Original Article

Prevalence of metabolic syndrome and its risk factors among newly diagnosed type 2 diabetes mellitus patients – A hospital-based cross-sectional study

Teja Rama Krishna S[1], Yogesh Bahurupi[1], Ravi Kant[2], Pradeep Aggarwal[1], Athulya V. Ajith[1]

[1]Department of Community and Family Medicine, All India Institute of Medical Sciences, Rishikesh, Uttarakhand, India, [2]Department of General Medicine, All India Institute of Medical Sciences, Rishikesh, Uttarakhand, India

Abstract

Context: Metabolic syndrome (MetS) raises the chance of cerebrovascular accidents and cardiovascular illness in type 2 diabetes mellitus (T2DM) individuals. Early identification of MetS allows for suitable prophylactic and treatment strategies to reduce the risks. **Aim:** To estimate the prevalence of MetS and its risk factors in T2DM individuals. **Settings and Design:** This cross-sectional study investigated MetS and its component's prevalence among newly diagnosed T2DM at the tertiary care hospital. **Methods and Material:** The study was conducted from January 2022 to December 2022 and included 300 participants above 18 years, with most being men (55%, 165), and using the World Health Organization (WHO) STEPS questionnaire for assessing selected risk factors. Along with blood glucose, different components of MetS were assessed, that is serum triglyceride (TG) level, serum high-density lipoprotein (HDL) level, blood pressure (BP) and waist circumference (WC), as per the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) criteria. **Statistical Analysis Used:** Data analysis includes mean and standard deviation (SD) for numerical variables with an unpaired *t*-test to compare means and percentage and proportions for categorical variables with the Chi-square test for the associations. Multivariate logistic regression was used for assessing the predictors of MetS. **Results:** The prevalence of components of MetS, that is obesity, hypertension (HTN), TG and HDL components, was 64.0% (192), 45.7% (137), 46.0% (138) and 30% (90), respectively. Overall, MetS was 57% (170). Moderate activity of 150 min/week, sitting/reclining, WC, diastolic BP, TG and HDL had a significant association with MetS. **Conclusions:** MetS was highly associated with newly diagnosed T2DM with obesity being the most common component.

Keywords: Blood pressure, hypertension, metabolic syndrome, National Cholesterol Education Program Adult Treatment Panel III, triglycerides, type 2 diabetes mellitus, waist circumference

Background

'The metabolic disorder known as Diabetes Mellitus (DM) is characterized by hyperglycemia brought on by abnormalities in insulin synthesis, insulin action, or both'. The prevalence of DM has risen globally and affects the two sexes uniformly. The massive increase in diabetes cases brought on by urbanization and technological advancement has put significant pressure on healthcare systems.[1] Every population and region in the globe, even rural areas of nations with low and moderate incomes, has DM.[2] As per the World Health Organization (WHO), 422 million persons had diabetes globally in 2014. Adult age-adjusted prevalence rose, with nations with low and moderate incomes

Address for correspondence: Dr. Pradeep Aggarwal, Department of Community and Family Medicine, All India Institute of Medical Sciences, Rishikesh, Uttarakhand, India.
E-mail: drpradeep_aggarwal@hotmail.com

Received: 10-01-2024 **Revised:** 08-04-2024
Accepted: 16-04-2024 **Published:** 26-07-2024

Access this article online

Quick Response Code:

Website: http://journals.lww.com/JFMPC

DOI: 10.4103/jfmpc.jfmpc_51_24

How to cite this article: Krishna ST, Bahurupi Y, Kant R, Aggarwal P, Ajith AV. Prevalence of metabolic syndrome and its risk factors among newly diagnosed type 2 diabetes mellitus patients – A hospital-based cross-sectional study. J Family Med Prim Care 2024;13:3325-31.

seeing the greatest rises, from 4.7% in 1980 to 8.5% in 2014.[2] Type 2 diabetes mellitus (T2DM) prevalence in Asiatic Indians rose from 5.5% in 1990 to 7.7% in 2016.[3]

A group of metabolic disorders known as metabolic syndrome (MetS) are intimately linked to non-communicable disease (NCD) risk factors. MetS includes measurements for cholesterol, blood sugar, blood pressure (BP) and waist circumference (WC). Several standards for determining MetS have been provided by various international organizations, such as WHO in 1996, The National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) in 2005 and the International Diabetes Foundation (IDF) in 2005.[4–6] In the Indian context, the definition offered by NCEP ATP III has widespread acceptance for both clinical and research purposes.[6] According to Nolan PB *et al.*'s[7] examination of pooled data, MetS prevalence in young adults over the world ranges from 5% to 7%. MetS affects between 25% and 45% of urban people in India.[8,9] Amidst disputes about the medical relevance of MetS, there is mounting evidence that it is a common syndrome associated with the onset of T2DM and heart disease (cardiovascular disease (CVD)).[10] MetS is linked to a 1.5-fold increase in the risk of total mortality, a 1.5-fold increase in the danger of CVD and CVD mortality, as well as a 1.5-fold enhanced stroke risk.[11]

MetS is thought to affect the vast majority of people with T2DM or impaired glucose tolerance, which is nearly double the prevalence in the general community.[12] MetS prevalence was found to be 25.8% among the common population and over 50% among the T2DM group in population-based research from Chennai in southern India.[10] DM and MetS together considerably increase the incidence of cardiovascular illnesses. DM is accompanied by a wide range of risk factors, which are heightened by the existence of MetS. CVD risk can be increased by two to four times by MetS with DM.[13] It has been documented that having MetS reduces survival in T2DM patients by at least 10 years.[14] MetS is a major problem in public health right now. Further study is consequently required. Because the two conditions are linked, diagnosing MetS components in diabetic patients is critical for recognizing, preventing and controlling the hidden threats and decreasing the frequency of CVD deaths. Evaluation of MetS and its components pinpoints clinically significant high-risk subgroups of T2DM for tailored CVD risk factor therapy and possible insulin resistance-targeting therapies. Numerous studies also failed to account for the length of diabetes, which may have resulted in estimates of the incidence and components of MetS that were inaccurate. This study aimed to estimate the burden of MetS and its components in T2DM patients with a 6-month illness duration.

Methods

A hospital-based cross-sectional study was conducted at the diabetes outpatient department (OPD) among newly diagnosed T2DM participants from January 2022 to December 2022.

To ensure the adequacy of the sample, the prevalence of MetS and its components among DM patients in an Indian study was taken as 49% for the hypertension (HTN) component.[15] After adjusting with population size and non-responders 5%, the final sample size was estimated as 300. A consecutive sampling method was used to select the participants above 18 years of age, T2DM diagnosed within the last 6 months. Pregnant women and first-year postpartum women were excluded.

Variable definition and instruments

The WHO STEPS tool was used to evaluate risk factors and measurements, such as anthropometry and BP.[16] The interview schedule was divided into the following sections: step 1 included obtaining information on the demographic profile and behavioural measurements, such as physical activity, tobacco use, medical history, alcohol consumption and dietary habits. Step 2 included selected physical measures, such as height, weight, BP and WC, and step 3 included obtaining fasting venous blood for the analysis of a few biochemical indicators, such as high-density lipoproteins (HDL), triglycerides (TG) and fasting blood sugars (FBS).

'According to the revised NCEP ATP III criterion for the classification of MetS, study participants should have at least three of the five following components: WC (>90 cm for males and >80 cm for females); BP (≥130/85 mm/Hg or use of anti-hypertensive drugs); HDL (<40 mg/dl for males and <50 mg/dl for females or use of antilipidemic drugs); TG (≥150 mg/dl or use of dyslipidemia drugs) and/or FBS (>100 mg/dl or use of hypoglycaemic drugs)'.[17]

For the study of Global Physical Activity Questionnaire (GPAQ) data in the WHO STEPS questionnaire and to describe the level of physical activity, METs (metabolic equivalents) were used. We can determine overall physical exercise by applying MET values to activity levels.[16]

WC was measured at the level of the midpoint between the high point of the iliac crest and last rib on the sides and the umbilicus anatomy, using a non-stretchable tape measuring with the person lightly clothed.[16]

Sitting BP was measured with an automated sphygmomanometer with a universal cuff placed just 1 to 2 centimetres above the elbow joint, using the patient's non-dominant arm and after 15 minutes of rest. Two readings were taken within a 3-minute relaxation period between two measurements, and the mean was used for analysis.[16]

Weight was obtained from patients, while they were barefoot and wearing light clothing, using a portable digital scale with 150 kg of capacity and 0.1 kg of accuracy.[16]

Height was assessed with a measuring tape with a scale of 0.5 cm. Aiming to guarantee the accuracy of measurements, participants

were instructed to stand upright and motionless, with their palms touching their thighs and their heads adjusted to the plane.[16]

A completely automatic instrument was used in the laboratory to quantify HDL, TG and FBS from venous blood samples that were taken after an overnight fast. Blood samples were taken in red and green vacutainers to assess fasting lipids (TG and HDL) and estimate FBS. Blood samples totalling 5 ml were taken from each subject.

The participants' informed written consent was obtained after they were made aware that their involvement in the research was voluntary and would not harm them in any way. Institutional ethical committee approval was obtained.

Data were entered and analysed using the Statistical Package for the Social Science (SPSS) version 23 software. Demographic indicators and different parameters for MetS recorded at the time of enrolment were analysed. Descriptive analysis was conducted and reported as mean, standard deviation (SD) and median for continuous variables and frequencies and percentages for categorical variables.

Results

Sociodemographic characteristics

Of the 300 study participants in the study, 185 (65%) were males. Around half of the total study participants (51.3%) were of the age group 41 to 60 years followed by 61 to 80 years (28.4%). Most of the participants were residents of rural areas (84.0%), Hindu by religion (92.7%) and were married (87.3%). More than half of the participants (52.7%) belonged to a joint family, and 39% of the participants belonged to socioeconomic class II as per the revised BG Prasad classification 2022.

MetS was found in 57% (170/300) of the patients in the total study, with prevalence rates of 47.9% and 67.4% for males and females, respectively. Participants with increased WC component were 193 (64%), BP component, 137 (45%), TG component, 138 (46%) and HDL component, 90 (30%). Among female participants, the most common elevated component was WC, and for male participants, it was the TG component [Figure 1].

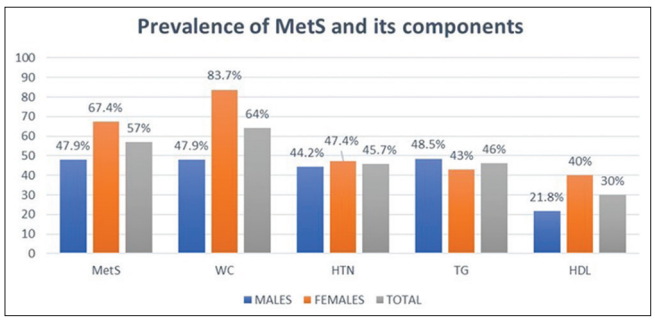

Figure 1: Prevalence of metabolic syndrome and its components among participants. Legends: blue – male participants, orange – female participants, grey – total participants

The proportion of study participants having only one component was 7.3%, whereas 34%, 29.7% and 21.7% had two, three and four components of MetS, respectively. All five components of MetS were present in 6.7% of participants [Figure 2].

A significant difference was observed between the groups in whom MetS was present and absent in the case of age category and gender ($P < 0.005$). No statistically significant difference was observed in the case of other sociodemographic variables, such as rural or urban residence, religion, marital status and socioeconomic class ($P > 0.05$) [Table 1].

Analysis of risk factors

The proportion of total study participants engaged in smoking was 15.7%, and MetS was absent in more than half of them (53.2%). About 28.7% of the study population consumed alcohol, and a higher proportion (54.7%) were positive for the presence of MetS. No significant difference was observed statistically between the two groups regarding alcohol consumption and smoking [Table 2]. The average amount of fruits consumed assessed as servings per week was higher among the MetS absent group, but the mean consumption of vegetables remained similar in both groups. The amount of consumption of fruits and vegetables did not show any significant statistical difference between both groups [Table 2]. The majority of the study participants were not engaged in vigorous physical activity, and the results were similar in both groups. Moderate physical activity was found to be higher among the MetS absent group and significantly different in both groups ($P = 0.001$). It was also observed to have a significant difference in the mean hours per day spent sitting or reclining among the two groups [Table 2].

The average weight among the study participants was 70 ± 8.9, having a significantly higher value among the MetS present group ($P = 0.001$). A significant difference was also observed in body mass index (BMI) and WC among the two groups, which was higher among the MetS present group ($P = 0.001$). Systolic and diastolic BP were also observed to be significantly high among the MetS present group similar to TG levels ($P < 0.05$). There was no significant difference in FBS levels among both groups; the mean FBS level was 156.9 ± 55.6 g/dl. The level of HDL was found to be significantly low among the MetS present group ($P = 0.001$).

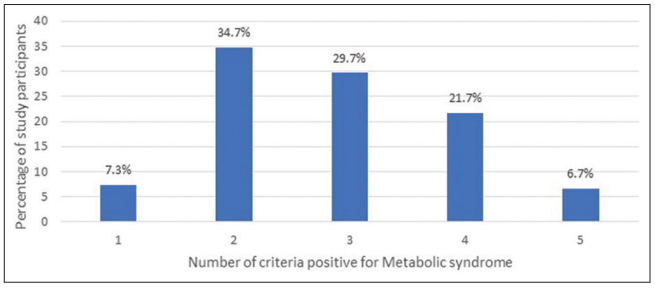

Figure 2: Distribution of the study participants according to the number of criteria fulfilled for metabolic syndrome

Table 1: Sociodemographic characteristics among the study participants

Characteristics	Total (*n*=300)	MetS present (*n*=170)	MetS absent (*n*=130)	*P*
Gender, *n* (%)				
Females	135 (45)	91 (67.4)	44 (32.6)	0.001
Males	165 (55)	79 (47.9)	86 (52.1)	
Age group (in years), *n* (%)				
18-40	61 (20.3)	24 (39.3)	37 (60.7)	0.001
41-60	154 (51.3)	92 (59.7)	62 (40.3)	
61-80	85 (28.4)	54 (63.5)	31 (36.5)	
Locality				
Urban	48 (16)	23 (47.9)	25 (52.1)	0.18
Rural	252 (84)	147 (58.3)	105 (41.7)	
Religion				
Muslim	22 (7.3)	16 (72.7)	6 (27.3)	0.11
Hindu	278 (92.7)	154 (55.0)	124 (44.6)	
Family type				
Joint	158 (52.7)	94 (59.5)	64 (40.5)	0.29
Nuclear	142 (47.3)	76 (53.5)	66 (46.5)	
Socioeconomic class[a], *n* (%)				
I (upper class)	72 (24.0)	38 (52.8)	34 (47.2)	0.76
II (upper middle class)	117 (39.0)	68 (58.1)	49 (41.9)	
III (middle class)	76 (25.3)	42 (55.3)	34 (44.7)	
IV and V (lower middle class and lower class)	35 (11.7)	22 (62.9)	13 (37.1)	

[a]Based on revised BG Prasad's socioeconomic status scale 2022

Table 2: Association of behavioural, anthropometric and biochemical risk factors with metabolic syndrome

Characteristics	Total (%) *n*=300	MetS present (%) *n*=170	MetS absent (%) *n*=130	*P*
Current smoker, *n* (%)				
Yes	47 (15.7)	22 (46.8)	25 (53.2)	0.13
No	253 (84.3)	148 (58.5)	105 (41.5)	
Alcohol consumption, *n* (%)				
Yes	86 (28.7)	47 (54.7)	39 (45.3)	0.19
No	214 (71.3)	123 (57.5)	91 (42.5)	
Vigorous activity of 75 min per week				
Not engaged	286	164 (57.3)	122 (42.7)	0.28
Engaged	14	6 (42.9)	8 (57.1)	
Moderate activity of 150 min per week				
Not engaged	233	162 (69.5)	71 (30.5)	0.001
Engaged	67	8 (11.9)	59 (88.1)	
Sitting (hr/day), mean±SD	6.8±1.5	7.7±0.7	5.6±1.6	0.001
Consumption of fruits (servings per week), mean±SD	4.0±2.1	3.9±2.1	4.2±2.1	0.8
Consumption of vegetables (servings per week), mean±SD	12.7±2.2	12.8±2.2	12.6±2.3	0.4
Anthropometric and biochemical measurements				
Weight (kgs)	70.4±8.9	75.1±15.8	64.3±11.2	0.001
Height (cm)	159.7±8.9	158.3±9.1	161.7±8.2	0.08
BMI (kg/m^2)	27.6±5.9	27.8±4.6	29.9±5.9	0.001
Waist circumference (cm)	98.5±14.8	105.7±13.6	89.2±10.5	0.001
Systolic blood pressure (mmHg)	130.2±18.6	137.2±22.1	119.9±14.2	0.001
Diastolic blood pressure (mmHg)	78.7±10.6	85.5±19.3	73.1±8.1	0.001
Fasting blood sugars (g/dl)	156.9±55.6	157.6±55.8	158.8±51.5	0.2
Triglycerides (g/dl)	173.5±89.0	208.6±102.7	137.5±48.7	0.001
High-density lipoproteins (g/dl)	45.4±12.4	44.3±13.8	50.3±8.7	0.001

Logistic regression

Selected risk factors that are associated significantly with a *P* value less than 0.05 were entered in univariate binary logistic regression. After considering probable confounding effects, risk factors with a *P* value of 0.05 or below on univariate logistic regression analysis were included in a multivariate binary logistic regression model to find risk factors that independently predict the MetS. It was observed from the above 'Table 3' that people

Table 3: Univariate and multivariate binary logistic regression

Variables	Odds ratio (95% CI)	Adjusted odds ratio (95% CI)	*P*
Gender			
Female	2.2 (1.4–3.6)	4.07 (0.84–19.7)	0.08
Male (ref)	1	1	-
Age category			
19–40 (ref)	1	1	-
41–60	2.2 1.2–4.1	0.90 0.21–3.79	0.89
61–80	2.6 (1.3–5.2)	3.91 (0.60–25.41)	0.15
Moderate activity of 150 mins per week			
Not engaged	16.8 (7.6–37.0)	5.50 (1.20–25.2)	0.02
Engaged	1	1	-
Siting/reclining (hrs/day)	2.98 (2.3–3.7)	3.56 (2.07–6.11)	0.001
Weight	1.05 (1.03–1.08)	0.98 (0.89–1.08)	0.80
BMI	1.2 (1.1–1.3)	1.05 (0.80–1.38)	0.71
Waist circumference	1.1 (1.07–1.1)	1.14 (1.07–1.21)	0.001
Systolic blood pressure	1.05 (1.03–1.06)	1.01 (0.97–1.06)	0.41
Diastolic blood pressure	1.1 (1.07–1.14)	1.12 (1.04–1.21)	0.001
Triglycerides	1.01 (1.01–1.02)	1.02 (1.01–1.21)	0.001
High-density lipoproteins	1.1 (1.07–1.14)	0.91 (0.86–0.96)	0.001

with elevated parameters, such as TG, diastolic BP, WC, sitting/reclining (hrs/day) and not engaged in the moderate activity of 150 mins/week, had a higher odd of 1.02, 1.12, 1.14, 3.56 and 5.50 times getting MetS among diabetes patients with a statistically significant *P* value less than 0.05. HDL was observed to have a protective effect (OR: 0.91) on MetS.

Discussion

The prevalence of MetS was estimated to be 65% in our study. Our findings are comparable to other studies which included the ones by Shiferaw W *et al.* (2020)[18] in sub-Saharan African nations and Nsiah K *et al.* (2015)[19] in Ghana, with the respective prevalence of 59.6% and 58.0%. On the contrary, a few studies by Pokharel D *et al.* (2014)[14] in Nepal, Surana S *et al.* (2014)[20] in India, MU Khan *et al.* (2021)[21] in Pakistan, Uprety T *et al.*[13] in Nepal in 2020 and Gemeda D *et al.*[22] in Ethiopia in 2022 found a higher prevalence of MetS among T2DM, with percentages of 83.0%, 77.2%, 73.6%, 68.5% and 68.3%, respectively. Disparities in the stated frequency between various research may be partly due to variances in the diagnosis parameters for this condition. The high prevalence of MetS found in our research was expected as MetS is present in nearly every person with T2DM or impaired glucose tolerance, making it twice as prevalent as in people in general..[12]

Elevated WC followed by increased TG and elevated BP are common cluster components of MetS among participants. Results were by the findings of MU Khan *et al.*,[21] whereas Pokharel D *et al.*[14] revealed that low HDL and increased TG followed by elevated BP are found to be potential risk factors for MetS.

Yadav *et al.*[12] reported that 87% of the study participants had elevated WC, whereas our study showed less prevalence of elevated WC (64%). This might be because of the study setting where our study included only newly diagnosed participants unlike Yadav *et al.*'s where the duration of diabetes among the study participants varied ranging from 1 to 20 years with an average of 6 years.

We observed that the prevalence of central obesity (83.7%, 47.9%) and low HDL (40.0%, 21.8%) was higher among females than males, whereas raised BP (44.2%, 47.4%) and high TG (43.0%, 48.5%) were higher in males similar to the findings reported by Pokharel D *et al.*[14] Due to their home-based activities and spending most of the time in the kitchen compared to other family members, increased chances of regular consumption of starchy foods, processed carbohydrates, late-night eating, exercising less frequently and leading a sedentary lifestyle might be the contributions to this. The most common factor in men was hypertriglyceridemia, which was subsequently followed in prevalence by high BP, an expanded WC and finally a decreased HDL. The findings of Nsiah K *et al.* and Felix Val *et al.* and this result are consistent.[19,23]

Predictors of MetS in T2DM

In our study 'Table 3', no physical activity for 150 minutes per week was the best predictor of MetS, whereas in Zerga *et al.*'s study,[24] BMI (>25 kg/m2) was found to be the greatest indicator of MetS among T2DM, with an adjusted odds ratio (aOR) of 9.59, followed by older age (aOR, 4.5), sedentary behaviours (aOR, 3.9) and frequency of red meat consumption (aOR, 2.61). Females were twice as likely as men to acquire MetS (aOR 2.3), whereas coffee consumption among T2DM patients had a negative relationship (aOR, 0.36) with MetS. The share of MetS components may vary depending on the nation, gender and ethnic group. Obesity is a key factor in the emergence of MetS and occurs before the other MetS components.[25] It is believed that the main event

in the progression of MetS is the onset of obesity, or more specifically, a rise in abdominal fat. Asian Indians are more likely to experience central obesity than overall fat.

Our study found no discernible distinction between individuals with MetS T2DM and those who did not in terms of their mean fruit and vegetable consumption [Table 2]. Nevertheless, Gemeda D *et al.*'s[22] findings show that as compared to respondents who ate fruit and vegetables twice more frequently per week, MetS was substantially more common among those who consumed these foods once per week and never. Fruits and vegetables have more fibre, antioxidant content and lower glycaemic index than other foods, which may account for their comparatively lower energy content.

Our findings regarding ever-alcohol consumers and current smokers' proportions [Table 2] corroborated with the research conducted by Gemeda *et al.*,[22] Nsiah K *et al.*,[19] and Lira Neto J *et al.* (2017)[26] in Brazil. On the contrary, in another study from China, drinking alcohol and smoking are linked to a higher proportion of MetS.[27] The outcomes of our research might not seem to support any judgments regarding MetS and addictions. Additional research on the subject revealed a significant discrepancy in findings about the relationship between MetS and addictions.[27] More studies in this area should be conducted with a bigger sample size to determine the precise relationships.

In our study, there was a significant link between moderate activity and MetS, and there was no correlation between strenuous exercise and MetS. The mean number of sedentary hours was greater for individuals with MetS than those without, and these differences were significant. As per Gemeda D *et al.*,[22] participants likely to have MetS were 6.9 times more, if they were not physically active. Zerga *et al.*[24] noted a substantial positive correlation between MetS and idle time spent engaging in sedentary activities. Participants who got to spend their leisure time reading, watching television or doing other sedentary activities had a 2.65 higher chance of developing MetS than those who strolled, cycled, performed sports or did housework. The correlation between physical activity, cardiorespiratory fitness, body weight and obesity has been demonstrated to be inverse, according to observational studies. In accordance with the 2008 Physical Activity Guidelines for Americans' recommendations, 'some physical activity is better than none', and 'additional benefits occur with more physical activity'. Physical activity's favourable impacts on body composition, such as increased skeletal muscle insulin sensitivity and decreased insulin resistance, could be used to explain the benefits. This could be because obesity, insulin resistance and impaired lipid metabolism are all brought on by sedentarism, which also causes MetS.

Strength and limitations

The major strength of our study is that it was conducted among newly diagnosed T2DM patients, unlike other studies where the duration of the study was not considered. We have also performed data triangulation as data were collected from the patient through history, anthropometry measurements and records through previous OPD prescriptions and investigation reports.

There might be recall bias and social desirability which might result in some degree of error when describing patterns of food diversification, alcohol intake, smoking and tobacco chewing.

Conclusion

The results of the research have worrying ramifications for India's prevalence of MetS in T2DM. MetS was found in 57% of the patients in the study, with higher prevalence rates among females. Elevated WC followed by increased TG and elevated BP are common cluster components of MetS among participants. The predictors of MetS include no moderate activity of 150 min/week being the strongest predictor followed by sitting/reclining, raised WC, elevated diastolic BP, increased TG and decreased HDL, which was remarkably linked with MetS.

Acknowledgements

The authors would like to thank the study participants and the Department of Community and Family Medicine, General Medicine, and Biochemistry, AIIMS Rishikesh. We would also appreciate Dr Nisarg Aravindan and Dr Aakriti Jasrotia for their assistance during the data collection and proofreading of the manuscript.

Ethical approval

Ethical approval – AIIMS/IEC/21/598 dated 26/11/2021 was obtained. Ethical approval is included as an Annexure 2.

Financial support and sponsorship

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Conflicts of interest

There are no conflicts of interest.

References

1. Khanal P, Mandar B, Patil BM, Hullatti KK. In silico antidiabetic screening of Borapetoside C, Cordifolioside A and Magnoflorine. Indian J Pharm Sci 2019;81:550–5.
2. World Health Organisation. Diagnosis and Management of Type 2 Diabetes. Available from: https://www.who.int/publications/i/item/who-ucn-ncd-20.1 [Last accessed on 2022 Feb 19].
3. Tandon N, Anjana RM, Mohan V, Kaur T, Afshin A, Ong K, *et al.* The increasing burden of diabetes and variations among the states of India: The Global Burden of Disease Study 1990–2016. Lancet Glob Health 2018;6:e1352–62.
4. Saklayen MG. The global epidemic of the metabolic syndrome. Curr Hypertens Rep 2018;20:1–8.

5. Ravikumar P, Bhansali A, Ravikiran M, Bhansali S, Walia R, Shanmugasundar G, *et al.* Prevalence and risk factors of diabetes in a community-based study in North India: The Chandigarh Urban Diabetes Study (CUDS). Diabetes Metab 2011;37:216–21.
6. Khan Y, Lalchandani A, Gupta A, Khadanga S, Kumar S. Prevalence of metabolic syndrome crossing 40% in Northern India: Time to act fast before it runs out of proportions. J Family Med Prim Care 2018;7:118–23.
7. Nolan PB, Carrick-Ranson G, Stinear JW, Reading SA, Dalleck LC. Prevalence of metabolic syndrome and metabolic syndrome components in young adults: A pooled analysis. Prev Med Rep 2017;7:211–5.
8. Park Y-W, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB. The metabolic syndrome: Prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988-1994. Arch Intern Med 2003;163:427–36.
9. Ford E, Giles W. A comparison of the prevalence of the metabolic syndrome using two proposed definitions. Diabetes Care 2003;26:575–81.
10. Billow A, Anjana RM, Ngai M, Amutha A, Pradeepa R, Jebarani S, *et al.* Prevalence and clinical profile of metabolic syndrome among type 1 diabetes mellitus patients in southern India. J Diabetes Complications 2015;29:659–64.
11. Mottillo S, Filion KB, Genest J, Joseph L, Pilote L, Poirier P, *et al.* The metabolic syndrome and cardiovascular risk a systematic review and meta-analysis. J Am Coll Cardiol 2010;56:1113–32.
12. Yadav D, Mahajan S, Subramanian SK, Bisen PS, Chung CH, Prasad G. Prevalence of metabolic syndrome in type 2 diabetes mellitus using NCEP-ATPIII, IDF and WHO definition and its agreement in Gwalior Chambal region of central India. Glob J Health Sci 2013;5:142–55.
13. Uprety T, Kunwar S, Gurung SH, Thapa S, Shrestha S, Rai A, *et al.* Prevalence of metabolic syndrome in type 2 diabetic patients 2020. doi: 10.21203/rs. 3.rs-42633/v1.
14. Pokharel DR, Khadka D, Sigdel M, Yadav NK, Acharya S, Kafle RC, *et al.* Prevalence of metabolic syndrome in Nepalese type 2 diabetic patients according to WHO, NCEP ATP III, IDF and Harmonized criteria. J Diabetes Metab Disord 2014;13:104.
15. Yadav D, Mishra M, Tiwari A, Bisen PS, Goswamy HM, Prasad GBKS. Prevalence of dyslipidemia and hypertension in indian type 2 diabetic patients with metabolic syndrome and its clinical significance. Osong Public Health Res Perspect 2014;5:169–75.
16. WHO STEPS surveillance manual : The WHO STEPwise approach to chronic disease risk factor surveillance/ Noncommunicable Diseases and Mental Health, World Health Organization. Available from: https://apps.who.int/iris/handle/10665/43376. [Last accessed on 2023 Feb 19].
17. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, *et al.* Diagnosis and management of the metabolic syndrome: An American Heart Association/ National Heart, Lung, and Blood Institute scientific statement: Executive Summary. Crit Pathw Cardiol 2005;4:198–203.
18. Shiferaw WS, Akalu TY, Gedefaw M, Anthony D, Kassie AM, Misganaw Kebede W, *et al.* Metabolic syndrome among type 2 diabetic patients in Sub-Saharan African countries: A systematic review and meta-analysis. Diabetes Metab Syndr 2020;14:1403–11.
19. Nsiah K, Shang Vo, Boateng Ka, Mensah F. Prevalence of metabolic syndrome in type 2 diabetes mellitus patients. Int J Appl Basic Med Res 2015;5:133.
20. Surana SP, Shah DB, Gala K, Susheja S, Hoskote SS, Gill N, *et al.* Prevalence of metabolic syndrome in an urban Indian diabetic population using the NCEP ATP III guidelines. J Assoc Physicians India 2008;56:865–8.
21. Khan MU, Baloch AA, Arsalan M, Adnan SM. Frequency of metabolic syndrome in patients with newly diagnosed Type II Diabetes at DOW University Hospital, Karachi-Pakistan. Professional Med J 2021;28:1546–51.
22. Gemeda D, Abebe E, Duguma A. Metabolic syndrome and its associated factors among type 2 diabetic patients in Southwest Ethiopia, 2021/2022. J Diabetes Res 2022;2022:8162342.
23. Titty FVK, Owiredu WKBA, Agyei-Frempong MT. Prevalence of metabolic syndrome and its individual components among diabetic patients in Ghana. J Biol Sci 2008;8:1057–61.
24. Zerga AA, Bezabih AM. Metabolic syndrome and lifestyle factors among type 2 diabetes mellitus patients in Dessie Referral Hospital, Amhara region, Ethiopia. PLoS One 2020;15:e0241432.
25. Sawant A, Mankeshwar R, Shah S, Raghavan R, Dhongde G, Raje H, *et al.* Prevalence of metabolic syndrome in Urban India. Cholesterol 2011;2011:920983.
26. Lira Neto JC, Xavier MA, Borges JW, Araújo MF, Damasceno MM, Freitas RW. Prevalence of metabolic syndrome in individuals with type 2 diabetes mellitus. Rev Bras Enferm 2017;70:265–70.
27. Yu M, Xu CX, Zhu HH, Hu RY, Zhang J, Wang H, *et al.* Associations of cigarette smoking and alcohol consumption with metabolic syndrome in a male Chinese population: A cross-sectional study. J Epidemiol 2014;24:361–9.