Original Article

Prevalence and influencing factors of metabolic syndrome among rural adult population in a district of South India

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Abstract

Background: Metabolic syndrome has increased globally due to sedentary lifestyles, unhealthy diets and obesity, which is posing a substantial burden on healthcare systems. Understanding the determinants of metabolic syndrome like lifestyle factors, socioeconomic status and the environment are vital for devising effective prevention and management. Research into these determinants helps to identify high-risk populations and develop interventions to reduce its occurrence. **Objectives:** i. To estimate the prevalence of metabolic syndrome among the adult population. ii. To determine the factors associated with metabolic syndrome among the adult population. **Methodology:** A cross-sectional study was carried out among 410 adults (≥18 years). A semi-structured questionnaire was used to collect data and National Cholesterol Education Program's Adult Treatment Panel III criteria was used to diagnose metabolic syndrome. Continuous and categorical data were represented as mean and proportion, respectively. The strength of the association was determined using the prevalence ratio and adjusted prevalence ratio. **Results:** The mean age of the participants was 44.97 ± 14.7, about 58.3% of them were females. Metabolic syndrome prevalence was 39.8%. Multivariate regression analysis demonstrated that being over 40 years old, marital status, higher socioeconomic status, skilled workers, physical inactivity and obesity were independently linked to metabolic syndrome. **Conclusions:** The burden can be reduced by identifying the risk factors at the early stage through screening and by adopting a healthy lifestyle.

Keywords: Diet, lifestyle, non-communicable disease, risk factor

Introduction

Worldwide, non-communicable diseases (NCDs) have emerged as the primary cause of illness and death, marking a shift from the previous trend of infectious diseases.[1] Within the Southeast Asia region, NCDs stand as leading causes of mortality, claiming around 8.5 million lives annually, with a significant portion being premature deaths. This situation notably impacts the workforce and economic productivity.[2]

In India, approximately 66% of all deaths are attributed to NCDs, which stem from various behavioural and metabolic risk factors.[3] NFHS – 5 Survey revealed alarming statistics related to non-communicable disease risk factors – prevalence of tobacco use (46.9%), alcohol consumption (31.8%), being overweight/obese (46.9%), elevated blood glucose level (29.1%) and having elevated blood pressure (45.3%).[4]

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These risk factors are collectively examined under the term "metabolic syndrome" defined by a combination of physiological, biochemical, clinical and metabolic elements directly linked to increased risks of conditions like atherosclerosis, type 2 diabetes mellitus (T2DM) and overall mortality. Metabolic syndrome heightens the likelihood of mortality from similar events compared to individuals without the syndrome.[5]

Various diagnostic criteria are used to identify individuals with metabolic syndrome among which World Health Organisation (WHO) established the first official diagnostic criteria for metabolic syndrome in 1998, identifying individuals with insulin resistance, hypertension, dyslipidaemia and microalbuminuria. The European Group for the Study of Insulin Resistance (EGIR) proposed similar criteria but emphasised that microalbuminuria was not essential for diagnosis. To address the focus on insulin resistance, the National Cholesterol Education Program Adult Treatment Panel (NCEP ATP III) criteria shifted the emphasis to abdominal obesity.[6–10]

South Asians, especially Indians, face higher risks of metabolic and cardiovascular diseases due to factors like abdominal obesity and insulin resistance. Estimating the prevalence of metabolic syndrome in India is crucial, considering its diverse sociocultural landscape. This diversity, particularly between urban and rural populations, underscores the need for tailored approaches to address varying risk factors effectively.[11] Understanding these nuances is essential for targeted prevention and management strategies. Recent data indicates that rural areas in the country are mirroring the urban trend, experiencing increasing rates of diabetes and a significant portion of mortality attributed to ischaemic heart disease and stroke. Limited data exists regarding the prevalence of lipid levels, obesity and metabolic syndrome in rural India making it challenging to assess their impact on cardiovascular disease within the rural communities.[12]

With this background, the study was carried out with the following objectives:

- To estimate the prevalence of metabolic syndrome among the rural adult population in Salem district.
- To determine the factors associated with metabolic syndrome among the rural adult population in Salem district.

Methodology

Study design

Community-based cross-sectional study.

Study area

The study was carried out in the field practice area attached to the Rural Health and Training Centre of the tertiary care hospital, Salem. The area has a population of 13,852 of which 7,039 were male while 6813 were females.

Study period

The study was carried out for a period of 6 months from March 2023 to August 2023 after obtaining Institutional Ethical Committee approval.

Study population

The study participants were adults aged ≥18 years residing in the field practice area attached to the Rural Health and Training Centre of the tertiary care hospital, Salem.

Inclusion criteria

Those who were willing to participate in the study after getting written informed consent were included in the study.

Exclusion criteria

Adults with intellectual disabilities or cognitive impairments, seriously ill patients, and pregnant and lactating mothers were excluded.

Sample size

From Venugopal *et al.*,[13] the prevalence of metabolic syndrome was 39.6%. Taking this as a reference value sample size was calculated using the formula $Z^2\ PQ/L^2$ $Z = 1.96$, $P = 39.6$, $Q = 100–39.6 = 60.3$, $L = 5\%$ (Absolute Precision). Adding 10% of non-response rate the final sample size was calculated to be 410.

Sampling method

The adult population covered under the rural field practice area is around 9902. The adults were listed from the family folder maintained in our Rural Health Centre and they were serially numbered. The study participants were selected using a simple random sampling technique and random numbers were generated using the Random (RAND) function in Microsoft (MS) Excel.

Informed consent

Consent was prepared in a local language as per Indian Council of Medical Research (ICMR) guidelines. Written informed consent was obtained from the study participants before data collection.

Ethical clearance

Following ethical clearance from the institution Institutional Ethical Committee of Vinayaka Missions Kirupananda Variyar Medical College and Hospitals (VMKVMCH/IEC/23/101), the study proceeded with the principal investigator conducting door-to-door data collection after securing written informed consent. Confidentiality of the collected data was strictly maintained throughout the process.

Data collection

After getting written informed consent from the participant face-to-face interview was done to collect information on

socio-demographic characteristics and behavioural risk factors (e.g. tobacco use, alcohol use, physical activity, diet and family history). Measurement of height, weight, waist circumference and blood pressure was taken by the investigator. After overnight fasting 5 ml sample of venous blood was collected in a tube by a trained phlebotomist. Fasting plasma glucose (FPG), triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) were measured with a chemical autoanalyser. Metabolic syndrome was diagnosed using the NCEP ATP III criteria.

Data analysis

Data was collected and entered in MS Excel and was analysed using Statistical Package for Social Sciences (SPSS) Software (Version 22). Categorical data was represented using frequency and percentage and numerical data was represented using mean and standard deviation. *P* value was calculated using the Chi-square test ($P < 0.05$, considered as significant). The strength of association was assessed using binary logistic regression. Adjusted prevalence ratios and their corresponding 95% Confidence Interval (CIs) were computed after adjusting for confounding variables to identify independent associations with metabolic syndrome.

Operational definitions:

1. According to the NCEP ATP III definition, metabolic syndrome is said to be present if three or more of the following five criteria are met.[14]
   i. Waist circumference over 40 inches (men) or 35 inches (women)
   ii. Blood pressure over 130/85 mmHg
   iii. Fasting TG >150 mg/dl
   iv. Fasting HDL <40 mg/dl (men) or <50 mg/dl (Women)
   v. FBS >100 mg/dl
2. **Tobacco usage:** Current smokers are those who have smoked tobacco products in the last 30 days.[15]
3. **Alcohol consumption:** Current episodic heavy drinking was considered as six or more drinks on any day in the past 30 days.[15]
4. **Diet:** Participants who ate less than five servings of fruits and vegetables per day were considered to have insufficient fruit and vegetable intake.[15]
5. **Physical activity:** Physical activity was analysed using global recommendations by WHO.[16] Adults should get involved in at least 150 minutes of moderate-intensity aerobic physical activity or at least 75 minutes of vigorous-intensity aerobic physical activity.
6. **Obesity:** Body mass index (BMI) of ≥30.0 and 25.0–29.9 kg/m^2 was considered as obese and overweight, respectively.[15]
7. **Waist hip ratio:** Waist hip ratio of >0.90 cm for males and >0.85 cm for females was considered as substantially increased.[15]
8. **Raised blood pressure:** Raised blood pressure was defined as having systolic blood pressure ≥140 mmHg and or diastolic blood pressure ≥90 mmHg or being previously treated for hypertension.[15]

Results

The demographic profile of the study participants is provided in Table 1. The mean age of the study participants was 44.97 years and the standard deviation of 14.7. More than half of the study participants were females (58.3%). Most of the study participants were Hindu (89.5%) by religion and were

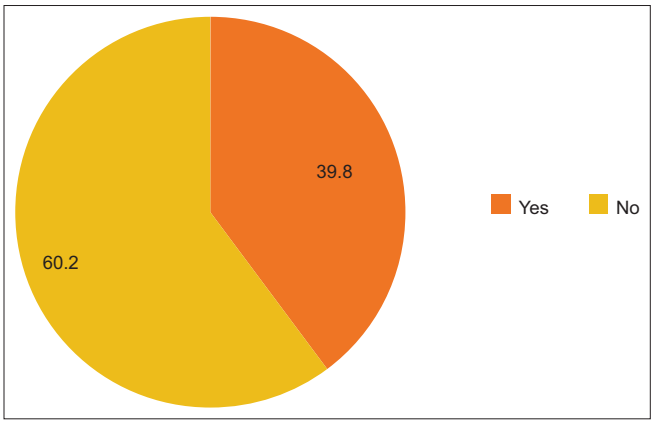

Figure 1: Prevalence of metabolic syndrome

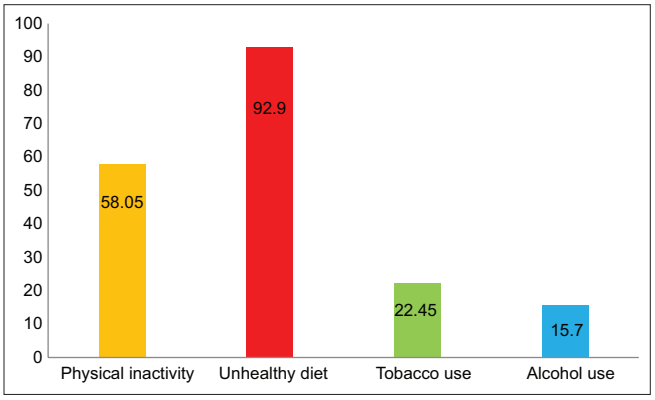

Figure 2: Prevalence of behavioural risk factors among the study population

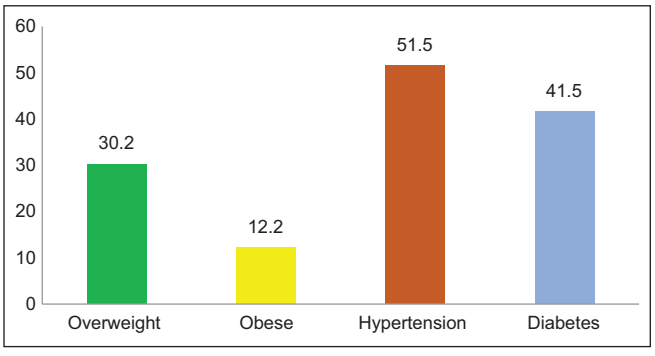

Figure 3: Prevalence of metabolic risk factors among the study population

married (67.8%) and 46.8% belonged to lower socioeconomic status.

Figure 1: The prevalence of metabolic syndrome was found to be 39.8% (95% CI: 35–44.7%).

Figure 2: Among the behavioural risk factors, the prevalence of unhealthy diet and Physical inactivity was found to be 92.9% and 58.05%, respectively.

Table 1: Socio-demographic details of the study participants

Socio-demographic variables	Frequency (*n*=410)	Percentage
Age		
>40 years	241	58.8
≤40 years	169	41.2
Sex		
Male	171	41.7
Female	239	58.3
Religion		
Hindu	367	89.5
Christian/Muslim	43	10.5
Education		
≥Higher Secondary	111	27.0
<Higher Secondary	299	73.0
Occupation		
Skilled worker and above	97	23.7
Below skilled worker	313	76.3
Marital status		
Married	278	67.8
Others	132	32.2
Socioeconomic status		
Upper/middle class	217	52.9
Lower class	193	47.1
Type of Family		
Nuclear family	287	70
Joint family/three Generation family	123	30

#Others: Single, widow and divorced.

Figure 3: Among the metabolic risk factors, hypertension and diabetes mellitus were seen in 51.5% and 41.5% of the study participants, respectively.

The association between demographic variables, risk factors and the metabolic syndrome is given in Tables 2 and 3. Age more than 40 years (Prevalence Ratio [PR] – 2.771, p value – < 0.001**), married persons (PR – 2.243, p value – <0.001**), upper/middle socio economic status (SES) (PR – 1.555, p value – 0.030*), physical inactivity (PR – 2.232, p value – <0.001**), tobacco consumption (PR – 3.148, p value – 0.001**), unhealthy diet (PR – 3.078, p value – 0.011*) and overweight/obese (PR – 3.548, p value – <0.001**) were identified as risk factors to develop Metabolic Syndrome (MS)

Table 4 Binary logistic regression analysis showed that age > 40 years (Adjusted Prevalence Ratio [APR] – 2.827, p value – <0.001**), upper/middle SES (APR – 1.833, p value – 0.021*), physical inactivity (APR – 2.632, p value – 0.008**) and overweight/obese (APR – 3.137, p value – 0.001**) were independently associated with MS.

Discussion

Metabolic syndrome, a lifestyle-related condition, poses a significant health challenge due to factors like urbanisation, sedentary lifestyle, lack of physical activity and excessive calorie intake. Its prevalence varies among populations due to differences in genetics, diet, activity levels, age and body weight. However, a higher prevalence increases the risk of cardiovascular disease.[17]

The prevalence of metabolic syndrome was 39.8% in our study, which was similar to Venugopal *et al.*,[13] Banerjee *et al.*[18] and Sinha *et al.*[19] study findings. In India, studies show different prevalence ranging from 9.2% to 47.4%.[20–22] Differences in

Table 2: Association between Sociodemographic factors and the Metabolic Syndrome

Variable	Metabolic Syndrome		*P*	PR (CI)
	Yes (*n*=163)	No (*n*=247)		
Age				
>40 years	119	122	<0.001**	2.771 (1.809–4.244)
≤40 years	44	125		1 (Reference)
Sex				
Male	77	94	0.065	1.457 (0.976–2.176)
Female	86	153		1 (Reference)
Marital Status				
Married	127	151	<0.001**	2.243 (1.430-3.517)
Others#	36	96		1 (Reference)
Education				
≥Higher Secondary	42	69	0.629	0.895 (0.572–1.401)
<Higher secondary	121	178		1 (Reference)
Occupation				
Skilled & above	37	60	0.710	0.915 (0.573–1.461)
Below Skilled	126	187		1 (Reference)
SES				
Upper/Middle	97	120	0.030*	1.555 (1.043-2.321)
Lower	66	127		1 (Reference)

*P<0.05, **P<0.01. #Others–Single, Widow, Divorce

Table 3: Association between Risk factors and the Metabolic Syndrome

Variable	Metabolic Syndrome		*P*	PR (CI)
	Yes (*n*=163)	No (*n*=247)		
Physical Inactivity				
Yes	110	119	<0.001**	2.232 (1.479–3.370)
No	53	128		1 (Reference)
Tobacco Usage				
Yes	52	32	0.001**	3.148 (1.196–5.171)
No	111	215		1 (Reference)
Alcoholic				
Yes	26	38	0.877	1.044 (0.606-1.797)
No	137	209		1 (Reference)
Unhealthy Diet				
Yes	157	221	0.011*	3.078 (1.238–7.655)
No	6	26		1 (Reference)
BMI Grading				
Overweight/Obese	99	75	<0.001**	3.548 (2.342–5.373)
Normal	64	172		1 (Reference)

*P<0.05, **P<0.01

Table 4: Binary logistic regression findings

Variable	Metabolic syndrome	
	P	APR (CI)
Age	<0.001**	2.827 (1.723–4.638)
Marital status	0.061	1.403 (0.451–2.579)
SES	0.021*	1.833 (1.095–3.069)
Physical inactivity	0.008**	2.632 (1.194–3.222)
Tobacco usage	0.122	1.557 (0.888–2.730)
Unhealthy diet	0.987	1.008 (0.377–2.694)
BMI grading	0.001**	3.137 (2.482–5.158)

*P<0.05; **P<0.01. #Others: Single, widow and divorced. Age, marital status, socioeconomic status, physical inactivity, tobacco usage, unhealthy diet and BMI grading were chosen for binary logistic regression and analysis was done using the Enter method

metabolic syndrome criteria, study settings and epidemiological characters of the study population have contributed to the wider prevalence range of metabolic syndrome observed in India.

While our study identified variations in metabolic syndrome occurrence among different age groups, we did not observe a significant rise in prevalence with advancing age, in contrast to findings by Pathania *et al.*[20] and Sarkar *et al.*[23] Our study observed a decrease in prevalence among those over 60 years, contrary to prior findings, possibly due to differences in population demographics and diagnostic criteria. This highlights the need to carefully consider these factors when interpreting prevalence rates.

Male preponderance of metabolic syndrome is a well-documented phenomenon globally. Men are more susceptible to central obesity and females traditionally have lower risk due to reduced intra-abdominal fat.[24] Whereas in our study higher prevalence was noted among females (52.8%) compared to males (47.2%), attributed to larger female participants. This aligns with the findings of studies by Kapil *et al.*,[25] Lokanath *et al.*[26] and Pemminati *et al.*[27]

The rural community due to lifestyle transition exhibits unhealthy dietary patterns, insufficient physical activity and a lack of awareness about the importance of exercise and weight management. Consequently, the prevalence of metabolic syndrome tends to be escalating among the rural population.[17]

In our study ages more than 40 years, upper SES, physical inactivity, tobacco consumption and unhealthy diet were identified as risk factors for developing MS, which is similar to that of Venugopal *et al.*[13] study. However, alcohol consumption was identified as a risk factor by Selvaraj *et al.*,[28] Trisrivirat *et al.*[29] and Mattoo *et al.*[30] and lacks significance in our study primarily due to the predominance of female participants and varying population demographics.

An unhealthy diet was identified as a risk factor for metabolic syndrome as established by other studies.[28,31] However, this differs from Sinha *et al.*,[19] Ramesh *et al.*[32] findings where they did not observe its significance, likely due to the use of different criteria. Metabolic syndrome was found to be significantly more common among those who were physically inactive and being overweight or obese. The results were similar to the findings from studies by Selvaraj *et al.*,[28] Kapil *et al.*[25] and Srinivasan *et al.*,[17] observed similar associations between physical inactivity and metabolic syndrome risk. Additionally Sinha *et al.*[19] and Barik *et al.*[24] found that as BMI increases, there is a rise in the prevalence of metabolic syndrome.

Conclusion

Metabolic syndrome holds the potential to significantly diminish an individual's quality of life and impose a burden on healthcare systems. Detecting potential issues early on involves focusing screening efforts on individuals aged 30 years and above with a positive family history, regardless of gender, facilitating timely identification. Thus, Information Education Communication (IEC) and behavioural change communication are vital at individual, family, and community levels to enhance awareness, education and prevention by advocating healthy

lifestyles, regular physical activity and improved dietary habits to mitigate the risk factors associated with metabolic syndrome.

Policymakers and healthcare providers can design effective and timely interventions for both primary and primordial prevention by addressing metabolic syndrome's risk factors. Additionally, further research is needed to ascertain and compare the prevalence of risk factors in various Indian settings.

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Conflicts of interest

There are no conflicts of interest.

References

1. Saklayen MG. The global epidemic of the metabolic syndrome. Curr Hypertens Rep 2018;20:1-8. doi: 10.1007/s11906-018-0812-z.
2. Dahal S, Sah RB, Niraula SR, Karkee R, Chakravartty A. Prevalence and determinants of non-communicable disease risk factors among adult population of Kathmandu. PLoS One 2021;16:e0257037. doi: 10.1371/journal.pone.0257037.
3. World Health Organization. Noncommunicable diseases: Progress monitor 2022. Available from: https://www.who.int/publications/i/item/9789240047761. [Last accessed on 2023 Nov 20].
4. International Institute for Population Sciences (IIPS) and ICF. 2021. National Family Health Survey (NFHS-5), 2019 – 21: India: Volume I. Mumbai: IIPS.
5. Krishnamoorthy Y, Rajaa S, Murali S, Rehman T, Sahoo J, Kar SS. Prevalence of metabolic syndrome among adult population in India: A systematic review and meta-analysis. PLoS One 2020;15:e0240971. doi: 10.1371/journal.pone.0240971.
6. Strazzullo P, Barbato A, Siani A, Cappuccio FP, Versiero M, Schiattarella P, *et al.* Diagnostic criteria for metabolic syndrome: A comparative analysis in an unselected sample of adult male population. Metabolism 2008;57:355-61.
7. Pagano G, Pacini G, Musso G, Gambino R, Mecca F, Depetris N, *et al.* Nonalcoholic steatohepatitis, insulin resistance, and metabolic syndrome: Further evidence for an etiologic association. Hepatology 2002;35:367-72.
8. Day C. Metabolic syndrome, or What you will: Definitions and epidemiology. Diab Vasc Dis Res 2007;4:32-8.
9. Rezaianzadeh A, Namayandeh SM, Sadr SM. National cholesterol education program adult treatment panel III versus international diabetic federation definition of metabolic syndrome, which one is associated with diabetes mellitus and coronary artery disease? Int J Prev Med 2012;3:552-8.
10. Saely CH, Koch L, Schmid F, Marte T, Aczel S, Langer P, *et al.* Adult treatment panel III 2001 but not International Diabetes Federation 2005 criteria of the metabolic syndrome predict clinical cardiovascular events in subjects who underwent coronary angiography. Diabetes Care 2006;29:901-7.
11. Sundarakumar JS, Stezin A, Menesgere AL, Ravindranath V. Rural-urban and gender differences in metabolic syndrome in the aging population from southern India: Two parallel, prospective cohort studies. EClinicalMedicine 2022;47:101395. doi: 10.1016/j.eclinm. 2022.101395.
12. Chow CK, Naidu S, Raju K, Raju R, Joshi R, Sullivan D, *et al.* Significant lipid, adiposity and metabolic abnormalities amongst 4535 Indians from a developing region of rural Andhra Pradesh. Atherosclerosis 2008;196:943-52.
13. Venugopal V, Dongre AR, Saravanan S. Prevalence and determinants of metabolic syndrome among the rural adult population of Puducherry. Indian J Community Med 2019;44:21.
14. Huang PL. A comprehensive definition for metabolic syndrome. Dis Model Mech 2009;2:231-7.
15. World Health Organization. WHO STEPS surveillance manual: the WHO STEPwise approach to chronic disease risk factor surveillance. World Health Organization; 2005. Available from: Noncommunicable Disease Surveillance, Monitoring and Reporting (who.int). [Last accessed on 2023 Nov 15].
16. World Health Organization. Global Physical Activity Questionnaire (GPAQ): Analysis Guide. Geneva: World Health Organization. Available from: https://www.who.int/publications/m/item/global-physical-activity-questionnaire. [Last accessed on 2023 Nov 10].
17. Srinivasan S, Lingegowda JB, Rajan C, Muddegowda PH, Kurpad R. Metabolic syndrome in rural Kerala: A hospital based study. Int J Adv Med 2016;3:898-904.
18. Banerjee R, Dasgupta A, Naskar NN, Kundu PK, Pan T, Burman J. A study on the prevalence of metabolic syndrome and its components among adults aged 18–49 years in an urban area of West Bengal. Indian J Community Med 2019;44:261.
19. Sinha N, Bhattacharya A, Deshmukh PR, Panja TK, Yasmin S, Arlappa N. Metabolic syndrome among elderly care-home residents in southern India: A cross-sectional study. WHO South East Asia J Public Health 2016;5:62-9.
20. Pathania D, Bunger R, Mishra P, Pathak R, Arora A. A study to assess prevalence of metabolic syndrome and its socio demographic risk factors in rural area of district Ambala, Haryana. J Community Med Health Educ 2013;3. doi: 10.4172/2161-0711.1000226.
21. Kanjilal S, Shanker J, Rao VS, Khadrinarasimhaih NB, Mukherjee M, Iyengar SS, *et al.* Prevalence and component analysis of metabolic syndrome: An Indian atherosclerosis research study perspective. Vascular Health Risk Manag 2008;4:189-97.
22. Mangat C, Goel NK, Walia DK, Agarwal N, Sharma MK, Kaur J, *et al.* Metabolic syndrome: A challenging health issue in highly urbanized Union Territory of north India. Diabetol Metab Syndr 2010;2:1-8. doi: 10.1186/1758-5996-2-19.
23. Sarkar P, Mahadeva SK, Raghunath H, Upadhya S, Hamsa M. Metabolic syndrome and its components among population of Holalu village, Karnataka. Int J Med Sci Public Health 2016;5:860-6.

24. Barik A, Das K, Chowdhury A, Rai RK. Metabolic syndrome among rural Indian adults. Clin Nutr ESPEN 2018;23:129-35.
25. Kapil U, Khandelwal R, Ramakrishnan L, Khenduja P, Gupta A, Sareen N, *et al*. Prevalence of metabolic syndrome and associated risk factors among geriatric population living in a high altitude region of rural Uttarakhand, India. J Family Med Prim Care 2018;7:709.
26. Lokanath DA, Chandrashekariah SA, Xaviour D, Rao J. The Incidence and alliance of metabolic syndrome with cardiovascular risk markers among Kodavas. Open J Endocr Metab Dis 2014;2014. doi: 10.4236/ojemd. 2014.46016.
27. Pemminati S, Adhikari PM, Pathak R, Pai MR. Prevalence of metabolic syndrome (METS) using IDF 2005 guidelines in a semi urban south Indian (Boloor Diabetes Study) population of Mangalore. J Asso Physicians India 2010;58:674-7.
28. Selvaraj I, Gopalakrishnan S, Logaraj M. Prevalence of metabolic syndrome among rural women in a primary health centre area in Tamil Nadu. Indian J Public Health 2012;56:314-7.
29. Trisrivirat K, Pinyopornpanish K, Jiraporncharoen W, Chutarattanakul L, Angkurawaranon C. Association between metabolic syndrome and alcohol consumption: A cross-sectional study. J Health Sci Medi Res 2021;39:145-55.
30. Mattoo SK, Nebhinani N, Aggarwal M, Basu D, Kulhara P. Metabolic syndrome among substance dependent men: A study from north India. Ind Psychiatry J 2013;22:60-4.
31. Verma P, Srivastava RK, Jain D. Association of lifestyle risk factors with metabolic syndrome components: A cross-sectional study in eastern India. Int J Prev Med 2018;9:6.
32. Ramesh S, Abraham RA, Sarna A, Sachdev HS, Porwal A, Khan N, *et al*. Prevalence of metabolic syndrome among adolescents in India: A population-based study. BMC Endocrine Disorders 2022;22:1. doi: 10.1186/s12902-022-01163-8.