N	N	N	N	N	N	Y	N	182	88	26.57	105.0	38.5	150	100	96	180	38	100	46
30	470081	M	64	Y	12	N	N	N	N	N	N	Y	N	N	N	160	82	32.03	102.0	42.5	140	90	144	214	31	110	36
31	469778	M	47	Y	6	N	N	N	N	N	N	N	N	Y	N	168	76	26.93	96.0	39.5	140	100	119	223	48	151	62
32	469316	M	55	Y	15	N	N	N	N	N	N	Y	N	Y	N	158	92	36.85	92.0	38.5	150	90	176	202	24	150	54
33	469322	F	53	Y	4	N	N	N	N	N	N	N	N	N	N	158	66	26.44	90.0	36.8	160	90	148	264	34	203	58
34	469792	M	37	Y	4	N	N	N	N	N	N	Y	N	Y	N	178	89	28.09	90.0	38.0	146	90	136	264	34	160	36
35	470144	M	52	N	-	N	N	N	N	N	N	N	N	Y	N	167	68	24.38	90.0	36.8	130	90	90	191	21	106	53
36	469358	M	46	Y	9	N	N	N	N	Y	N	Y	N	Y	N	180	90	27.78	98.0	38.4	150	100	138	196	46	115	67
37	467858	F	32	Y	4	N	N	N	N	N	N	N	N	Y	N	160	68	26.56	84.0	37.0	140	90	190	154	52	160	36
38	450168	M	25	Y	3	N	N	N	N	N	N	Y	N	N	N	180	90	27.78	104.0	40.5	130	80	176	153	35	150	90
39	450731	F	22	N	-	N	N	N	N	N	N	N	N	Y	N	158	60	24.03	88.0	36.2	130	90	108	160	52	132	46
40	1896734	M	59	Y	20	N	N	N	N	N	N	Y	N	Y	N	164	68	25.28	104.0	40.5	150	90	138	153	35	150	90

ANNEXURE III - MASTER CHART

				History												Clinical examination							Investigations				
				T2 DM			Cardio vascular events														BP (mm Hg)						
Serial Number	In Patient Number	Sex	Age (Years)	History	Duration (Years)	Cerebrovascular events	Angina	Myocardial Infarction	Ischeamic heart disease	Peripheral vascular disease	Peripheral neuropathy	Diabetic retinopathy	Diabetic nephropathy	Hypertension	Dislipidemia	Height (Cms)	Weight (Kg)	BMI (Kg/m2)	Waist Circumference (Cms)	Neck Circumference (Cms)	Systolic	Diastolic	Fasting blood sugar (mg/dL)	Total triglycerides	Total HDL	Total CHL	Estimated LDL
41	451307	F	59	Y	9	N	N	N	N	N	N	Y	N	Y	N	168	70	24.80	87.0	35.4	160	90	118	156	39	100	51
42	1906813	F	50	N	-	N	N	N	N	N	N	N	N	Y	N	170	84	29.07	90.0	37.5	140	90	145	155	52	190	64
43	451959	M	24	N	-	N	N	N	N	N	N	N	N	Y	N	180	79	24.38	104.0	39.0	156	90	90	192	26	200	80
44	461938	F	53	Y	10	N	N	N	N	N	N	Y	N	Y	N	161	68	26.23	88.0	36.2	146	84	120	180	54	180	68
45	451816	F	46	N	-	N	N	N	N	N	N	N	N	Y	N	158	66	26.44	94.0	36.6	130	90	120	233	30	170	90
46	452191	F	28	N	-	N	N	N	N	N	N	N	N	Y	N	165	68	25.16	88.5	37.0	150	80	78	251	44	202	105
47	411941	F	40	N	-	N	N	N	N	N	N	N	N	Y	N	172	69	23.32	92.0	36.7	140	90	177	242	44	192	76
48	458816	M	60	Y	6	N	N	N	N	N	N	N	N	Y	N	163	68	25.59	99.0	38.5	148	100	190	160	57	127	74
49	1482102	F	40	Y	2	N	N	N	N	N	N	N	N	Y	N	177	88	28.09	96.0	36.2	156	80	110	110	41	124	68
50	1819307	M	58	Y	8	N	N	N	N	N	N	Y	N	Y	N	160	74	28.91	101.0	39.0	146	98	128	140	39	124	64
51	409488	M	72	Y	16	N	N	N	N	N	N	Y	N	Y	N	174	78	25.76	104.0	38.8	160	90	108	140	39	209	78
52	405589	F	68	N	-	N	N	N	N	N	N	N	N	Y	N	164	64	23.80	92.0	37.4	140	100	89	208	44	221	120
53	1012171	M	64	Y	16	N	N	N	N	N	N	Y	N	Y	N	176	80	25.83	103.0	41.5	160	80	180	200	30	164	64
54	453070	M	52	N	-	N	N	N	N	N	N	N	N	Y	N	169	76	26.61	100.0	39.0	170	90	124	190	35	140	50
55	455053	F	30	N	-	N	N	N	N	N	N	N	N	Y	N	161	69	26.59	92.0	37.8	148	100	112	180	34	184	76
56	402201	F	40	N	-	N	N	N	N	N	N	N	N	Y	N	162	60	23.00	89.0	35.8	140	90	102	200	40	208	80
57	405254	F	93	Y	10	N	N	N	N	N	N	N	N	Y	N	165	69	25.34	88.0	38.0	188	80	200	190	30	220	100
58	456455	F	60	N	-	N	N	N	N	N	N	N	N	Y	N	160	67	26.37	86.5	37.0	140	100	92	190	30	220	110
59	485791	M	42	Y	6	N	Y	N	N	N	Y	Y	N	N	N	175	78	25.62	102.0	38.5	160	80	155	210	90	225	90
60	461986	M	42	Y	3	N	Y	N	N	N	N	N	N	N	N	159	68	26.90	103.0	38.8	140	90	156	154	60	196	56
61	462475	M	50	N	-	N	N	N	N	N	N	N	N	N	N	176	79	25.50	104.0	39.5	120	70	86	168	38	200	84
62	461919	F	40	N	-	N	N	N	N	N	N	N	N	Y	N	168	70	24.80	99.0	37.4	140	110	138	166	88	155	55
63	460686	F	60	N	-	N	N	N	N	N	N	N	N	Y	N	162	69	26.29	87.5	37.8	160	90	210	204	32	230	86
64	405981	F	60	N	-	N	N	N	N	N	N	N	N	Y	N	160	69	26.95	88.0	36.8	150	90	148	200	38	208	80
65	462901	M	44	N	-	N	N	N	N	N	N	N	N	N	N	164	89	33.09	104.0	41.0	110	80	120	160	38	200	84
66	462611	M	62	Y	9	N	N	N	N	N	N	Y	N	N	N	164	80	29.74	104.0	40.2	114	80	138	155	55	166	88
67	462056	M	44	Y	10	N	N	N	N	N	N	Y	N	N	N	168	84	29.76	102.0	38.5	110	90	122	100	38	198	90
68	460956	M	65	Y	6	N	N	N	N	N	N	Y	N	Y	N	170	88	30.45	103.5	42.0	140	90	140	155	56	244	66
69	409548	M	52	N	-	N	N	N	N	N	N	N	N	Y	N	168	76	26.93	90.0	38.9	140	110	148	168	44	200	78
70	411261	M	69	Y	16	N	N	N	N	N	N	Y	N	Y	N	164	79	29.56	102.0	41.5	160	90	104	188	34	218	90
71	411810	M	55	N	-	N	N	N	N	N	N	N	N	Y	N	168	84	29.76	102.0	40.0	140	100	148	168	44	200	78
72	410767	M	60	Y	15	N	N	N	N	N	N	Y	Y	Y	N	170	88	30.45	100.0	41.0	140	90	144	166	34	218	98
73	461759	M	50	N	-	N	N	N	N	N	N	N	N	Y	N	164	78	29.00	104.0	38.8	140	90	108	172	56	192	79
74	412091	F	78	N	-	N	N	N	N	N	N	N	N	Y	N	170	84	29.24	88.0	37.4	140	96	104	146	38	154	60
75	412143	F	64	Y	10	N	N	N	N	N	N	Y	N	N	N	166	80	29.03	90.0	37.8	110	80	108	150	38	176	60
76	409488	M	71	Y	10	N	Y	N	N	N	N	Y	N	Y	N	168	84	29.76	102.0	42.8	140	90	136	190	34	210	86
77	416025	M	58	Y	10	N	Y	N	N	N	N	Y	N	Y	N	170	84	29.07	102.0	41.5	160	90	130	168	30	170	65
78	416147	M	57	Y	8	N	N	N	N	N	N	Y	N	Y	N	168	84	29.76	103.0	42.0	160	90	166	170	32	210	88
79	416221	M	35	Y	2	N	N	N	N	N	N	N	N	Y	N	167	69	24.92	104.0	43.0	140	90	110	220	40	128	90
80	416486	F	75	Y	15	N	N	N	N	N	N	Y	N	Y	N	166	69	25.22	88.0	38.9	140	80	190	179	23	190	68

ANNEXURE III - MASTER CHART

Serial Number	In Patient Number	Sex	Age (Years)	History												Clinical examination							Investigations				
				T2 DM		Cerebrovascular events	Cardio vascular events			Peripheral vascular disease	Peripheral neuropathy	Diabetic retinopathy	Diabetic nephropathy	Hypertension	Dislipidemia	Height (Cms)	Weight (Kg)	BMI (Kg/m2)	Waist Circumference (Cms)	Neck Circumference (Cms)	BP (mm Hg)		Fasting blood sugar (mg/dL)	Total triglycerides	Total HDL	Total CHL	Estimated LDL
				History	Duration (Years)		Angina	Myocardial Infarction	Ischeamic heart disease												Systolic	Diastolic					
81	416491	F	52	Y	8	N	N	N	N	N	N	Y	N	Y	N	164	74	27.51	88.0	37.0	140	90	132	170	39	160	82
82	416605	M	58	N	-	N	N	N	N	N	N	N	N	Y	N	170	76	26.30	102.0	39.8	140	90	106	178	39	160	80
83	416630	M	48	Y	2	N	N	N	N	N	N	N	N	Y	N	166	80	29.03	99.0	40.0	150	90	168	210	52	189	78
84	409781	F	64	N	-	N	N	N	N	N	N	N	N	Y	N	168	76	27.10	94.0	37.2	140	100	96	170	52	230	88
85	416682	F	52	N	-	N	Y	N	N	N	N	N	N	Y	N	178	80	25.25	89.5	38.0	140	90	98	179	49	192	79
86	416795	M	70	Y	25	N	N	N	N	N	N	Y	N	Y	N	168	74	26.22	100.0	39.0	140	90	138	210	36	178	80
87	416947	F	60	N	-	N	N	N	N	N	N	N	N	Y	N	170	88	30.45	90.0	38.0	140	90	220	160	48	190	78
88	417027	F	60	Y	10	Y	N	N	N	N	N	Y	N	N	N	166	80	29.03	88.0	37.0	150	96	110	142	46	160	58
89	417128	M	80	Y	25	N	Y	N	N	N	N	Y	N	Y	N	170	84	29.07	102.0	37.8	156	90	150	146	52	190	88
90	417218	M	68	N	-	Y	N	N	N	N	N	N	N	Y	N	169	80	28.01	102.5	39.8	140	90	100	208	36	200	60
91	416398	M	65	Y	10	N	N	N	N	N	N	N	N	N	N	176	90	29.05	102.0	39.5	110	70	168	190	36	290	148
92	417577	M	56	Y	6	N	N	N	N	N	N	N	N	Y	N	170	88	30.45	102.0	42.8	146	92	118	220	36	280	108
93	416636	M	80	N	-	N	N	N	N	N	N	N	N	Y	N	169	77	26.96	104.0	39.5	140	94	120	166	52	190	60
94	417600	M	66	Y	10	N	N	N	N	N	N	Y	N	Y	N	170	80	27.68	102.0	38.4	160	94	156	140	36	200	89
95	416467	M	66	N	-	N	N	N	N	N	N	N	N	Y	N	164	70	26.03	102.0	41.0	148	92	190	166	38	200	96
96	417690	M	54	Y	6	N	N	N	N	N	N	N	N	Y	N	165	72	26.63	101.0	37.9	146	100	122	160	50	178	110
97	416131	M	50	Y	4	N	N	N	N	N	N	N	N	Y	N	168	82	29.05	100.0	38.0	170	90	136	141	39	180	64
98	417361	M	77	Y	10	N	N	N	N	N	N	Y	N	N	N	165	76	27.92	101.0	39.5	160	90	112	198	36	200	96
99	417409	M	49	N	-	N	N	N	N	N	N	N	N	Y	N	164	78	29.00	104.0	40.2	160	90	104	166	38	180	86
100	416418	M	78	Y	20	N	N	N	N	N	N	Y	N	Y	N	170	88	30.45	100.0	39.0	150	90	176	180	41	240	121

Annexures

Annexure III

ANNEXURE III – KEY TO MASTER CHART

BMI	– Body mass index
BP	– Blood pressure
CHL	– Cholesterol
Cms	– Centimetres
dL	– Decilitres
F	– Female
FBS	– Fasting blood sugar
HDL	– High density lipoproteins
HTN	– Hypertension
I	– Insulin
IHD	– Ischaemic heart disease
Kg	– Kilogram
LB	– Labourer
LDL	– Low density Lipoprotein
M	– Male
m	– Metre
mg	– Milligram
MI	– Myocardial infarction
mm Hg	– Millimetre of mercury
N	– No
T2DM	– Type 2 diabetes mellitus
Y	– Yes