The aims of this study were as follows: (1) to assess the prevalence and its predictors of obesity among the urban population, (2) to analyze the association of obesity with MetS, and (3) to analyze the correlation of obesity with different components of MetS. Materials and Methods: A community-based cross-sectional study was conducted in an urban area of Rishikesh. The World Health Organization STEPS instrument and protocol were used for the assessment of risk factors and measurements. The sample size was calculated to be 478. Data were analyzed using SPSS version 20.0. Appropriate statistical tests for bivariate and multivariate analysis were done. P < 0.05 was considered statistically significant. Results: The prevalence of MetS among obese individuals was significantly higher (57%) according to the National Cholesterol Educational Program Adult Treatment Panel 3 definition (P < 0.001). The prevalence of MetS in male and female obesity was 56.8% and 57.1%, respectively. Body mass index was significantly correlated with systolic blood pressure (BP) (r = 0.238, P = 0.001), diastolic BP (r = 0.281, P = 0.001), Fasting blood glucose (FBG) (r = 0.136, P = 0.003), and triglycerideTriglycerides (TG) (r = 0.12, P = 0.009) and negatively correlated with High Density Lipoproteins (HDL) (r = −0.041, P = 0.37). Whereas, waist–hip ratio was significantly correlated with systolic BP (r = 0.277, P = 0.001), diastolic BP (r = 0.251, P = 0.001), FBG (r = 0.232, P = 0.001), and TG (r = 0.273, P = 0.001) and not with HDL (r = 0.033, P = 0.466). Conclusions: As the prevalence of MetS is higher among obese individuals, health interventions required to reduce the morbidity/mortality and need to be addressed in adult populations.

Keywords: Metabolic syndrome, National Cholesterol Educational Program Adult Treatment Panel 3 criteria, noncommunicable disease, obesity, Uttarakhand

Introduction

Obesity represents a rapidly growing menace to the health of many developed and developing countries. It is now replacing traditional problems such as undernutrition and infectious diseases as the most significant causes of ill health.[1] According to the World Health Organization (WHO) in 2016, more than 1.9 billion adults were overweight and over 650 million among them were obese. Nearly 39% of adults aged more than 18 years were overweight and 13% were obese.[2] More than 135 million individuals were affected by obesity in India.[3] Raised body mass index (BMI) is a major risk factor for noncommunicable diseases such as cardiovascular diseases (CVDs), stroke, diabetes, musculoskeletal disorders, and some cancers.[2] In 2015, the ICMR-INDIAB study reported that the prevalence rate of obesity and central obesity varies from 11.8% to 31.3% and 16.9% to 36.3%, respectively. Abdominal obesity is one of the major risk factors for CVDs in India. Various researches have proven that the prevalence of obesity among women changed into significantly higher in comparison to men.[5] Kandpal et al. reported more than 50% of obesity (54.8% males and 57.6% females) in Uttarakhand region which is higher than the previous National Family Health Survey-4 report.[5] Metabolic syndrome (MetS) is a cluster of disorders, which includes blood sugar, blood
pressure (BP), waist circumference (WC), and cholesterol. Several international agencies such as the WHO, European Group for the Study of Insulin Resistance, National Cholesterol Educational Program Adult Treatment Panel III (NCEP ATP III) criteria, and International Diabetes Federation have given different criteria for defining MetS [6-8]. In Uttarakhand, limited studies are available on MetS. Therefore, the current study was conducted in urban areas under the Municipal Corporation of Dehradun district to estimate the prevalence of MetS and its associated risk factor obesity in people 19–60 years of age. The objective of the study is to assess the prevalence and its predictors of obesity among the urban population and to analyze the association of obesity with MetS and to analyze the correlation of obesity with different components of MetS.

**Materials and Methods**

A community-based cross-sectional study was conducted from April 2018 to March 2019 for a duration of 1 year in the age group of more than 19–60 years residing in urban areas of Rishikesh. Assuming the proportion of MetS in young adults is 34.3%, the sample size was calculated to be 227 by keeping relative precision of 18%. Applying a design effect of 2.0, the sample size was calculated to be 454. Considering a dropout rate of 5%, the final sample size was calculated to be 478. Individuals in the age group of 19–60 years on the day of data collection and who consent to participate in the study and residing for more than 6 months in the area were eligible for inclusion in the study. Diagnosed cases of cirrhosis of the liver, chronic kidney disease, Cushing’s syndrome, and hypothyroidism were excluded from the study. Patients with Type 1 diabetes mellitus and secondary hypertension and those on drugs causing overweight/obesity such as steroids, oral contraceptives, and antidepressants were also excluded. Pregnant females were also excluded.

Rishikesh is a Nagar Palika Parishad city in district Dehradun, Uttarakhand. Rishikesh city is divided into 20 wards with population of 70,189 as per the Census India, 2011. Cluster sampling technique, which is a kind of two-stage sampling technique, was used to select the representative population of urban areas of Rishikesh. At the first stage, a list of urban areas from the District Urban Development Authority office was taken, and then, ten clusters were selected. At the second stage, 48 study participants from each of the selected clusters were selected. The chit lifting technique was used to select one individual from 19 to 60 years from each household.

If all the 48 study participants could not be found from a single cluster, then the contiguous cluster was taken until the desired number was completed. It was ensured to select only one study participant from each selected house. With a dropout of 2, the final analysis was done for 478 participants. Informed written consent from the participants was obtained after informing them that the participation was voluntary, and there was no harm to the participant due to or during our study. A pretested interview schedule was used for data collection regarding sociodemographic characteristics. The WHO STEPS instrument and protocol were used for the assessment of risk factors and measurements.[11]

The study was started after getting approval from the Ethics Committee of the institution (Ref. no.: AIIMS/IEC/18/95), AIIMS, Rishikesh. Confidentiality of the information obtained from the patient was maintained, and the identity of the patient was not revealed. Descriptive statistics were used for getting percentages, proportion, mean (standard deviation), and median (interquartile range). Chi-square test was used to examine the association between categorical variables. A significance level of 5% was used for all of the statistical tests. The data were analyzed using SPSS version 20.0 (IBM Corp., Armonk, N.Y., USA).

Body weight (nearest 0.5 kg), height (nearest 0.1 cm), waist (nearest 0.2 cm), and hip circumferences (nearest 0.2 cm) were obtained using standard tool. The BMI (kg/m²) and waist–hip ratio (WHR) were subsequently computed. WC was measured at the end of normal expiration, with the arms relaxed on the sides, at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest (hip bone). The data were analyzed using cutoff points of 90 cm in men and 80 cm in women. WHR was calculated by dividing WC (in cm) by hip circumference (cm). Hip circumference was measured at a level parallel to the floor at the largest circumference of the buttocks. The cutoff points are 0.95 in men and 0.80 in women to denote abdominal obesity.[13] An accredited social health activist worker of the particular ward is trained for the assessment of anthropometric measures for females and they measured.

BP was measured for each participant using the auscultatory method with a standardized aneroid sphygmomanometer (Rossmax Swiss GmbH).[11] Laboratory assessments included measurements of high-density lipoproteins (HDLs), triglycerides (TGs), and fasting blood sugar (FBS) obtained by venous blood samples. The day before the blood sample collection, participants were informed to be in overnight fasting for 12 h, and a total 5 ml of blood samples was collected in the next day morning from 6 a.m. to 8 a.m. after ensuring the participant in fasting. The analysis was carried on an automated clinical chemistry analyzer. Beckman reagents and Beckman Coulter AU480 and AU680 calibrators were used for the analysis. Control sera were included in each batch of samples analyzed. All measurements were carried out in the Biochemistry Laboratory, AIIMS, Rishikesh.

BMI is defined as a person’s weight in kilograms divided by the square of the person’s height in meters (kg/m²) [Table 1].[14]

Defining criteria for MetS using NCEP ATP 3 Criteria: When three of the following five conditions met:[15]

1. Fasting blood glucose (FBG) ≥100 mg/dL or Type 2 diabetes receiving drug therapy for hyperglycemia
2. High BP ≥130/85 mm Hg or high BP receiving drug therapy
3. TGs ≥150 mg/dL or treatment for plasma hypertriglyceridemia value

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4. HDLs <40 mg/dL in men and <50 mg/dL in women or if under therapy for reduced HDL-cholesterol (HDL-C) levels
5. WC of ≥90 cm in men and ≥80 cm in women.

RESULTS

The number of participants included in the study was 478 (men/women, 165/313). The study reveals that the majority (32.8%) of the study participants were in the age group of 31–40 years. Females constituted 65.5% of the total sample. Twenty-nine percent were high school pass and another 24.9% had completed education till higher secondary certificate. A little more than half (56.3%) were unemployed.

The mean age of these participants was 42 ± 12.0 years and mean BMI was 24.7 ± 5.04 kg/m² (23.38 ± 4.06 in men and 25.46 ± 5.35 in women).

Analysis of BMI among study participants according to the WHO classification showed that the proportion of people who were underweight was 11.2%, whereas the proportion of overweight and obese people was 32.4% and 13.3%, respectively [Table 2]. The corresponding proportion of overweight and obese Grade 1, and obese Grade 2 categories, respectively [Table 2]. The corresponding proportion of overweight and obese Grade 2 among males was observed to be 6.4%, whereas that among females was found to be 9.6%, 21.8%, and 11.9%, respectively.

Analysis of WC showed that about half of the males (47.2%) and three-fourth of the females (73.1%) had a WC greater than the cutoff of 90 cm and 80 cm, respectively, whereas only 2.4% and 1.2% had WHR within the specified limits of <0.95 and 0.80 [Table 3].

It was observed that the mean weight, WC, WHR, BMI, and hip circumference were greater among those with MetS, and these differences were found to be statistically significant at P = 0.05.

The prevalence of MetS among obese individuals was significantly higher (57%) according to NCEP ATP III definition (P < 0.001). The prevalence of MetS in male and female obesity was 56.8% and 57.1%, [Table 4].

BMI was significantly correlated with systolic BP (r = 0.238, P = 0.001), diastolic BP (r = 0.281, P = 0.001), FBG (r = 0.136, P = 0.003), and TG (r = 0.12, P = 0.009) and negatively correlated with HDL (r = −0.041, P = 0.37). Whereas, WHR was significantly correlated with systolic BP (r = 0.277, P = 0.001), diastolic BP (r = 0.251, P = 0.001), FBG (r = 0.232, P = 0.001), and TG (r = 0.273, P = 0.001) and not with HDL (r = −0.033, P = 0.466) [Figures 1 and 2].

DISCUSSION

MetS is an important determinant of CVDs and stroke. This

| Grades          | WHO general population classification | Asia-Pacific classification |
|-----------------|--------------------------------------|-----------------------------|
| Underweight     | <18.5                                | <18.5                       |
| Normal          | 18.5-24.9                            | 18.5-22.9                   |
| Overweight      | 25-29.9                              | 23-24.9                     |
| Obesity Class I/Grade 1 | 30.0-34.9                | 25-30                       |
| Obesity Class II/Grade 2 | 35.0-39.9             | ≥30                         |
| Obesity Class III | Above 40                               | -                           |

WHO: World Health Organization

Table 2: Distribution of study participants body mass index according to the World Health Organization Classification for the general population

| Variables                      | Cutoff level | Males (n=165), n (%) | Females (n=313), n (%) | Total (n=478), n (%) | 95% CI |
|--------------------------------|--------------|----------------------|------------------------|---------------------|--------|
| According to the WHO classification for the general population |              |                      |                        |                     |        |
| Underweight                    | <18.5        | 26 (15.7)            | 28 (8.9)               | 54 (11.2)           | 8.3-14.0 |
| Normal                         | 18.5-24.9    | 51 (30.9)            | 124 (25.9)             | 205 (42.8)          | 38.5-47.3 |
| Overweight                     | 25-29.9      | 7 (4.2)              | 42 (8.8)               | 49 (10.2)           | 7.5-13.0 |
| Obesity Class 1                | 30.0-34.9    | 0                    | 13 (2.7)               | 13 (2.7)            | 1.3-4.2 |
| Obesity Class 2                | 35.0-39.9    | 0                    | 2 (0.4)                | 2 (0.4)             | 0-1.0   |
| According to the WHO Asian classification |              |                      |                        |                     |        |
| Underweight                    | <18.5        | 26 (5.4)             | 28 (5.9)               | 54 (11.2)           | 8.3-14.0 |
| Normal                         | 18.5-22.9    | 50 (10.4)            | 78 (16.7)              | 128 (26.7)          | 22.7-30.6 |
| Overweight                     | 23-24.9      | 31 (6.4)             | 46 (9.6)               | 77 (16.1)           | 12.8-19.3 |
| Obese Grade 1                  | 25-29.9      | 51 (10.6)            | 104 (21.8)             | 155 (32.4)          | 28.2-36.6 |
| Obese Grade 2                  | ≥30          | 7 (1.45)             | 57 (11.9)              | 64 (13.3)           | 10.2-16.3 |

CI: Confidence interval, MetS: Metabolic syndrome
study was an attempt to assess the relationship between obesity and MetS. The prevalence of MetS is increasing exponentially in India, both in the urban and rural areas. It has escalated in different parts of India to figures now ranging from 11% to 41%.\(^{16}\) Asian Indians are a high-risk population for MetS with respect to diabetes and CVD, and numbers are consistently on the rise.\(^{17}\) The prevalence of MetS and obesity in Asian Indians varies according to the region, the extent of urbanization,
lifestyle patterns, and socioeconomic cultural factors. Recent data showed that about one-third of the urban population in India’s major cities have MetS.\[18\]

Considering the above situation, the present study was conducted with 478 study participants, out of which 34.5% were males and 65.4% were females. A study conducted by Sawant et al. and Singh et al. revealed that there were 56.7% and 48.1% of males, respectively, in their study.\[19,20\] However, in our study, 34.5% of males only participated in spite of taking all necessary efforts.

In the current study, the prevalence of MetS by modified NCEP ATP III criteria came out to be 38.2%. The prevalence in males and females was found to be 33.9% and 40.5%, respectively. Banerjee et al., Bandela et al., Ramachandran et al., and Chinawale et al. reported a slightly higher prevalence of MetS in their study, which was 44.6%, 42.15%, 41.1%, and 40.01%, respectively.\[21-24\]

On the contrary, the lower prevalence of MetS was also observed by several studies by Singh et al., Singh et al., and Das et al., who reported the MetS prevalence of 34.3%, 26.6%, and 31.4%, respectively.\[9,20,25\]

Obesity and insulin resistant are the principal causative factors in the development of MetS.\[26\] The findings of this study revealed that most of the adults have high central obesity according to NCEP ATP III criteria (64.2%). Moreover, the overall overweight and obesity had reached an alarming rate (61.9%) in this group (16.1% overweight and 45.8% obese) and significantly higher among females (61.1%) than males (53.9%). The majority of the females (47.8%) had also increased central obesity compared to males (16.3%) and had shown significantly increased clustering of metabolic abnormalities compared to men.

According to NCEP ATP III definition, the prevalence of MetS had increased significantly from 35% among overweight participants to 53.5% among obese Grade 1 and 65.6% among obese Type 2. Talking about Uttarakhand, Rautela et al. revealed that the prevalence of overweight was 14.8% and obesity was 55.5%.\[27\] According to the Annual Health Survey in all empowered action groups states, the percentage of overweight population (BMI ≤25) is highest in Uttarakhand as 21.6% in 2014, but our study results still higher than this in 2019.\[28\]

The most prevalent component of MetS among study participants was low HDL-C (70.9%), followed by central obesity and elevated blood sugar (64.2% and 38.7%, respectively) according to NCEP ATP III criteria. Therefore, it is essential to increase the awareness in the population about methods of raising the concentration of HDL such as weight loss, aerobic exercise, smoking cessation, and pharmacologic management with niacin and fibrates.\[29\]

Singh et al. also noted similar to our study, central obesity found to be the strongest predictor of MetS. Also noted, females had three times more chances of developing MetS as compared to males, whereas overweight and obese participants had two to three times more chances of having MetS.\[20\]

Hence, the risks of MetS and its components significantly increased with BMI categories in men and women, and there was a significant association present.
CONCLUSIONS AND RECOMMENDATIONS

The prevalence of MetS was found to be higher in people with obesity. Health interventions required to prevent or reduce the morbidity/mortality need to be addressed in the adult population starting from their childhood. In people with obesity, intervention strategies for the control of hypertension, hyperglycemia, and dyslipidemia would lead to reductions in the subsequent MetS. Early identification through screening of the general population or high-risk individuals can be done for those where there is positive family history and belongs to the age group of more than 30 years for both sexes. Females are a higher risk of obesity and MetS from the study, which shows that they need health education and regular recreational activities other than household work. Moreover, approaches such as weight reduction will be useful strategies for increasing insulin sensitivity. The implementation of these strategies is important in the adult population.

Limitation

Among the study participants, the females (65.5%) were higher than the males (34.5%). The reason for females being higher in the study population was because of higher proportion of males were working group in the study area and the data was collected in the day time and hence they were missed from the study. However, each selected participant was approached three times for inclusion within the study as 3 separate days.

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Conflicts of interest

There are no conflicts of interest.

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