Original Article

Prevalence of metabolic syndrome and associated risk factors among geriatric population living in a high altitude region of rural Uttarakhand, India

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Abstract

Introduction: Metabolic syndrome (MetS) is responsible for 2.5-fold increase in cardiovascular mortality and a 5-fold higher risk of developing diabetes. **Materials and Methods:** A community-based cross-sectional study was conducted during 2015–2016 in District Nainital. A list of all villages was developed. From this list, thirty villages were identified using population proportionate to size sampling method. From each village, thirty geriatric subjects (GSs) were selected. The study population included 979 GSs aged 60 years and above. The data were collected on anthropometry, blood pressure, blood glucose, and lipid profile from all the enrolled subjects. The prevalence of MetS was estimated using International Diabetes Federation criteria. Univariate and multivariate analysis was done to identify factors associated with MetS. **Results:** The prevalence of MetS was found to be 28.6%. Step-wise multivariate logistic regression analysis found that female gender, higher income, and body mass index ≥25 were significant and independent risk factors of MetS amongst GP. **Conclusion:** There is a need for screening of GP living in high altitude region so that efforts can be initiated to prevent complications of MetS.

Keywords: Geriatric, high altitude region, metabolic syndrome

Introduction

Metabolic syndrome (Mets) is a clustering of impaired glucose metabolism, dyslipidemia, hypertension, and central obesity. It is associated with the subsequent development of cardiovascular diseases and type 2 diabetes mellitus.[1] Studies reported that MetS is responsible for 2.5-fold increase in cardiovascular mortality and a 5-fold higher risk of developing diabetes.[2] Sociodemographic and lifestyle factors have found to be associated with MetS.[3,4] Geriatric population (GP) considered as a vulnerable population for the development of MetS.[5] In India, the prevalence of MetS among GP has been earlier reported as 42.1% in Hyderabad,[3] 35.6% in Kolkata,[6] and 29.9% in Karnataka.[7] A strong association of the geographical region with the MetS has also been noted.[8] The early detection of MetS is essential to prevent complication related to diabetes and cardiovascular disease among GP. There is a lack of data on the prevalence of MetS among GP living in high altitude region. Hence, to fill the gap in the existing knowledge, the present study was conducted to assess the prevalence of MetS and associated

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risk factors among GP living in high altitude region of rural Uttarakhand, India.

Methodology

A community-based cross-sectional study was conducted during 2015–2016 in District Nainital, Uttarakhand state, India. The district is situated at an altitude of 2084 m. A total of 1003 GP were enrolled from thirty clusters (villages) identified using population proportionate to size sampling methodology. After reaching the village, the village president member was contacted. From the selected village, one lane was selected randomly. From the selected lane, one household was selected randomly. The survey was initiated from the selected first household and contiguously covered all the required number subjects from that cluster. Thirty geriatric subjects (GS) in the age group of 60 and above were selected from each cluster by house-to-house visit. The GSs were identified with the help of village level health and nutrition functionaries such as Anganwadi workers. However, they did not participate in data collection. The objectives and procedure of data collection were explained to each subject. An informed written consent was obtained from each subject before data collection.

Sociodemographic profile

An oral questionnaire was administered to obtain identification of data and sociodemographic profile such as gender, age, caste, religion, financial dependency, educational qualification, occupation, family monthly income, type of house, type of family, marital status, living arrangement, type of fuel used, and physical activity.

Anthropometric assessment

All the measurements were taken by an investigator trained by the first author.

Waist circumference was measured using SECA-203 fiberglass tape. Waist circumference was measured in standing position. A measurement was taken with abdomen relaxed and weight equally divided over both legs. The waist circumference was measured in the direction of the horizontal plane, midway between the inferior margin of the rib, and the superior border of the iliac crest. The reading was recorded to the nearest 0.1 cm.[9] Precaution was taken to keep the head of the subject straight and arms relaxed.

Three readings were taken to minimize variation, and the average value was considered as WC of the subject.

Weight

Weight (in Kilograms) was measured with an electronic weighing scale SECA Model-813 to the nearest 100 g. The elderly subjects were asked to be barefoot and wear light clothing. They were asked to stand straight on a firm horizontal flat surface of scale, and weight on the screen was recorded.

Height

Height (in centimeters) was measured using SECA-213 portable stadiometer to the nearest 0.1 cm. The individual was asked to stand upright without shoes with his/her back against the vertical backboard, heels together, and eyes directed forward.

Body mass index

Body mass index (BMI) was calculated using the formula: BMI (kg/m^2) = Weight (kg)/Height (m^2). BMI (kg/m^2) was classified as <18.5 (underweight), 18.5–24.9 (normal), 25–29.9 (overweight and preobese), and ≥30 (Obese [OB]) as per the World Health Organization classification.[10]

Clinical assessment

Blood pressure (BP) was measured using the digital OMRON HEM– 7080 BP apparatus in the sitting position. Participants were restricted from alcoholic or caffeinated beverages and smoking at least 30 min before measurements. Two readings of BP were taken at 15 min intervals on the same arm; the mean of the two measures was taken as final reading.

Triglycerides and total cholesterol assessment

This was assessed using dried blood spot (DBS) methodology.[11-13]

Collection of dried blood spot

Whatman filter paper number 3 was properly labeled with the unique identification, date, and center code. Each subject was requested to clean and rub his/her hands against each other to stimulate blood flow. Third (middle) or fourth (ring) finger of each subject was selected for the finger prick.

Fingertip of each subject was wiped with alcohol swab completely and was allowed to air dry.

Subject's hand was gently kneaded from palm toward fingertip. The fingertip was pricked using lancet device and a full drop of blood was allowed to form on finger. First drop of blood was wiped off using a sterile swab and waited for the next large drop of blood to form.

Blood drop was allowed to fall on one side of the filter paper without making any contact between finger and filter paper. The uniform distribution of blood on filter paper was ensured.

Five blood drops from each subject were collected on filter paper in the similar manner.

Drying of blood spots

Filter papers were kept at room temperature for 4 h to allow the blood spot air dry completely.

Drying process was considered to be completed when the blood spots had a uniformly dark brownish color, and no red areas were visible.

Storage and transportation of dried blood spot

The following steps were taken for the storage and transportation of DBS filter paper:

Each DBS filter paper was sealed in an autoseal plastic bag to protect from dust and moisture after drying out. A total of ten small pouches containing DBS filter paper were transferred into a larger ziplock bag. A desiccant was kept inside each ziplock bag before zipping it. The sealed filter papers were repacked into icebox containing ice packs and transported to central laboratory AIIMS, New Delhi. Filter papers were stored at 4°C before analysis for up to 6 months.

Elution of dried blood spot

For the estimation of triglycerides (TG) and total cholesterol (TC), two 5 mm filter paper disc (10 μl of blood) was punched out. The punched blood spot was transferred into test tubes with Teflon screw cap. The 200 μl of methanol was added into test tubes. The tubes were incubated at 37°C for 1 h, with shaking at 100 rotations in an Environ Shaker.

Analysis of eluates

Biochemical estimation of TG was estimated by glycerophosphate oxidase–peroxidase method and TC was done by the cholesterol oxidase method using enzymatic kits from Randox Laboratories, Ltd., United Kingdom. For the measurement of TG and TC, 100 μl solution was extracted from the test tube. For TG, 50 μl of the extract was placed into test tubes and 50 μl of the extract was placed into Eppendorf for the analysis of TC. Commercially available enzymatic reagent (1 ml) was added in test tubes and eppendorf. The reaction mixture was stirred on a vortex mixer. Test tubes were incubated at 37°C for 15 min in water bath. Measurements of TG and TC were taken in spectrophotometer at 540 nm.

High-density lipoprotein assessment

Low-density lipoprotein (LDL) was derived using a new formula.[14]

High-density lipoprotein (HDL) derived using a standard Friedewald formula.[15]

Impaired fasting glucose Assessment

Blood sugar was measured using ACCU-CHEK active glucometer. Participants were instructed to be fasting for 12 h to assess blood sugar. Investigator inserted a test strip into a glucometer. Second drop of blood was used to fill up the blood glucose strip. Drop of blood put at the edge of the blood glucose test strip and blood entered in blood glucose strip. The blood sugar reading noted down after 5 s. All biohazardous waste (lancets, alcohol swabs, gauze, and gloves) collected into a plastic bag and burnt.

The study was approved by the Ethical Committee of All India Institute of Medical Sciences, New Delhi.

Metabolic syndrome criteria

The MetS classification by Indian Diabetic Federation was used.[16] A subject was identified suffering from MetS if he/she had abnormal central obesity (≥90 cm in men and ≥80 cm in women) along with any of the following two metabolic indicators: (i) elevated TG (≥150 mg/dl), (ii) Low HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women), (iii) HT (≥130/85 mm/Hg), and (iv) impaired fasting glucose (IFG) (≥100 mg/dl).

Hypercholesterolemia was defined as TC ≥200 mg/dL.[17]

High LDL was defined as LDL ≥130 mg/dL.[17]

Sample size

The estimates are proposed to be generated at the district level in each state. Assuming the prevalence of malnutrition to be 50%,[18] the desired sample size using the formula:

$$N = \frac{z^2_{crit}\, p(1-p)}{D^2}$$

where z is standard normal variate corresponding to 5% level with 50% prevalence rate, 95% confidence level, 5% relative precision, design effect of 2, and 15% nonresponse; the total sample size was 883 and rounded up equivalent to 900 after considering. However, we included 979 GPs in the study.

Statistical analysis

Statistical Package for the Social Sciences (SPSS) version 20.0, IBM Corp., Armonk, NY, USA was utilized for conducting the statistical analysis of the data. Chi-square test was applied to analyze the association of various parameters with MetS and without MetS among the GP. Step-wise logistic regression analysis was applied to assess the independent contribution of different factors to the presence of MetS.

Results

A total of 1003 geriatrics were enrolled. Twenty-four subjects were excluded due to incomplete information. Hence, 979 subjects were analyzed.

The sociodemographic details of the GP are depicted in Table 1. Six hundred and forty (63.8%) females and 363 (36.2%) males were included in the study. The mean age of subjects was 69.5 ± 7.4 years for male and 67.8 ± 7.2 years for female. Majority of the subjects were living in pucca house (70.1%).

Most common contributing factor for Mets was HDL (83.9%), whereas least common factor was hypertriglyceridemia (42.5%). The high BP was more prevalent in males (96.5%) than in females (77.0%); however, elevated level of HDL was found to be higher among females (97.7%) compared to males (31.0%) [Table 2].

Table 1: Distribution of elderly subjects according to sociodemographic profile (*n*=1003)

Sociodemographic profile	Male (*n*=363), *n* (%)	Female (*n*=640), *n* (%)	Total (*n*=1003), *n* (%)
Age (years)			
60-<70	197 (54.3)	397 (62.0)	594 (59.2)
70-<80	120 (33.0)	177 (27.7)	297 (29.6)
≥80	46 (12.7)	66 (10.3)	112 (11.2)
Caste			
SC	61 (16.8)	94 (14.7)	155 (15.5)
ST	12 (3.3)	10 (1.6)	22 (2.2)
OBC	6 (1.6)	10 (1.6)	6 (1.6)
Others	284 (78.2)	526 (82.2)	810 (80.7)
Religion			
Hindu	357 (98.3)	629 (98.3)	986 (98.3)
Muslim	3 (0.8)	1 (0.2)	4 (0.4)
Sikh	Nil	4 (0.6)	4 (0.4)
Christian	3 (0.8)	6 (0.9)	9 (0.9)
Economic dependency			
Yes	123 (33.9)	453 (70.8)	576 (57.4)
No	240 (66.1)	187 (29.2)	427 (42.6)
Education			
Illiterate	81 (22.3)	446 (68.7)	527 (52.5)
Primary school certificate	120 (33.1)	124 (19.4)	244 (24.3)
Middle school certificate	62 (17.1)	36 (5.6)	98 (9.8)
High school certificate	49 (13.5)	22 (3.4)	71 (7.1)
Intermediate or posthigh school diploma	28 (7.7)	6 (0.9)	34 (3.4)
Graduate and postgraduate	11 (3.0)	1 (0.2)	12 (1.2)
Professional and honors	12 (3.3)	5 (0.8)	17 (1.7)
Occupation			
Unemployed	54 (14.9)	481 (75.1)	535 (53.3)
Unskilled worker	133 (36.6)	104 (16.2)	237 (23.6)
Clerical, shop owner, farmer	13 (3.6)	2 (0.3)	15 (1.5)
Professional	163 (44.9)	53 (8.3)	216 (21.6)
Family income per month (Rs.)			
≤1865	93 (25.6)	138 (21.6)	231 (23.0)
1866-5546	125 (34.4)	286 (44.7)	411 (41.0)
5547-9248	46 (12.7)	103 (16.1)	149 (14.8)
9249-13,873	39 (10.7)	41 (6.4)	80 (8.0)
13,874-18,497	30 (8.3)	30 (4.7)	60 (6.0)
18,498-36,996	23 (6.3)	33 (5.1)	56 (5.6)
≥36,997	7 (1.9)	9 (1.4)	16 (1.6)
Type of house			
Kuccha	43 (11.8)	79 (12.3)	122 (12.2)
Semi-pucca	73 (20.1)	105 (16.4)	178 (17.7)
Pucca	247 (68.1)	456 (71.2)	703 (70.1)
Type of family			
Nuclear	124 (34.1)	164 (25.6)	288 (28.7)
Joint	223 (61.4)	445 (69.5)	668 (66.6)
Extended	16 (4.4)	31 (4.8)	47 (4.7)
Marital status			
Married	328 (90.4)	265 (41.4)	593 (59.1)
Widowed	32 (8.8)	373 (58.3)	405 (40.4)
Divorced/separated	1 (0.3)	2 (0.3)	3 (0.3)
Never married	2 (0.5)	Nil	2 (0.2)
Living arrangement			
Alone	12 (3.3)	33 (5.2)	45 (4.5)
With spouse	40 (11.0)	48 (7.5)	88 (8.8)
With spouse and married children	196 (53.9)	191 (29.8)	387 (38.6)
With spouse and unmarried children	53 (14.6)	31 (4.8)	84 (8.4)
With married children only	62 (17.1)	337 (52.7)	399 (39.7)

SC: Scheduled caste; ST: Scheduled tribe; OBC: Other backward classes

Table 2: Prevalence of metabolic syndrome and its components according to the International Diabetic Federation 2006 (280/979)

Metabolic syndrome	Total (*n*=280)	Male (*n*=58)	Female (*n*=222)
Central obesity (WC male ≥90 cm, females ≥80 cm)	280 (100.0)	58 (100.0)	222 (100.0)
Systolic blood pressure (≥130 mmHg)	227 (81.0)	56 (96.5)	171 (77.0)
Diastolic blood pressure (≥85 mmHg)	175 (62.5)	42 (72.4)	133 (59.9)
Hypertriglyceridemia (≥150 mg/dl)	119 (42.5)	28 (48.3)	91 (41.0)
HDL (<40 mg/dl in men and <50 mg/dl in women)	235 (83.9)	18 (31.0)	217 (97.7)
Fasting blood glucose (≥100 mg/dl)	178 (63.6)	43 (74.1)	135 (60.8)

WC: Waist circumference; HDL: High-density lipoprotein

Table 3 depicts the distribution of GS having elevated levels of various components of MetS. It was found that majority (39.3%) of GS had derangement in four components followed by the subjects having abnormality in 5 (30.0%), 3 (19.3%), and 6 (11.4%) components.

The overall prevalence of MetS was found to be 28.6% (280/979).

The prevalence of MetS was significantly associated with female gender, higher income level, and BMI ≥25 (all $P < 0.001$).

The prevalence of MetS decreasing with ageing years ($P = 0.013$). The percentage of geriatric subjects with MetS in each age group was 60−<70 years (32.1%), 70−<80 years (24.4%) and ≥80 years.

MetS found to be higher among GS who were not doing regular physical activity 172 (61.4%) than those who were doing regular physical activity 108 (38.6%) ($P = 0.004$) [Table 4].

It was found that decreasing age, female gender, higher income (13874 and above), irregular physical activity, and BMI ≥25 found to be significantly associated with MetS in univariate analysis.

Further, the female had a higher risk of developing MetS 2.77 (95% confidence interval [CI]: 2.0–3.8) as compared to their male counterparts.

The present study found that subjects with higher income (Rs. 13,874 and above) had 2.53 (95% CI: 1.5–4.0) times more risk of developing MetS compared to those with lower income ≤1865 [Table 4].

In stepwise multivariate logistic regression analysis, female gender, higher income (13874 and above), and BMI (≥25) were found significant and independent risk factors of MetS among GP.

Females subjects had 2.81 (95% CI: 1.8–4.4) times higher risk than males for developing Mets.

GS having BMI ≥25 had 34.34 (95% CI: 22.1–53.3) times higher risk of MetS than who had BMI ≤25.

Table 3: Distribution of geriatric subjects according to the number of components of metabolic syndrome (280/979)

Number of components of MetS	Number of subjects (*n*=280), *n* (%)
All 6	32 (11.4)
Any 5	84 (30.0)
Any 4	110 (39.3)
Any 3	54 (19.3)
Any 2	0

MetS: Metabolic syndrome

In the present study, irregular physical activity was found to be an independent risk factor of MetS; however, this variable was not statistically significant for the risk factor of MetS [Table 4].

Discussion

The prevalence of MetS is increasing in both developed and developing countries.[19] The number of GP is also growing in India.[20] Many studies conducted on GP found that, with aging, the glucose tolerance deteriorates[21-24] and CVD-related complications also increase.[24,25] MetS is a premorbid condition that helps in identifying the risk of diabetes and cardiovascular disease.[26] Therefore, this cross-sectional study was conducted for the first time among GP living in high altitude region of rural Uttarakhand, India, to see the prevalence of MetS.

The present study revealed the prevalence of MetS as 28.6%. Several studies in India have shown different rates of prevalence in different parts of the country ranging from 9.3% to 47.5%.[27] The prevalence found in the present study was similar to earlier studies which documented 28.2% among rural population[28] and 28.1% among eastern GP.[29] However, earlier studies conducted on GP documented the higher prevalence of MetS as 43.6% in rural Haryana,[30] 35.2% in Punjab,[31] 51.3% in Goa,[32] and 65% in Kerala.[33] The differences in the prevalence of MetS in different states of India may be due to different criteria used, different geographical area, different lifestyle, and different trend of prevalence of individual components of the MetS.

In the present study, low HDL was found to be most common abnormality among GP. Earlier study also documented low HDL

Table 4: Factors associated with metabolic syndrome: Results of bivariate and stepwise multivariate logistic regression analysis

	Subject with Mets (*n*=280)	Subject without MetS (*n*=699)	*P*	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Age (years)					
60-<70	186 (32.1)	394 (67.9)	0.013	1.0	-
70-<80	71 (24.4)	220 (75.6)		0.68 (0.5-0.9)	
≥80	23 (21.3)	85 (78.7)		0.57 (0.3-0.9)	
Gender					
Male	58 (16.5)	294 (83.5)	<0.001	1.0	1.0
Female	222 (35.4)	405 (64.6)		2.77 (2.0-3.8)	2.81 (1.8-4.4)
Education					
Illiterate	150 (29.3)	362 (70.7)	0.009	1.0	-
Primary school C	52 (21.7)	188 (78.3)		0.66 (0.4-0.9)	
Middle school C	28 (29.2)	68 (70.8)		0.99 (0.6-1.6)	
High school certificate and above	50 (38.2)	81 (61.8)		1.48 (0.9-2.2)	
Income (Rs.)					
≤1865	45 (20.0)	180 (80.0)	<0.001	1.0	1.0
1866-5546	106 (26.4)	296 (73.6)		1.43 (0.9-2.1)	1.08 (0.6-1.8)
5547-9248	55 (37.9)	90 (62.1)		2.44 (1.5-3.9)	1.77 (0.9-3.3)
9249-13,873	24 (30.8)	54 (69.2)		1.77 (0.9-3.1)	1.33 (0.6-2.9)
13,874 and above	50 (38.8)	79 (61.2)		2.53 (1.5-4.0)	2.06 (1.1-3.9)
Physical activity					
Regular	108 (24.0)	341 (76.0)	0.004	1.0	1.0
Irregular	172 (32.4)	358 (67.6)		1.51 (1.1-2.0)	1.41 (0.9-2.1)
Type of fuel					
Low pollution fuel	187 (36.8)	323 (63.3)	<0.001	1.0	-
High pollution fuel	93 (19.8)	376 (80.2)		0.43 (0.3-0.6)	
BMI (kg/m^2)					
≤25	97 (13.1)	644 (86.9)	<0.001	1.0	1.0
≥25	182 (84.3)	34 (15.7)		35.54 (23.2-54.3)	34.34 (22.1-53.3)

OR: Odds ratio; CI: Confidence interval; MetS: Metabolic syndrome; BMI: Body mass index

as a most prevalent contributing factor for developing MetS.[29,34] We observed that prevalence of low HDL was much higher among female than males. A similar finding has been noticed in other studies which attributed higher prevalence of low HDL cholesterol in females (70.4%) compared to males (37%).[33]

On the other hand, elevation of the BP was the second most prevalent criterion, with a frequency of 81.0%. It is an important aspect of the present study because most of the studies reported that GS with high BP has high MetS prevalence and it is one of the most prevalent criteria.[6,29,34-36]

The prevalence of MetS was found to be decreased with advancing age. Earlier studies have demonstrated that, with increasing age, the prevalence of Mets increased.[7,30,32] However, various other studies conducted on GP have found no significant difference with aging.[3,6]

In the present study, the prevalence of MetS was higher in females (79.3%) as compared to males (20.7%). Majority of Indian studies reported similar results.[7,30,37] An earlier study done by Srinivasan *et al.* showed the prevalence of 50% for males and 80% for females.[33] Similarly, Prasad *et al.* in their study reported higher prevalence among females (52.4%) than males (47.6%).[29] We observed higher prevalence among elderly female was probably due to a higher prevalence of impaired blood glucose and low HDL cholesterol levels [Table 2].

With respect to income level, we found independent and significantly increased prevalence of MetS with increase in income. Similarly, prestudies documented that there are marked increases in the prevalence of MetS with increase in income.[29,34] On the contrary, an earlier study reported the prevalence of MetS significantly higher in a lower income group.[8]

In our study, odds ratio indicated that irregular physical activity independently increased the risk of MetS 1.51 times. In other parts of India, similar observations were noted among subjects who were physically inactive.[29,33,38] This finding support that physical activity lowers the risk of MetS in GP. Epidemiological studies have also supported our findings which documented direct relation between physical inactivity and the presence of cardiovascular risk factors, insulin resistance, and diabetes.[39-42]

We found association between BMI ≥25 and MetS. The occurrence of MetS among overweight/OB was significant (OR = 34.34; 95% CI = 22.1–53.3). Previous studies reported a higher risk of developing MetS among overweight/OB people compared

with those having normal weight.[3,29,32,36] Preventive lifestyle modification that can lower the BMI should be targeted among GP.

Strengths of the present study include a large population-based sample, representative sampling methodology, use of standardized data collection protocols, and first study among GP of Uttarakhand. This study had a very high response rate (96.6%).

Conclusion

The present study documented higher prevalence of MetS in a high altitude region of Uttarakhand. There is a need for regular screening of GP living in high altitude region for the presence of metabolic risk factors of MetS so that preventive action can be initiated to prevent complications of cardiovascular disease and diabetes mellitus.

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Conflicts of interest

There are no conflicts of interest.

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