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Magnitude of metabolic syndrome and its components among adult residents of Mekelle city, Northern Ethiopia, community-based cross-sectional study.

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Abstract

Background: Metabolic Syndrome is becoming a big public health problem in developing countries like Ethiopia. The risk of dying from NCDs in low and lower-middle-income countries is almost two times that in high-income countries. NCDs account for 42% of deaths in Ethiopia. The trend of deaths due to NCD is increasing over time in Ethiopia. The objective of this study was to assess the magnitude of metabolic syndrome and its components among adult residents of Mekelle city.

Method: a community-based cross-sectional study was conducted from July to September 2019 among adults aged 20 years and above in Mekelle city. Around 266 study participants were selected using a simple random sampling technique. Sociodemographic, lifestyle, anthropometric measurements, and blood biochemical tests were performed using WHO stepwise technique. Blood glucose and lipid profiles were determined after overnight fasting. The classification of metabolic syndrome was based on the international diabetic federation criteria. Descriptive statistics and logistic regression analysis were done using SPSS version 24.

Result: the prevalence of Metabolic syndrome was 21.8%. Elevated waist circumference was the most prevalent metabolic syndrome component followed by hypertriglyceridemia, with a prevalence of 41.7% and 38.0% respectively. The prevalence of the remaining three components of MetS were also 33.8%, 32.7%, 21.4%, and 14.3% for systolic blood pressure, diastolic blood pressure, fasting blood glucose, and lower high-density lipoprotein cholesterol respectively. Age of 40 years and above, the highest rank of monthly income, blood cholesterol greater than 200mg/dl, waist to height ratio greater than 0.55, and walking at least 10 minutes daily were identified as significant predictors of metabolic syndrome.

Conclusion : Adult residents of Mekelle city have a high magnitude of Metabolic syndrome and its components which may aggravate the risk of developing cardiovascular disease. This result emphasizes an urgent need for a public health strategy for preventive, early detection, and management of metabolic syndrome, and its individual components.

Background

Metabolic Syndrome (MetS) is a group of the most dangerous heart attack risk factors: diabetes and raised fasting plasma glucose, abdominal obesity, elevated triglyceride (TG), low High-Density Lipoprotein cholesterol (HDL-c), and high blood pressure [1]. Many people are dying prematurely because of four non-communicable diseases (NCD) (Cardio-Vascular Disease (CVD), cancer, chronic respiratory disease, and diabetes). Four main risk factors (tobacco use, harmful use of alcohol, unhealthy diets, and physical inactivity) are responsible for the occurrence of the four NCDs [2]. Metabolic syndrome has become a global problem due to the spread of the Western lifestyle across the globe [3]. Premature mortality from NCDs creates one of the major challenges for development in the 21st century [4]. Its prevalence is more in the urban population of some developing countries than its Western counterparts [3].

Weight gain during adulthood mainly accompanied by intra-abdominal fat accumulation with increased waist circumference is considered as the main risk factor for MetS. Adults with the history of intra-uterine growth retardation were more prone to weight gain, and then to MetS. Genetic factor can also trigger manifestations of the MetS [5]. Central obesity and insulin resistance are considered as the primary underlying causes of MetS [6]. Obesity is associated with premature development of diabetes or heart disease [4]. An increase in consumption of high-calorie low fiber fast foods and the decrease in physical activity are also responsible for spreading MetS [3]. Overweight and obesity, sedentary lifestyle, non-vegetarian diet, positive family history, inadequate sleep, and alcohol consumption have been identified as risk factors for MetS. Being female, advancing age, illiteracy, and unemployment are additional contributing factors to MetS [7].

People with type 2 diabetes who also have MetS carry a much higher risk of CVD than those who have type 2 diabetes alone [1]. People with MetS are much more likely to develop chronic health conditions, including CVD and diabetes [8]. A large number of individuals with MetS have insulin resistance and central obesity. People with MetS are twice and five times at higher risk of developing CVD and type II Diabetic Mellitus (DM) respectively over the next 5–10 years. MetS alone predict approximately 25% of all new-onset CVD cases [9].

According to the World Health Organization (WHO) report, NCDs kill 41 million people each year, equivalent to 71% of all deaths globally. Over 85% of these deaths occur in low and middle-income countries. CVD account for most NCD deaths, or 44.0% annually, followed by cancers 22.0%, respiratory diseases 9.5%, and diabetes 4.0%. These four groups of diseases account for over 80% of all premature NCD deaths [10]. The risk of dying prematurely from NCDs in a low or lower-middle-income country is almost two times that in high-income countries [2].

In Ethiopia, NCD accounts for 42% of deaths among all age groups and 27% among under 70 years [11]. Study on patterns of mortality in Addis Ababa found that 31% and 12% of deaths were due to NCD and injuries respectively. The trend of deaths due to NCD is increasing over time in Ethiopia [12]. A systematic review conducted in Ethiopia also found that CVD accounts for 24% of deaths in Addis Ababa. Also, diabetes and the chronic obstructive pulmonary disease accounts for 5% and 3% of deaths respectively [13]. NCDs were the primary causes of the age-standardized death rate in Ethiopia in 2015. During the stated year, the prevalence of metabolic syndrome was 4.4%, and the prevalence of different metabolic risk factors like high blood pressure, elevated blood glucose, hypercholesterolemia, overweight, and Obesity was 16%, 5.9%, 5.6%, 5.2%, and 1.2% respectively [14].

According to a steps survey conducted in Ethiopia, the overall prevalence of MetS was 4.8% (11.7% and 3.2% in the urban and rural area respectively) [15]. Facility-based cross-sectional studies have been conducted in different University Hospitals of Ethiopia and found 48.7% and 40.7% prevalence of metabolic syndrome among hypertensive individuals from Hawassa [16], and Gondar [17] university respectively. Besides, 26% among outpatient department of Jimma University Hospital [18]; 24.3% and 21.1% among individuals under Highly Active Anti-Retroviral Therapy (HAART) from Hawassa [19] and

Jimma [20] university teaching hospitals respectively. The highest prevalence of MetS has been reported among individuals with type II diabetic mellitus under follow up in Hawassa university teaching hospital with 70.1% [21]. According to different research findings from Ethiopia, low HDL cholesterol was the most frequently encountered component of metabolic syndrome [17, 22–23], and females are at higher risk of developing metabolic syndrome [17–18, 20, 22].

The burden of NCD is increasing at an alarming rate in developing countries like Ethiopia, and the national health system is not strong enough to handle this malady. Since management and treatment of NCD are difficult and too costly, more emphasis should be given to the upstream risk factors (Metabolic syndrome and its five components). A very limited number of studies have been conducted in Ethiopia, were facility-based and conducted among individuals with a certain health problem. Therefore, it was the first community-based study in the regional state. The finding is laboratory-based and timely. This finding is an important input to convince the government to give attention to the hidden burden. This study aimed to assess the magnitude of MetS, its components, and factors associated with it among adult residents of Mekelle city.

Method And Materials

Study design and setting: a community-based cross-sectional study was conducted among 266 adult study participants in Mekelle city, Northern Ethiopia. Mekelle is the capital city of Tigray regional state and is one of the seven zones in the regional state, divided into seven sub-cities and found 783km north of the capital city Addis Ababa. It is the second-largest city next to Addis Ababa in Ethiopia. There are eight governmental health centers, two general hospitals, one referral hospital, and many private clinics in the city. The data were collected from July 10 to September 30, 2019.

Participants:

All adult individuals aged 20years and above living in Mekelle city at least for 6-months were considered as the study population. Pregnant women, first 6months of lactation, critically ill (unable to undergo anthropometric measurement) have been excluded from the study.

Sample size calculation and sampling technique

Single population proportion formula has been used to calculate the sample size by considering the proportion of metabolic syndrome in urban Ethiopia 11.7% [15], 95% level of confidence, and 4% margin of error. The calculation resulted in 248, and after adding 10% of the calculated sample size (248 + 25) for the non-response rate, the total sample size was 273.

A stratified sampling technique was used using age since the probability of having metabolic syndrome increases with age. Two age groups have been created (20-39 and >= 40years). Then, the total sample size was proportionally allocated to the two groups based on the number of population in the respective age group. Besides, the total sample size was proportionally allocated to the 7sub-cities of the city and the list of households was used as a sampling frame in each sub-city. The required number of HHs were selected by simple random sampling technique from each sub-city. Within the household, a single individual was selected by the lottery method from among all the eligible individuals.

Operational definition

Metabolic syndrome: According to the International Diabetic Federation (IDF) criteria [24], an individual is classified as having MetS if the following criteria have been met. A compulsory raised waist circumference (WC) of ≥94cm for men and ≥80cm for women plus two of the remaining four metabolic syndrome components. Elevated triglycerides (TG) ≥150mg/dl; low high-density lipoprotein-cholesterol (HDL-c) of <40mg/dl for men and <50mg/dl for women; raised blood pressure (BP) ≥130/85 mmHg or on hypertension treatment; and raised fasting blood glucose (FBG) ≥100mg/dl or on diabetes treatment.

Hyperglycemia: raised fasting blood glucose (≥100mg/dl) or on diabetes treatment.

Hypertriglyceridemia: Elevated triglycerides (≥150mg/dl).

Low high-density lipoprotein-cholesterol: <40mg/dl for men and <50mg/dl for women

Raised blood pressure (BP) ≥130/85 mmHg or on hypertension treatment

Raised waist circumference (WC): ≥94cm for men and ≥80cm for women

Hypercholesterolemia: raised blood cholesterol level (≥200mg/dl)

Elevated low-density lipoprotein cholesterol: ≥150mg/dl

Data collection and measurement

Data collectors were recruited based on their prior experience and educational background. One data collection team with four members was established and consisted of a team leader, measurer, assistant measurer, and a blood sample collector. A supervisor was assigned to the team. All data collectors and the supervisor were BSc Public health professionals and MSc Medical Laboratory technologist performed the laboratory test for lipid profile and fasting blood glucose. The data collection team was responsible for anthropometric measurement, sample collection and managing interviews. The team leader uses an assessment guide to monitor the team throughout the data collection period.

Training of data collection team

The data collection team was trained for two days covering anthropometric measurements mainly waist circumference, height, hip, and weight measurement techniques and precautions on taking measurements. How to measure blood pressure; sample collection techniques and precautions; sample handling, storage and transport to the laboratory; and standardization. Data collection, interview techniques, and procedures; how to fill the questionnaire properly with practice (data recording procedure and precautions). Ethical considerations during the data collection; and how they organize the overall data collection process, methodology including the selection of respondents.

Standardization test

During training, we standardize measurements. As part of standardization, we have selected 10 adults of different ages. Each measurer including the supervisor measured each adult. Measurers have a break after the first round measurement. Each measurer measured each adult two times for each measurement. We entered the data into ENA software on the computer during the standardization test session on the spot. The software calculates how precise (ability to get the same result on the same adult each time) and how accurate (how close the individual measurement is to the “true” value, which was taken to be the supervisor’s value). After training and practice, team members who were unable to measure and record the anthropometry of adults within the limits set by the ENA for SMART software program were retrained until the required skill has been achieved. Enumerators with the best precision and accuracy were assigned to take anthropometric measurements.

Data collection

A structured questionnaire adapted from the WHO STEPS survey questionnaire [25], and translated to the local language (Tigrigna) was employed for each study participant. We have collected Anthropometric measurements from all study participants. We have collected all the necessary data at the household level. Data collectors have used stadimeter for height measurement, with the subjects positioned at the Frankfurt plane and the four points (heel, calf, buttock, and shoulder) touching the vertical stand and without shoes. Besides, we have used roller meter for the measurement of waist and hip (with pants) circumference. Weight was measured using a digital scale with light closes and without shoes. The validity of the weighing scale was checked before starting in the morning and between measurements using a known weight. The height and weight measuring devices were placed on a level surface. All study participants were measured three times for all anthropometric measurements and blood pressure and the average was used. The supervisor has closely supervised the data collector team throughout the data collection period.

Blood sample collection and laboratory analysis

Around 5ml of venous blood was collected after an overnight (8-12hours of) fasting for FBS, HDL, TG, LDL, and blood cholesterol test. To do so, study participants were appointed the next day after data collection to the nearby health facility to give fasting venous blood in the early morning (8:00 am – 9:00 am). An appropriate test tube was used (container with glycolytic inhibitors) to minimize the consumption of glucose by cells in the blood and serum was separated as soon as possible (within 30minutes of sample collection). After retracting the clot, the sample was centrifuged at 4000 revolutions per minute for 5 minutes and 2.5 ml pure serum sample was transferred to Nunc tube within 30 minutes. The sample was analyzed using Bio-system A25 automated chemistry machine. Before sample analysis, the machine was checked using controls and blank on a daily basis. We proceed to sample analysis once the test was passed for the stated parameters.

Data quality control

All filled questionnaires were checked each evening. Data were entered daily with continuous identification and correction of missing or flag data. Based on the errors that we found, the supervisor gave feedback to the data collectors, and go back to the respective household with missing or dubious data. Different individual to clarify the collected data has revisited questionnaires (households) with unusual findings. The quality of data was ensured through training of all data collectors and the supervisor; translation of the questionnaire to the local language (Tigrigna). Cross-checking of the filled questionnaires daily. Every evening, a discussion was arranged with the data collection team to identify and address any difficulties encountered during fieldwork, and to solve the challenges and to give directions. Weighing scale was calibrated using known weight before starting in the early morning and between each measurement.

Data management and analysis

We have coded the filled questionnaire, entered into epi-data, exported to and analyzed using Statistical Package for the Social Sciences (SPSS) version 24. Before data analysis, we have cleaned the data. Data were analyzed using descriptive and analytical statistical techniques; summarized and presented using text, tables, and graphs. Since the dependent variable is dichotomous (presence or absence of metabolic syndrome), we have used binary logistic regression to assess factors associated with the dependent variable. We have used bivariate logistic regression to select candidate variables with a p-value of =<0.2. Multivariable logistic regression was used to assess the adjusted odds ratio and variables were considered significant if the p-value is <0.05. Before the inclusion of predictors to the final logistic regression model, the multi-collinearity was checked using the Variance Inflation Factor (VIF) <10 for continuous independent variables. The goodness of fit of the final logistic model was tested using Hosmer and Lemeshow test at a p-value of >0.05. Outcome measures were indicated by the odds ratio with 95% confidence interval, and the significant association was declared at p< 0.05 for the final model.

Results

Socio-demographic characteristics

From the expected total study participants of 273, 266 were participated in the study with a response rate of 97.4%. More than half (53.4%) of the study participants were females; 67.3% married; 89.9% were literate, and around one quarter were private sector employees (table 1). Around 4.9% of the study participants were smokers, and 4.1% live with smokers, and four out of five (80.8%) were alcohol consumers. None of the female study participants were smokers, whereas 1 out of 10 male study participants were smokers. More than half (55.3%) were ever been measured for blood pressure, of whom 8.6% have been told having raised blood pressure; 3.8% are under treatment for hypertension. Besides, 47.7% of the study participants were ever been measured for blood glucose, of whom 5.6% have been told of having raised blood glucose; 1.5% are under treatment for diabetes. More females were tested for blood pressure, and blood glucose (Table 2).

Table 1: Socio-demographic characteristics of the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

Variables		Frequency	Percent
Sex	Male	124	46.6%
	Female	142	53.4%
Marital status	Single	73	27.4%
	Married	179	67.3%
	Others	14	5.3%
Educational status	Illiterate	27	10.1%
	1-8	37	13.9%
	9-12	115	43.2%
	Diploma	35	13.2%
	Degree	38	14.3%
	Masters and above	14	5.3%
Occupation	Government employee	28	10.5%
	Private sector employee	68	25.5%
	Merchant	53	19.3%
	Daily laborer	14	5.3%
	Student	9	3.4%
	Housewife	63	23.7%
	Others	30	11.3%
Number of family members	1	25	9.4%
	2	25	9.4%
	3-6	174	65.4%
	>=7	42	15.8%

Table 2: Lifestyle, biomedical diagnosis and treatment history of the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

Variable		Male (n = 124) n (%)	Female (n = 142) n (%)	Total n (%)
Smoking	Yes	13 (10.5%)	0 (0.0%)	13 (4.9%)
	No	111 (89.5%)	142 (100.0%)	253 (95.1%)
Alcohol consumption	Yes	108 (87.1%)	107 (75.4%)	215 (80.8%)
	No	16 (12.9%)	35 (24.6%)	51 (19.2%)
Living with smoker	Yes	7 (5.6%)	4 (2.8%)	11 (4.1%)
	No	117 (94.4%)	138 (97.2%)	255 (95.9%)
Ever measured blood pressure	Yes	60 (48.4%)	87 (61.3%)	147 (55.3%)
	No	64 (51.6%)	55 (38.7%)	119 (44.7%)
Ever told having raised blood pressure	Yes	10 (8.1%)	13 (9.2%)	23 (8.6%)
	No	114 (91.9%)	129 (90.8%)	243 (91.4%)
On treatment for HTN	Yes	5 (4.0%)	5 (3.5%)	10 (3.8%)
	No	119 (96.0%)	137 (96.5%)	256 (96.2%)
Ever measured blood sugar	Yes	47 (37.9%)	80 (56.3%)	127 (47.7%)
	No	77 (62.1%)	62 (43.7%)	139 (52.3%)
Ever told having raised glucose	Yes	8 (6.5%)	7 (4.9%)	15 (5.6%)
	No	116 (93.5%)	135 (95.1%)	251 (94.4%)
On treatment for diabetes	Yes	1 (0.8%)	3 (2.1%)	4 (1.5%)
	No	123 (99.2%)	139 (97.9%)	262 (98.5%)

Magnitude of metabolic syndrome and its components

Around 21.8% of the study participants were positive for metabolic syndrome according to IDF criteria. The prevalence of MetS was 24.6% among females, slightly higher than in males (18.5%). Elevated waist circumference was the most prevalent MetS component followed by hypertriglyceridemia, with a prevalence of 41.7% and 38.0% respectively. The prevalence of the remaining three components of MetS were also 33.8%, 32.7%, 21.4%, and 14.3% for systolic blood pressure, diastolic blood pressure, fasting blood glucose, and lower high-density lipoprotein cholesterol respectively. Around half (50.4%) of the study participants were found to have elevated LDL cholesterol. In addition, 29.7% of the study participants have elevated blood cholesterol (≥200 mg/dl). Males have more hyperglycemia and hypertriglyceridemia with a prevalence of 25.0% and 47.6% respectively, and this figure was 18.3% and 29.6% for females respectively. We also found a big difference in elevated WC, and HDL-c with a prevalence of 55.6% 19.7% for females and 25.8% and 8.1% among males respectively. Females were also more prone to both underweight and obesity than males with a prevalence of 11.3% and 13.4% respectively. Only 8.1% and 6.4% of males were underweight and obese respectively (Table 3).

Table 3: biomedical and anthropometric findings of the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

NA: Not Applicable; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; BMI: Body Mass Index; IDF: International

Variables	Overall mean (SD)	Cut-off	Prevalence		
			Male (n= 124), n(%)	Female (n=142), n(%)	Total (n=266) n(%)
Blood Cholesterol (mg/dl)	181.2 (51.5)	<200	89 (71.8%)	98 (69.0%)	187 (70.3%)
		>=200	35 (28.2%)	44 (31.0%)	79 (29.7%)
Blood glucose (mg/dl)	96.7 (36.5)	<100	93 (75.0%)	116 (81.7%)	209 (78.6%)
		100-125	19 (15.3%)	16 (11.3%)	35 (13.1%)
		>=126	12 (9.7%)	10 (7.0%)	22 (8.3%)
Triglyceride (mg/dl)	165.0 (144.9)	<150	65 (52.4%)	100 (70.4%)	165 (62.0%)
		>=150	59 (47.6%)	42 (29.6%)	101 (38.0%)
HDL (mg/dl)	M=53.6 (10.6)	M>=40/F>=50	114 (91.9%)	114 (80.3%)	228 (85.7%)
	F=61.3 (13.3)	M<40/F<50	10 (8.1%)	28 (19.7%)	38 (14.3%)
LDL (mg/dl)	143.6 (50.1)	<130	65 (52.4%)	67 (47.2%)	132 (49.6%)
		>=130	59 (47.6%)	75 (52.8%)	134 (50.4%)
Waist circumference (cm)	M=84.3 (11.6) F=82.2	M<94/F<80	92 (74.2%)	63 (44.4%)	155 (58.3%)
	(14.0)	M>=94/F>=80	32 (25.8%)	79 (55.6%)	111 (41.7%)
SBP (mm Hg)	126.7 (20.4)	<130	82 (66.1%)	94 (66.2%)	176 (66.2%)
		>=130	42 (33.9%)	48 (33.8%)	90 (33.8%)
DBP (mm Hg)	80.4 (11.4)	<85	81 (65.3%)	98 (69.0%)	179 (67.3%)
		>=85	43 (34.7%)	44 (31.0%)	87 (32.7%)
Metabolic syndrome IDF	NA	Positive	23 (18.5%)	35 (24.6%)	58 (21.8%)
(ADA)		Negative	101 (81.5%)	107 (75.4%)	208 (78.2%)
Age	38.0 (14.8)	NA	NA	NA	NA
Weight	62.6 (12.7)	NA	NA	NA	NA
Height	162.5 (9.0)	NA	NA	NA	NA
Hip circumference	93.4 (9.9)	NA	NA	NA	NA
BMI	23.7 (4.7)	Underweight	10 (8.1%)	16 (11.3%)	26 (9.8%)
		Normal	72 (58.1%)	78 (54.9%)	150 (56.4%)
		Overweight	34 (27.4%)	29 (20.4%)	63 (23.7%)
		Obese	8 (6.4%)	19 (13.4%)	27 (10.1%)

Diabetic Federation; ADA: American Dietetic Association; LDL: Low-Density Lipoprotein; HDL: High-Density Lipoprotein.

Of all study participants with metabolic syndrome, around half (53.4%) have three metabolic syndrome components and more than one-third (36.2%) have four metabolic syndrome components. All five MetS components were detected in 1 out of 10 study participants. The most prevalent metabolic disorder was elevated LDL cholesterol, detected in half (50.4%) of the study participants followed by elevated WC (41.7%) and triglyceride (38.0%). Around one-third of the study, participants were found to have elevated blood pressure with 33.8% and 32.7% for SBP and DBP respectively (Fig 1).

Around one-quarter (23.7%) of the study participants were overweight and a significant number (10.1%) were also obese. Also, 9.8% were underweight, of whom 1.5% were severely undernourished with a BMI of <16.0, which shows the double burden of malnutrition (both under and over) (Fig 2). The risk of having metabolic abnormalities is consistently increased with increasing body mass index. All components of metabolic syndrome and related variables increase with increasing BMI. Taking obese individuals as an example, 77.8%, 58.7%, 59.3%, 55.6%, and 51.9% have elevated LDL, blood cholesterol, TG, SBP, and DBP respectively (fig 3).

Magnitude of metabolic syndrome with respect to different variables

The prevalence of metabolic syndrome varies with respect to different variables. The prevalence was higher among females, medium age adults, and among higher-income with 24.6%, 43.2%, and 29.8% respectively. The higher the biochemical test result, the more the probability of having metabolic syndrome. Of all the study participants with MetS, two-third (66.7%) were obese, more than one-third were overweight, one in ten were normal, and none of them was underweight (table 4, fig 4 and fig 5).

Table 4: prevalence of MetS with respect to different variables among the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

Variables		Metabolic Syndrome	
		n	**%**
Sex	Male	23	18.5%
	Female	35	24.6%
Age	20-39	19	11.3%
	40-59	32	43.2%
	>=60	7	29.2%
Marital status	Married	47	26.3%
	Single	7	9.6%
	Others	4	28.6%
Monthly income rank	Poor	9	8.8%
	Medium	21	25.3%
	Rich	28	34.6%
Blood glucose	Normal (<100mg/dl)	26	12.4%
	Pre-diabetic (100-125mg/dl)	16	45.7%
	Diabetic (>=126mg/dl)	16	72.7%
Triglyceride	<150	9	5.5%
	150-199	14	35.9%
	>=200	35	56.5%
Blood cholesterol	<200	26	13.9%
	200-239	19	40.4%
	>=240	13	40.6%
High density lipoprotein	M>=40/F>=50	38	16.7%
	M<40/F<50	20	52.6%
Low density lipoprotein	<130	14	10.6%
	130-159	13	28.9%
	160-189	10	25.6%
	>=190	21	42.0%
Systolic blood pressure	Normal (=<129mm Hg)	16	9.1%
	Raised (>=130mm Hg)	42	46.7%
Diastolic blood pressure	Normal (=<84mm Hg)	19	10.6%
	Raised (>=85mm Hg)	39	44.8%
Body mass index	Underweight	0	0.0%
	Normal	16	10.7%
	Overweight	24	38.1%
	Obese	18	66.7%

The mean age of study participants with metabolic syndrome was higher than those without metabolic syndrome. The same is true for all components of metabolic syndrome, blood cholesterol level, LDL cholesterol level, and body mass index (Table 5). The mean blood cholesterol, LDL cholesterol, age and BMI of individuals with MetS is higher than study participants without MetS with 217.7mg/dl, 175.3mg/dl, 46.4years, and 28.4kg/m^2 respectively. The mean waist to hip and waist to height ratio are higher among MetS positive than negative study participants with a ratio of 0.96 and 0.6 respectively (Fig 6).

Table 5: distribution of MetS with respect to different variables among the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

Variable (mean (SD))	Metabolic syndrome	
	Yes	No
Age in years	46.4 (12.7)	35.6 (14.5)
Cholesterol in mg/dl	217.7 (63.3)	171.1 (42.7)
FBG in mg/dl	121.8 (58.0)	89.6 (23.5)
Triglyceride in mg/dl	252.4 (157.0)	140.6 (131.7)
LDL in mg/dl	175.3 (53.8)	134.8 (45.3)
SBP in mm Hg	143.4 (22.2)	122.0 (17.3)
DBP in mm Hg	88.3 (8.7)	78.3 (11.1)
Waist to hip ratio	0.96 (0.08)	0.87 (0.09)
Waist to height ratio	0.60 (0.06)	0.49 (0.07)
Body mass index	28.4 (4.8)	22.4 (3.7)
Monthly income in EBr	6,038.9 (5,271.5)	5,620.7 (4,954.5)
Waist circumference in cm	97.0 (8.9)	79.3 (11.2)

SD: Standard Deviation; FBG: Fasting Blood Glucose; LDL: Low-Density Lipoprotein; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure.

Factors association with metabolic syndrome:

In multivariable logistic regression age, monthly income, blood cholesterol, waist to height ratio, and walking at least 10 minutes daily were significantly associated with MetS. The estimated odds of developing MetS was 2.7 times higher among 40 years and above than below 40 (AOR (95% CI) = 2.734 (1.244, 6.006), a p-value of 0.012), adjusting for all other variables in the model. Individuals on the highest rank of monthly income were 5.5 times more likely to have MetS than their poor counterparts (AOR (95% CI) = 5.521 (1.955, 15.590, a p-value of 0.001). Study participants with hypercholesterolemia were 2.5 times more likely to develop MetS than individuals with normal blood cholesterol (AOR (95% CI) = 2.545 (1.156, 5.601, a p-value of 0.02). Persons who have a waist to height ratio of 0.55 and above were around 15.2 times more likely to have MetS compared to those who have less than 0.55 (AOR (95% CI) = 15.166 (6.575, 34.981, p-value <0.001). Persons who did not walk for at least 10 minutes daily were around 3.3 times more likely to develop MetS compared to individuals who walk at least for the stated time daily (AOR (95% CI) = 3.297 (1.197, 9.080, a p-value of 0.021). In other words, persons who walk for at least 10 minutes daily were 70% less likely to develop MetS (OR = 1/3.297 = 0.303) (Table 6).

Table 6: Results from binary and multivariable logistic regression on MetS among the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

Variable		Metabolic syndrome		COR (95% CI)	p-value	Betta	AOR (95% CI)	p-value
		Yes (n (%))	**No (n (%))**					
Age	20-39	19 (11.3)	149 (88.7)	1		0	1	
	>=40	39 (39.8)	59 (60.2)	5.184 (2.773,9.692)	<0.001*	1.006	2.734 (1.244,6.006)	0.012*
Sex	Female	35 (24.6)	107 (75.4)	1.436 (0.794,2.597)	0.231			
	Male	23 (18.5)	101 (81.5)	1				
Educational status	Illiterate	7 (25.9)	20 (74.1)	1				
	1-12	30 (19.7)	122 (80.3)	0.703 (0.272,1.815)	0.466			
	>=13	21 (24.1)	66 (75.9)	0.909 (0.337,2.449)	0.850			
BMI	=<24.9	16 (9.1)	160 (90.9)	1		0	1	
	25-29.9	24 (38.1)	39 (61.9)	6.154 (2.987,12.680)	<0.001*	0.177	1.194 (0.404,3.526)	0.748
	>=30.0	18 (66.7)	9 (33.3)	20.000 (7.727,51.164)	<0.001*	0.759	2.136 (0.519,8.793)	0.293
Monthly income (rank)	Poor	9 (8.8)	93 (91.2)	1		0	1	
	Medium	21 (25.3)	62 (74.7)	3.500 (1.504,8.143)	0.004*	1.043	2.837 (0.981,8.202)	0.054
	Rich	28 (34.6)	53 (65.4)	5.459 (2.396,12.436)	<0.001*	1.709	5.521 (1.955,15.590)	0.001*
Wealth index (PCA Factor 1)	Poor	26 (29.2)	63 (70.8)	2.008 (0.978,4.124)	0.057*	-0.258	0.773 (0.238,2.511)	0.668
	Medium	17 (19.1)	72 (80.9)	1.149 (0.534,2.474)	0.722	0.123	1.130 (0.368,3.471)	0.830
	Rich	15 (17.0)	73 (83.0)	1		0	1	
Blood Cholesterol	=<199.9	26 (13.9)	161 (86.1)	1		0	1	
	>=200.0	32 (40.5)	47 (59.5)	4.216 (2.288,7.768)	<0.001*	0.934	2.545 (1.156,5.601)	0.020*
Type of oil	Liquid	25 (18.8)	108 (81.2)	1				
	Solid	33 (24.8)	100 (75.2)	1.426 (0.793,2.563)	0.236			
Intensity of activity (daily work)	Low	11 (35.5)	20 (64.5)	6.325 (1.250,32.007)	0.026*	0.325	1.384 (0.188, 10.200)	0.750
	Moderate	45 (21.4)	165 (78.6)	3.136 (0.713,13.806)	0.131*	0.319	1.376 (0.430,4.401)	0.590
	Vigorous	2 (8.0)	23 (92.0)	1		0	1	
Sitting time per day	=<5hrs	37 (20.4)	144 (79.6)	1				
	>=6hrs	21	64	1.277	0.433			

		(24.7)	(75.3)	(0.693,2.353)				
W_Ht_R	<0.55	11 (6.1)	170 (93.9)	1		0	1	
	>=0.55	47 (55.3)	38 (44.7)	19.115 (9.077,40.254)	<0.001*	2.719	15.166 (6.575,34.981)	<0.001*
Walking at least 10 minutes daily	Yes	43 (19.1)	182 (80.9)	1		0	1	
	No	15 (36.6)	26 (63.4)	2.442 (1.192,5.002)	0.015*	1.193	3.297 (1.197,9.080)	0.021*
Vigorous & moderate activity	Yes	3 (9.1)	30 (90.9)	1		0	1	
	No	55 (23.6)	178 (76.4)	3.090 (0.908,10.56)	0.071*	0.374	1.453 (0.309,6.834)	0.636
Ever consumed Alcohol	Yes	48 (22.3)	167 (77.7)	1.178 (0.550,2.525)	0.673			
	No	10 (19.6)	41 (80.4)	1				
Current alcohol consumption	Yes	47 (22.1)	166 (77.9)	1.081 (0.516,2.263)	0.836			
	No	11 (20.8)	42 (79.2)	1				
House ownership	Yes	38 (30.2)	88 (69.8)	2.591 (1.412,4.756)	0.002*	0.263	1.300 (0.529,3.195)	0.567
	No	20 (14.3)	120 (85.7)	1		0	1	
House servant	Yes	21 (33.3)	42 (66.7)	2.243 (1.191, 4.227)	0.012*	0.075	1.077 (0.408,2.849)	0.880
	No	37 (18.2)	166 (81.8)	1		1		
Having laundry machine	Yes	28 (37.3)	47 (62.7)	3.197 (1.739,5.878)	<0.001*	0.524	1.690 (0.717,3.979)	0.230
	No	30 (15.7)	161 (84.3)	1		0	1	

Maximum SE 0.542, Hosmer and Lemeshow 0.661; COR: Crude Odds Rati; AOR: Adjusted Odds Ratio; W_Ht_R: Waist to Height Ratio; PCA: Principal Component Analysis; BMI: Body Mass Index.

Discussion

The prevalence of MetS in this study was 21.8%, which was higher than previously reported prevalences from urban areas of Ethiopia like Mizan Aman town (9.6%) [26], and at a national level (11.7%) [15]. Since the study was conducted among healthy adult individuals, this prevalence was considered high. This could be due to improved income, which leads to nutrition transition (a shift from a fiber-rich traditional diet to refined sugar and fat-rich western-style diet). A systematic review finding by Roomi MA and Mohammadnezhad M from Pakistan and a cross-sectional study by Herningtyas and Ng from Indonesia reported a similar prevalence of MetS (21.7% [27] and 21.66% [28] respectively). According to a study conducted by A. Tran et al. among working adults in Addis Ababa (Ethiopia), the overall prevalence of MetS was 17.9% using IDF criteria which were lower than this study finding [22]. A lower prevalence of 16.7% of MetS has been reported by health facility-based study conducted among men study participants in India [29]. Hospital-based cross-sectional studies from Ethiopia also reported a higher prevalence of MetS with a prevalence 70.1% among diabetic Mellitus patients from Hawassa referral hospital [21]; 48.7% and 40.7% among hypertensive individuals from Hawassa [30] and Gondar [17] referral hospitals respectively; and 24.3% and 21.1% among individuals under HAART in Hawassa [19] and Jimma [20] referral hospitals respectively. Higher prevalence of MetS was reported from different African countries like farmworkers of South Africa [31]; urban inhabitants of Kenya [32]; outpatient attendants of Botswana (using NCEP ATP-III criteria) [33]; and Nigeria [34] with a prevalence of 42.6%, 25.6%, 27.1%, and 29.1% respectively.

Elevated waist circumference was the most prevalent MetS component followed by hypertriglyceridemia, with a prevalence of 41.7% and 38.0% respectively. The prevalence of the remaining three components of MetS was also higher with 33.8%, 32.7%, 21.4%, and 14.3% for systolic blood pressure, diastolic blood pressure, fasting blood glucose, and lower high-density lipoprotein cholesterol respectively. A study conducted by Kerie and his colleagues in Mizan Aman town, Southern Ethiopia reported similar rank except being lower prevalence and reduced HDL-c was the highest in prevalence with a prevalence of 26.2%, 22.8%, 16.9%, 7.1%, and 50.9% for elevated waist circumference, triglyceride, systolic blood pressure, diastolic blood pressure, fasting blood glucose, and lower high-density lipoprotein cholesterol respectively [26]. An occupational study conducted in Ethiopia by Nshisso et al. also found a prevalence of 19.1% and 6.5% for hypertension and diabetes respectively [35]. A study done by Young, *et al*. in Nigeria also found a higher prevalence of low HDL-c and lower hypertriglyceridemia with a prevalence of 40.0% and 14.4% respectively [34]. A study done by Anas Ahmad Sabir et al. in Nigeria reported a high prevalence of MetS and its components using NCEP ATP III criteria with a prevalence of 35.1%, 56.1%, 46.1%, 32.7%, 28.0%, and 22.4% for MetS, low HDL-c, hypertension, dysglycemia, central obesity, and elevated triglyceride respectively [36]. A study conducted in South Africa among farmworkers also indicated the prevalence of the individual metabolic syndrome components as 64.9%, 56.4%, 56.4%, 31.9% and 23.4% for hypertension, abdominal obesity, low HDL cholesterol, elevated triglyceride level, and elevated fasting blood glucose respectively [31]. Abdominal obesity (53%), low HDL-c (34%), high triglyceride (21%) and hyperglycemia (20%) were the most frequently occurring risk factors for metabolic syndrome in the United Arab Emirates [37].

Age is significantly associated with MetS in this study. The likelihood of having MetS among study participants over the age of 40 years was around 2.7 times higher than those within the age range of 20-39years (AOR (95% CI) = 2.734 (1.244, 6.006), p-value 0.012). This could be due to decreased activity level; physiological changes like increased fat mass accompanied by decreased muscle mass; and increased alcohol consumption. A similar finding has been reported from Mizan Aman town in Southern Ethiopia, with a risk of MetS was lower among lower age groups [26]. A study conducted in Addis Ababa also found that the prevalence of MetS increased with age, with the highest prevalence reported among 45-54years old adults [22]. A study conducted by Pradeep Selvaraj and Logaraj Muthunarayanan in India also reported the same finding [29]. According to a study finding from South Africa, MetS was highest among 40-49years old individuals and decrease thereafter [31]. Systematic review findings from Iran indicated that being older adults, and those with low physical activity have been reported to have a higher rate of MetS [38]. The tendency of developing MetS increases with age [39-40]. Older adults are at higher risk of having MetS [41].

According to this study finding, study participants who did not walk at least 10 minutes on daily basis were more than 3 times more likely to develop MetS than their counterparts (AOR (95%CI): 3.297 (1.197, 9.080), p-value 0.021). This could be due to the benefit of walking on burning more energy, which can prevent weight gain and fat accumulation. In addition, walking can improve insulin sensitivity and build muscle mass rather than fat mass [42]. An increase in the consumption of high calorie-low fiber-fast foods and the decrease in physical activity are the two basic forces responsible for spreading MetS [3]. According to the study finding conducted by Workalemahu and his colleagues in Ethiopia, physical activity was inversely associated with MetS among men only [43].

The present study also showed that study participants in the highest rank of monthly income were more than 5 times more likely to develop MetS than in the lowest income ranks (AOR (95% CI): 5.521 (1.955, 15.590), p-value 0.001). This may be due to increased access to energy-dense foods, alcohol consumption, and motorized transportation. The contradictory finding has been reported from Angola, which revealed that metabolic syndrome was not statistically associated with social class [39]. Whereas another study from Korea revealed different findings, only women with higher income had a lower risk of developing MetS [40].

Waist to height ratio was also significantly associated with MetS. Study participants with waist to height ratio >=0.55 were around 15 times more likely to develop MetS than in their lower ratio counterparts with (AOR (95% CI): 15.166 (6.575, 34.981), p-value <0.001). This could be due to the reason that the higher the waist circumference, the higher the ratio, and if an individual has high waist circumference, this shows central obesity and that is one component of MetS. On top of that, individuals with central obesity are at higher risk of insulin resistance (hyperglycemia), elevated triglyceride and lower HDL-c. But the literature on the effect of the waist to height ratio on metabolic syndrome in adults is limited.

Elevated concentration of blood cholesterol was also significantly associated with MetS. Research participants with a blood cholesterol level of above 200mg/dl were around 2.5times more likely to develop MetS than individuals with normal blood cholesterol concentration (AOR (95% CI): 2.545 (1.156, 5.601), p-value 0.020). The reason behind may be, elevated blood cholesterol directly related to most components of MetS, like elevated triglyceride and which is also inversely related to HDL-c. It also leads to hypertension due to artery plaque formation and atherosclerosis. The tendency of having high blood cholesterol can also increase with weight and central obesity. A similar finding has been reported by Herningtyas, and Ng from Indonesia [28].

Conclusion

Metabolic syndrome and its components were highly prevalent among healthy adult individuals in the city. This shows Ethiopia is in a transition stage from communicable to non-communicable disease burden. In addition, Ethiopia is on a double burden of both under and over nutrition. Emphasis should be given especially for adult urban inhabitants because of improved economic status and lower activity levels. Routing screening, counseling, and management scheme of MetS should be in place in the health facilities at the national level, especially in the urban areas. Addressing the upstream risk factors of MetS is cost-effective and feasible for developing countries like Ethiopia prior to the creation of the NCD epidemic. Since most adults in Ethiopia were under-nourished during their childhood and adolescent period, they are more prone to late over nutrition. So if attention is not given to MetS, the worst is yet to come. In addition, adult individuals are advised to enhance physical activity and adopt a healthy lifestyle.

Abbreviation

BMI: Body Mass Index; BP: Blood Pressure; BW: Body Weight; DBP: Diastolic Blood Pressure; DM: Diabetic Mellitus; FBG: Fasting Blood Glucose; IDF: International Diabetic Federation; LDLc: Low-Density Lipoprotein cholesterol; MetS: Metabolic Syndrome; NCDs: Non-Communicable Diseases; NCEP ATP-III: National Cholesterol Education Program Adult Treatment Panel III; SBP: Systolic Blood Pressure; TC: Total Cholesterol; TG: Tri-Glyceride; WC: Waist Circumference; WHO: World Health Organization.

Declarations

Ethics approval and consent to participate:

The Institutional Review Board of Jimma University has approved the proposal with a reference number of **IHRPGD/349/2019**, and we obtain written informed consent from each study participant.

Consent for publication:

Not applicable

Availability of data and materials:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

Funding:

Jimma and Adigrat Universities have funded this research in collaboration. The funding organization has no role in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.

Authors' contributions

GG and DT designed the study; they had full access to all of the data in the study and take responsibility for the integrity of the data, the accuracy of the data analysis, the interpretation of the data and drafted the manuscript. TB and KM critically revised the manuscript. All authors read and approved the final version of the manuscript.

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Figures

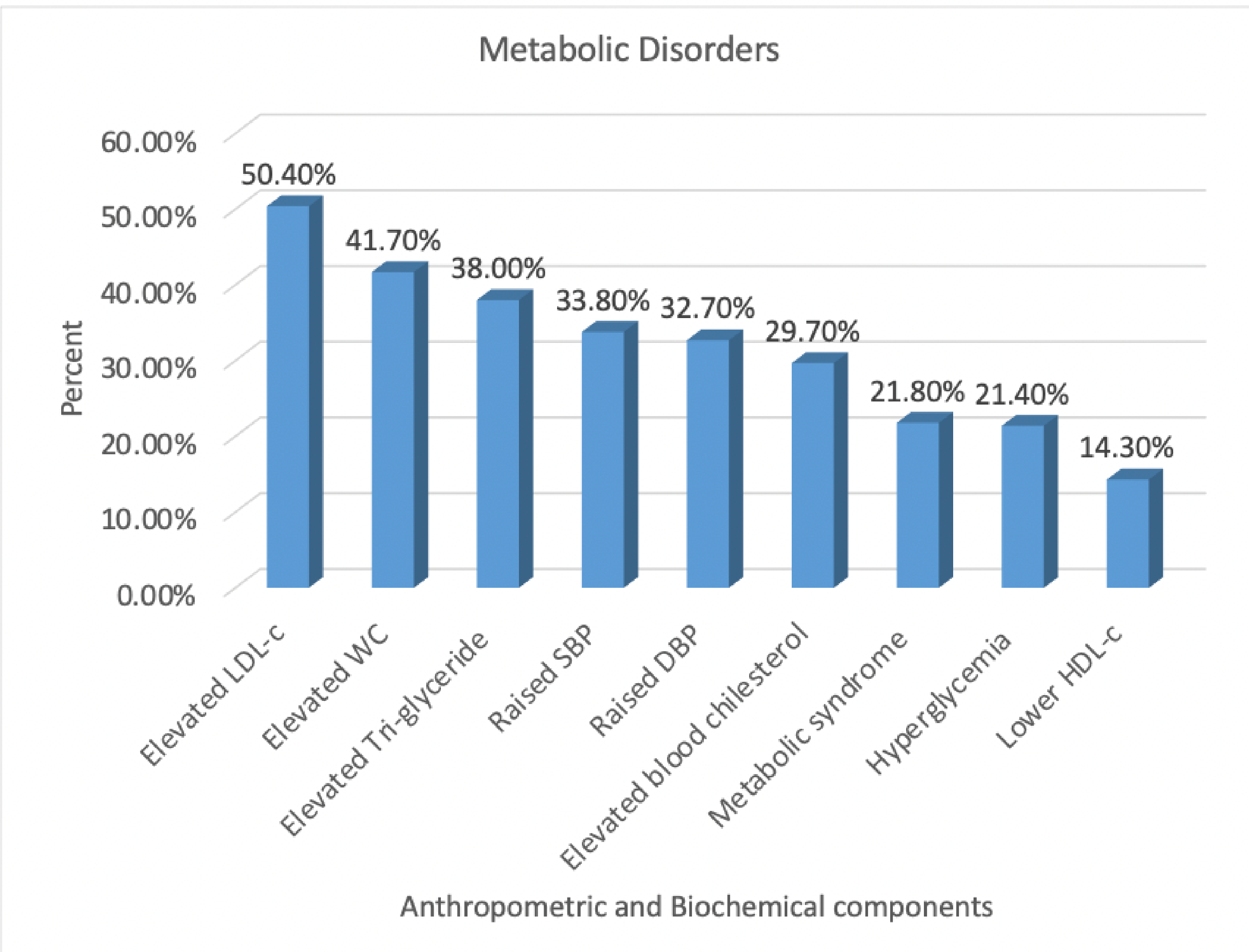

Figure 1

Elevated biomedical and anthropometric findings among the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

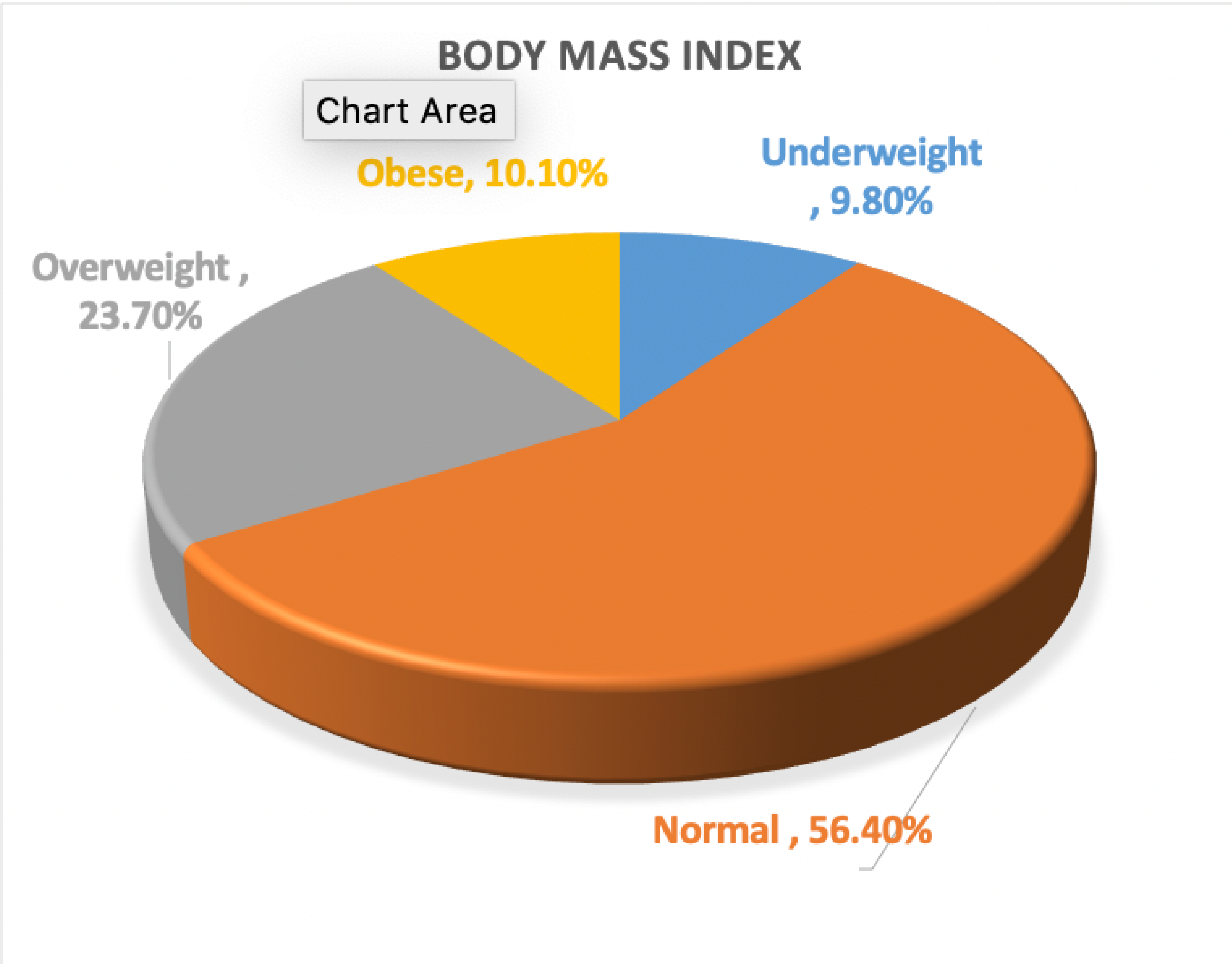

Figure 2

BMI category of the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

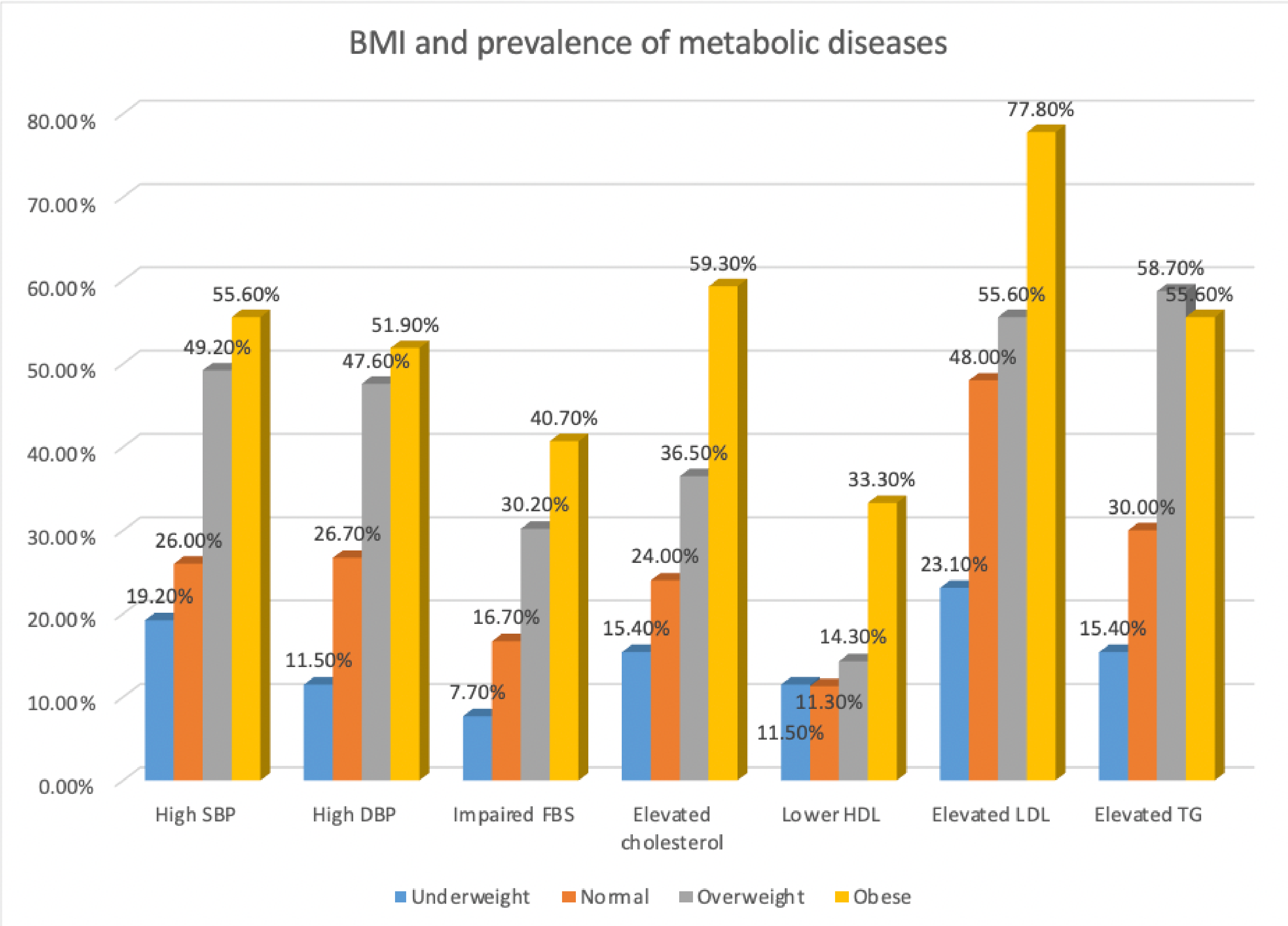

Figure 3

biomedical findings with respect to BMI among the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

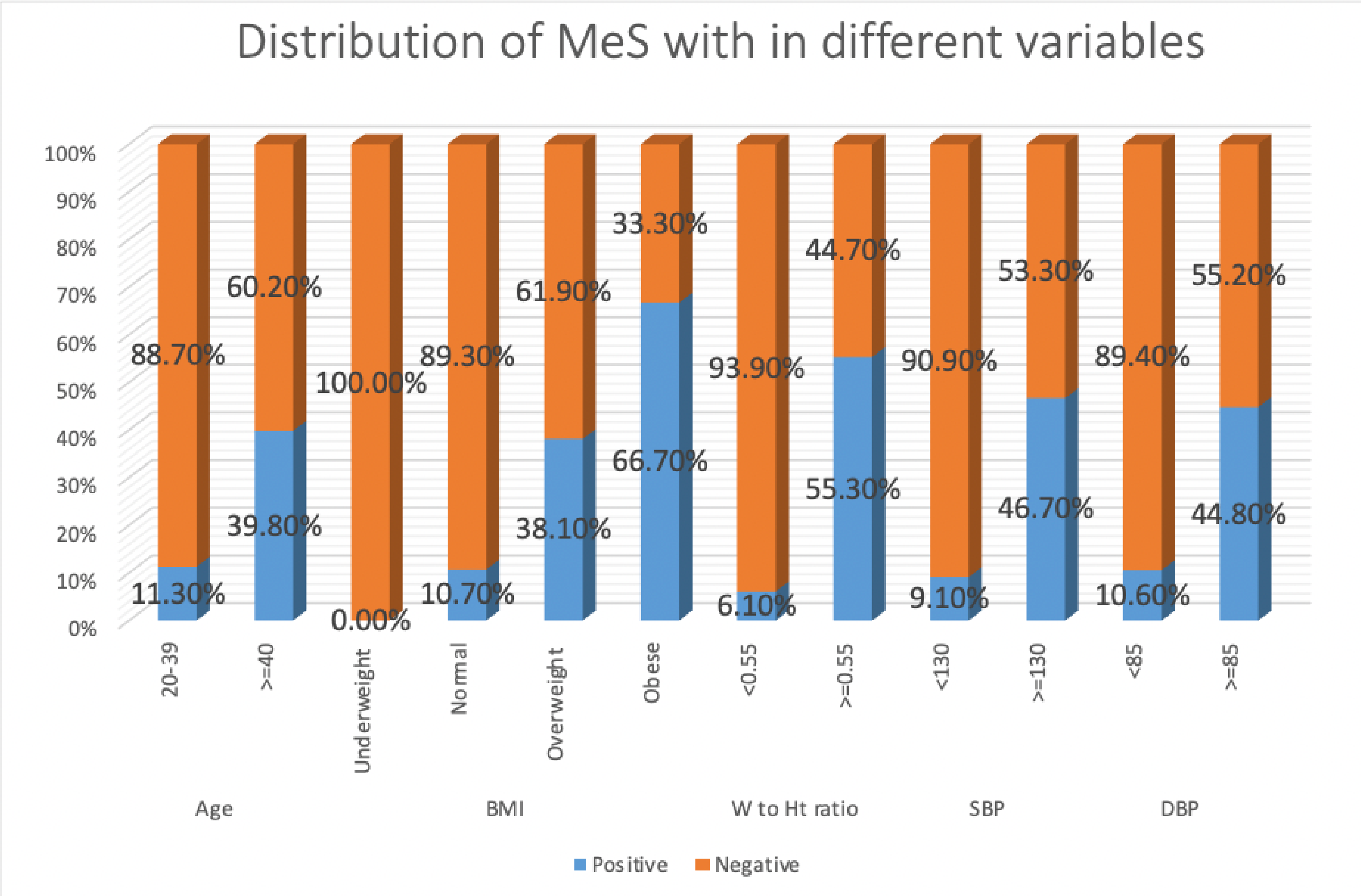

Figure 4

distribution of MetS with respect to different variables among the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

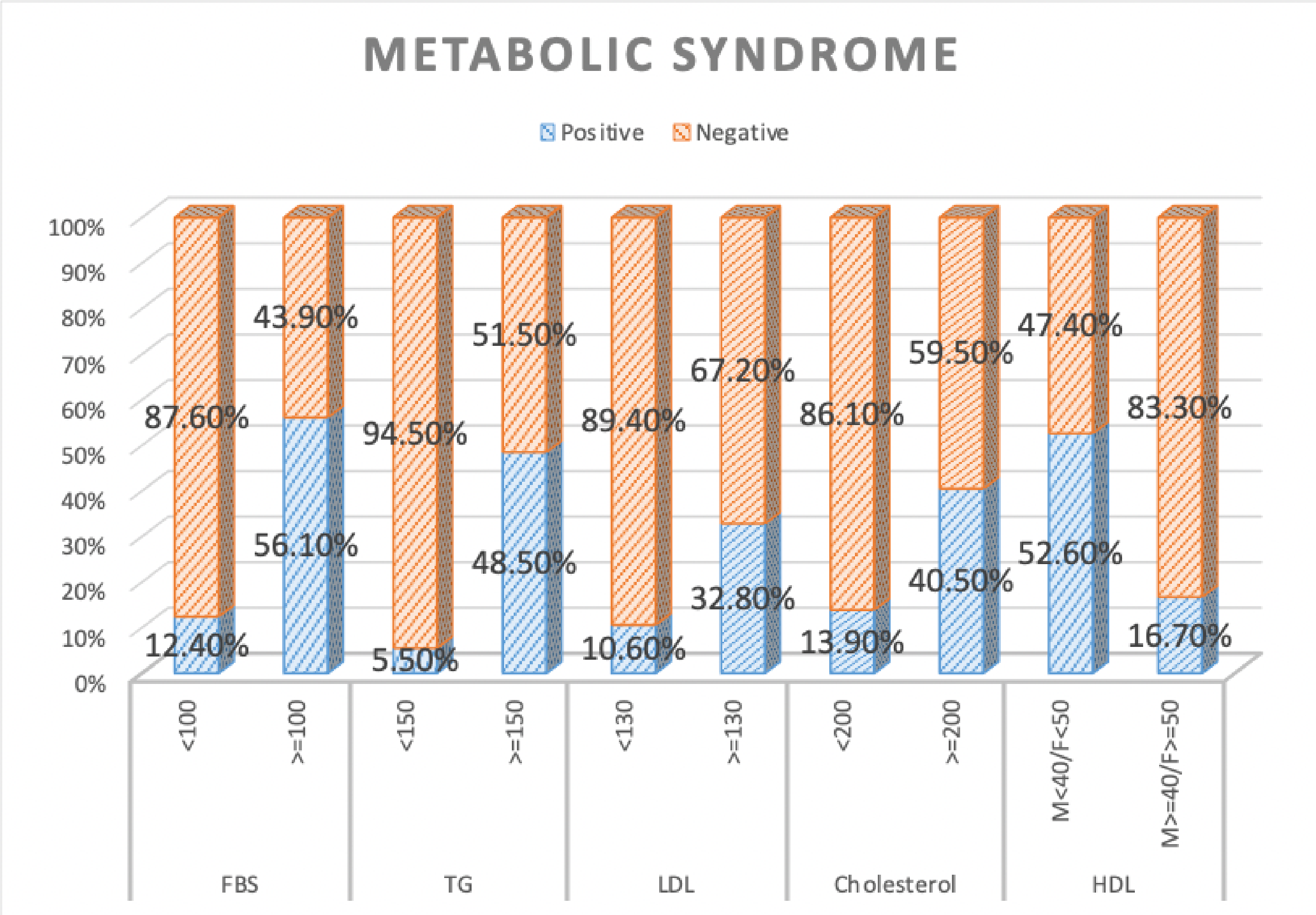

Figure 5

distribution of MetS with respect to different variables among the study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).

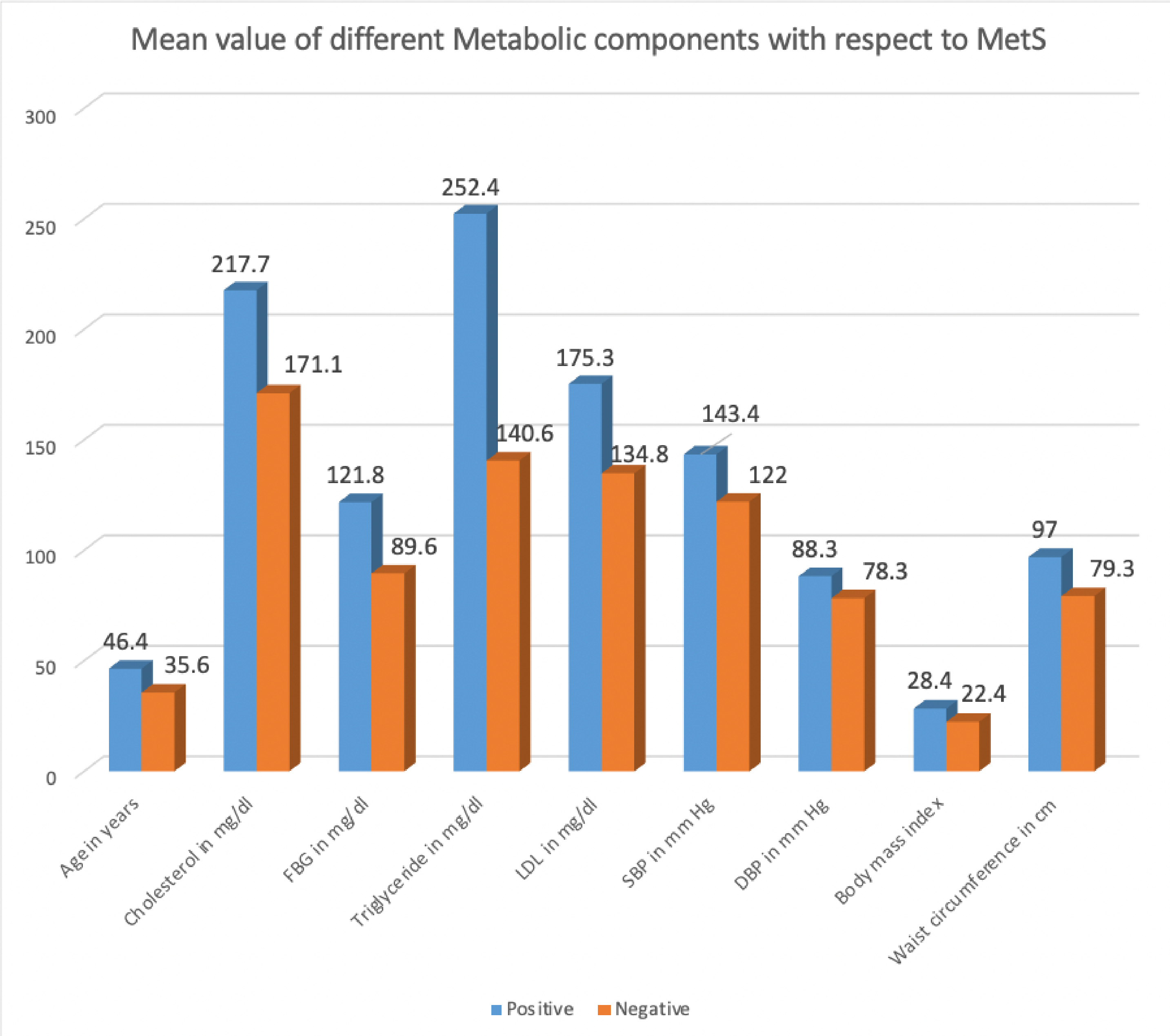

Figure 6

Mean value of different MS components for MetS positive and negative study participants in Mekelle city, Northern Ethiopia, 2019 (n = 266).