Prevalence of Metabolic Syndrome among Kumaoni Population of Uttarakhand: A Comprehensive Study

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ABSTRACT: Metabolic Syndrome (MetS) is a combination of physiological, clinical, metabolic and biochemical risk factors that involves central obesity, dyslipidemia, glucose intolerance, and hypertension. This syndrome is mainly responsible for 2.5 times increase in cardiovascular (CVD) death and 5 times more risk of raising diabetes. Cross-sectional research was done during the period 2019-2021 in the Kumaoni region of Uttarakhand. The list of all the areas was prepared and consequently four places were selected for data collection. A total of 500 subjects, who visited the clinic were considered in the study. The data were collected on blood pressure, anthropometry, lipid profile and blood glucose level from all the registered subjects. The prevalence of Metabolic Syndrome was assessed using the standards given by International Diabetes Federation (IDF). The parameters taken into consideration are sex, age, blood pressure, fasting plasma glucose, HDL, triglycerides, and BMI. Females were found to be more prone to metabolic syndrome as compared to males. The prevalence of Metabolic Syndrome was found to be 27% in overall population. The low percentage of participants with controlled and normal factors recommends a requirement for awareness programs and lifestyle/health wellness programs for the control and prevention of Metabolic Syndrome.

INTRODUCTION

Metabolic Syndrome (MetS) is a combination of dyslipidemia, impaired glucose metabolism, central obesity and hypertension. This syndrome is mainly related with the ensuing development of Type II diabetes mellitus (T2DM) and cardiovascular illnesses (Pradeepa *et al*., 2016). As per various studies, metabolic syndrome is accountable for 2.5 times increase in death because of cardiovascular risks and 5 times increase in developing T2DM (Moreira *et al*., 2014). The lifestyle parameters and socio-demographic characteristics have been found to relate to MetS. MetS are found to be the main force for the world-wide prevalenceof CVDs and T2DM (Sinha *et al*., 2016). This is the main reason more efforts have been taken to understand the patho-physiology of MetS, its associated risk factors and prevalence level in different countries to recognize strategies to treat/manage MetS at early and later ages. A strong association between geographical areas with Metabolic Syndrome has also been observed (Mohan *et al*., 2001; Kapil and Kaur., 2010). Increased body mass index (BMI) is one of the major risk parameters for non-communicable diseases (NCDs) like stroke, cardiovascular diseases (CVDs), musculoskeletal disorders, cancers and diabetes (Dakshinamurthy *et al*., 2020).

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Different guidelines by various international agencies have been used to define Metabolic Syndrome. Reaven first explained the MetS in 1988 as a constellation of changes linked with resistance to insulin-mediated uptake of glucose that includes an increase in triglycerides, high BP (blood pressure) and decrease in HDL - high-density lipoprotein (Reaven *et al*., 1988). World Health Organization (WHO) (Avogadro *et al*., 1965), the National Cholesterol Education Program and Adult Treatment Panel III (NCEP-ATP III) (NCEP, 2002), International Diabetes Federation (IDF, 2007) and the American Association of Clinical Endocrinologists (AACE) published their guidelines for defining MetS (Einhorn *et al*., 2003).

According to the Kumaon division, Office of the Commissioner Kumaon, Nainital, Kumaon is one of the region and administrative divisions of Uttarakhand, a mountainous state of northern India. It is a distinct geographical entity spread over 21,035 sq km. It includes districts of Almora, Baghweshwar, Champawat, Nainital, Udham Singh Nagar and Pithoragarh.

High-altitude environmental areas affect the prevalence of MetS from various aspects. The first point is that individuals living in high-altitude regions are thinner compared to those living in low-height areas. This opposite relation is independent of income, ethnicity and lifestyle (Woolcott *et al*., 2014). Obesity is a well-established risk parameter for type 2 diabetes (T2DM). The low prevalence of obesity can show the low incidence between the prevalence of hypertension and altitude. Various epidemiological studies recommend that high elevations could be related to dyslipidemia. In contrast, it is also reported that individuals living in high-elevated areas have a favorable increase in cardiovascular diseases and respiratory effectiveness, in spite of low oxygen availability**.** It is also observed that individuals at height have lower low-density lipoprotein (LDL), better fasting glucose levels, high HDL, reduced obesity (Anderson and Honigman, 2011).

In Uttarakhand, limited researches are available on MetS. Therefore, the current study was undertaken in Kuamoni areas under the Nainital district to establish the prevalence of MetS and its related risk factors in individuals 18-60 years of age. Thus, the objective of this research is to identify the MetS components that cross-sectional researchers use to determine Kumaon populations living in high-altitude areas.

MATERIALS & METHODS

Community-based cross-sectional research was undertaken in 2019-2021 in Uttarakhand, India. Uttarakhand is situated at an altitude of 640 meters (2100 ft) to 1000 meters (3280 ft) above the sea level. The study is conducted in Base Hospitals and private clinics of Haldwani, Almora, Pithoragarh and Uddham Singh Nagar. Data is collected from all the individuals visiting the hospital/clinic by taking consent to participate in the study. Pregnant females and people with more than 60 years of are excluded from the research. The objectives of the study and the procedure of collecting data were explained to each participant before initiating the study.

Socio-demographic Profile: Questionnaire was prepared to collect data and information regarding socio-demographic traits like age, gender, religion, caste, educational qualification, financial dependency, family income (monthly), occupation, family type, type of house, arrangement of living, marital status, physical activity and type of fuel used, were collected.

Anthropometric Measurement of MetS Risk Factors

Measurements of all the risk factors were taken under the supervision of a medical professional:

Waist Circumference (WC): It is measured using fibre-glass tape. WC was measured while the participant was standing. The participant should stand with a relaxed abdomen, and with weight divided equally over both his/her legs. This measurement was taken in the horizontal plane's direction, mid-way between the inferior rib's margin and the superior margin of the iliac crest. The observations were obtained and recorded at around 0.1 cm.

Body Weight: Weight was measured using a digital weighing machine. The participants were asked to stand with barefoot and wear light clothes. Participants were instructed to stand in a straight position on a steady flat surface of weighing scale and then the reading was recorded.

Height: Height was measured in centimeters using a stadiometer. Participants were instructed to stand in eye-ear plane without wearing shoes, with their back resting at the vertical background, heels together, and keeping eyes in a forward direction.

Body Mass Index (BMI): BMI was computed using the formula as follows:

$$BMI\ (kg/m^2) = Weight\ (kg)/Height\ (m^2)$$

TABLE 1

World Health Organization classification of BMI

<18.5	Underweight
18.5-24.9	Normal
25-29.9	Overweight and Pre-obese
30.0 – 34.9	Grade 1/Obesity Class 1
35.0-39.9	Grade21/Obesity Class 2
>40	Obesity Class 3

Source: Dakshinamurthy *et al*., 2020; WHO, 2010.

Clinical Determination of MetS Risk Factors

Blood Pressure: Blood pressure (BP) was measured using the digital BP machine in the sitting relaxed position. Subjects were asked to abstain from consuming alcohol or caffeinated drinks and smoking at least half an hour before taking measurements. Two readings were taken at the intervals of 15 min on the same arm and then the mean of the readings were taken as a final observation.

Collection of Blood Samples: Blood sample was collected from the all the people after 8 to 10 hours of fasting to measure Fasting blood glucose (FBG) using Erba glucose kit. Triglycerides were measured using Erba Triglyceride Des Kit and HDL-c by cholesterol kit. All the factors were measured in a completely automated analyzer.

Criteria of Metabolic Syndrome

The diagnosis criteria include: Waist Circumference – $\geq$ 90cm and $\geq$ 80cm for South Asian male and female respectively along with any 2 of the following factors:

- Increased levels of triglycerides (TGs) – $\geq$150 mg/dl or treatment of increased triglycerides
- Decreased HDL-c – < 40 mg/dl in males or < 50 mg/dl in females
- Hypertension – $\geq$130 mmHg (systolic) or $\geq$ 85 mmHg (diastolic)
- Increased FPG – $\geq$100 mg/dl or earlier diagnosis with diabetes (Alberti *et al*., 2005).

Statistical Analysis

SPSS version 20.0 was used for analysing the data. The test of Chi-square was applied to evaluate the relation of various factors with Metabolic Syndrome and without Metabolic syndrome among the Kumaoni population.

There are no such conflicts of interest in this document presented.

RESULTS

A total of 500 subjects were registered, out of which there were 293 (58.60%) males and 207 (41.40%) females. The socio-demographic information of the Kumaoni population is explained in Table 2. The inclusive mean age of the population under investigation was 35.41 years with a range of 25 to 65 years. The majority of the females were aged (30-40 years) while males were aged (35-45 years). Males are older than females. And, majority of the population lives in pucca house (70%).

TABLE 2

Distribution of participants according to socio-demographic characteristics

Parameters	Male (%) n=293	Female (%) n=207	Total (n=500)
Age			
<30	13 (4.4%)	25 (12.07%)	38 (7.6%)
30-40	80 (27.3%)	72 (34.7%)	152 (30.4%)
41-50	80 (27.3%)	36 (17.39%)	116(23.2%)
51-60	53 (18.08%)	51 (24.6%)	104 (20.8%)
>60	67 (22.8%)	23 (11.11%)	90 (18%)
Marital Status			
Single	96 (32.7%)	47 (22.7%)	143 (28.6%)
Married	197 (67.2%)	160 (77.29%)	357 (71.4%)
Economic Dependency			
Yes	99 (33.7%)	146 (49.8%)	287 (57.40%)
No	194 (66.2%)	61 (29.46%)	213 (42.60%)

Education			
Illiterate	45(15.3%)	87 (42%)	132 (26.4%)
Primary School Certificate	32 (10.9%)	24 (11.5%)	56 (11.2%)
Middle School Certificate	54 (18.4%)	30 (14.4%)	84 (16.8%)
Secondary School	69 (23.5%)	21(10.1%)	90 (18%)
High School Certificate	51 (17.40%)	20 (9.6%)	71 (14.2%)
College and above	42 (14.3%)	25 (12.07%)	67 (13.40%)
Occupation			
Unemployed	67 (22.8%)	141(68.10%)	208 (41.60%)
Unskilled Worker	98 (33.4%)	34 (16.40%)	132 (26.40%)
Clerical, shop owner, farmer	17 (5.8%)	8 (3.86%)	25 (5%)
Professional/Business	111 (37.8%)	24 (11.59%)	135 (27%)
Type of House			
Kuccha	34 (11.6%)	26 (12.56%)	62 (12.4%)
Semi-pucca	59 (20.1%)	34 (16.42%)	88 (17.6%)
Pucca	200 (68.25%)	147 (71.01%)	350 (70%)
Type of family			
Nuclear	100 (34.12%)	53 (25.60%)	143 (28.6%)
Joint	180 (61.4%)	144 (69.56%)	333 (66.6%)
Extended	13 (4.4%)	10 (4.83%)	24 (4.8%)

The most common factor that contributes to Metabolic Syndrome (MS) is HDL i.e., 83.7%, whereas one of the least common factor is hypertriglyceridemia, i.e. 42%. High blood pressure is more prevalent in males (84.6%) in comparison to females (78.3%), however, increased HDL levels were found to be higher in females (97.5%), than males (38.4%) (Table 3).

TABLE 3

Prevalence of MetS and its constituents- IDF (135/500)

Metabolic Syndrome	Total (n=135)	Male (n=52)	Female (n=83)
Central Obesity (WC male>102cm, female >88cm)	87	37	50
Systolic Blood Pressure (>130mmHg)	109	44	65
Diastolic Blood Pressure >85mmHg)	84	34	50
Hypertriglyceridemia (>150mg/dl)	57	23	34
HDL (<40mg/dl in men and <50 mg/dl in women)	101	20	81
Fasting Blood Glucose (>100mg/dl)	86	35	51

Table 4 indicates the distribution of the population having increased levels of various components of Metabolic Syndrome. It was found that majorly 39.2% of the population had derangement in 4 segments followed by the participants having 5 (30.3%), 3 (19.2%), and 6 (11.1%) components.

TABLE 4

Number of Metabolic Syndrome components – distribution of Kumaoni participants

Number of components of MS	Number of subjects (n=135)	n(%)
All 6	15	11.1
Any 5	41	30.3
Any 4	53	39.2
Any 3	26	19.2
Any 2	%	%

As per the above-mentioned table, the overall prevalence of Metabolic Syndrome (MetS) was found to be 27% (135/500). The MetS prevalence was majorly associated with females, higher income level individuals, and those having $\geq$ 25 BMI.

The prevalence of MetS increases with years of aging. The percentage of subjects with metabolic syndrome in each age group was explained in the table below. Metabolic syndrome is found to be higher among the Kumaoni population who were not doing physical activity on a regular basis than those who were doing regular physical activity (Table 5).

It was reported that in females, a decrease in age, more income, inconsistent physical activity and a BMI of more than 25 are found to be largely linked with Metabolic Syndrome. Moreover, females are more at risk of developing MetS in comparison to males.

TABLE 5

Factors related to Metabolic Syndrome

Parameters	Subjects with MS (n=135)	n (%)	Subject without MS (n-365)	n (%)
Age (years)				
<30	5	3.7%	20	5.47%
30-40	34	25.18%	119	32.6%
41-50	35	25.9%	85	23.28%
51-60	40	29.6%	70	19.17%
>60	21	15.5%	71	19.45%
Gender				
Male	38	27.9%	153	41.9%
Female	97	71.8%	212	58%
Education				
Illiterate	72	53.3%	189	51.7%
Primary School Certificate	25	18.5%	98	26.8%
Middle School Certificate	14	10.3%	36	9.86%
High School Certificate and above	24	17.7%	42	11.5%
Physical Activity				
Regular	51	37.7%	178	48.7%
Irregular	84	62.2%	187	51.2%
BMI				
<=25	47	34.8%	336	92%
>=25	88	65.18%	29	7.9%

DISCUSSION

The study was conducted to unravel the prevalence of Metabolic Syndrome among the Kumaoni population of India. The gender distribution and geographical-based study were also done to estimate the large differences in the MetS. The Metabolic Syndrome prevalence is increasing in both developing and developed countries (Cornier *et al*., 2008). MetS is a premorbid condition that helps recognize the risk of cardiovascular diseases and diabetes (Via-Sosa *et al*., 2014).

Asian Indians are at a higher risk in terms of diabetes and cardiovascular disease, and the number of people at risk is also consistently increasing (Enas *et al*., 2006). So this research was designed to determine the incidence of Metabolic Syndrome and evaluate the significance of several MetS constituents of patients visiting the clinic.

Thus, the cross-sectional study performed for the Kumaoni population of India living in high altitudes was limited. The current study showed the prevalence of Metabolic Syndrome as 27%. Various studies in India have observed different prevalence rates in different parts of India ranging from 9.3 – 47.5% (Mangat *et al*., 2010). The present study showed a higher prevalence of MetS in females than in males. However, these findings were quite synchronized with a few earlier studies. For example, Singh *et al*. conducted a study in J&K, and a largely higher prevalence was found among males (Singh *et al*., 2013). On the other hand, other two studies in North India observed a higher prevalence among females (Kapil and Kaur, 2010; Vikram *et al*., 2006). There are a few conditions specifically for females, like menopause, pregnancy, and PCOS, which may increase the risk of cardiovascular diseases in relation to MetS (Chatzi *et al*., 2009).

More young subjects are found to have a MetS where all the metabolic risk factors related to MetS are disturbed with increasing age (Ferrara *et al*.,1997). The variation is mainly because of the changing lifestyle of younger people over the last few years and because of increased consumption of junk food and lower physical activity. Additionally, the laborious lifestyle behaviour of the hilly population has also shifted to modest in this era because of economic easiness or liberalization (Gupta *et al*., 2009).

The cardiovascular risk parameters are increasing in a young group of Asian Indians. It has also been reported that diabetes (Sharma *et al*., 2005) and MetS are linked with inflammation and increased oxidative stress (Goyal *et al*., 2012).

In the present study, low HDL levels were found to be one of the most contributing factors among the

Kumaoni population of Uttarakhand. Earlier studies have reported that low HDL as the most important risk factor in the development of Metabolic Syndrome (Prasad *et al*., 2012; Ravikaran *et al*., 2010). It has been observed that the incidence of low HDL was higher among females compared to male counterparts. A similar result has been observed in various researches, which refers to the higher incidence of low HDL-c in females compared to males (Srinivasan *et al*., 2016).

The study found that 28.1 % of individuals are underweight, and 18.1% are obese. In 2008, the IDSP (Integrated Disease Surveillance Project) for Uttarakhand proposed that the Prevalence of central obesity and overweight was 18% and 14%, respectively. The National Family Health Survey 3, 2005-06, reported that 13% and 9% of females and males, respectively, were obese/overweight (Arnold *et al*., 2005-06).

A significant number of MetS population had increased blood pressure, and the difference was not that important. The incidence of a history of high BP was not found mainly in research on MetS in urban India, strengthening the current findings (Sawant *et al*., 2011).

The main strengths of the current study involve large population sample, utilization of standardized data collection guidelines, a representative sampling method, and limited to study among Kumaon population.

CONCLUSION

The current study recognized higher Prevalence of Metabolic Syndrome in high-altitude areas of Kumaon, Uttarakhand. There is a requirement for screening on a regular basis of people living in high altitude areas for the presence of metabolic risk parameters of Metabolic Syndrome so that the preventive measures can be started to prevent difficulties of diabetes mellitus and cardiovascular diseases.

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