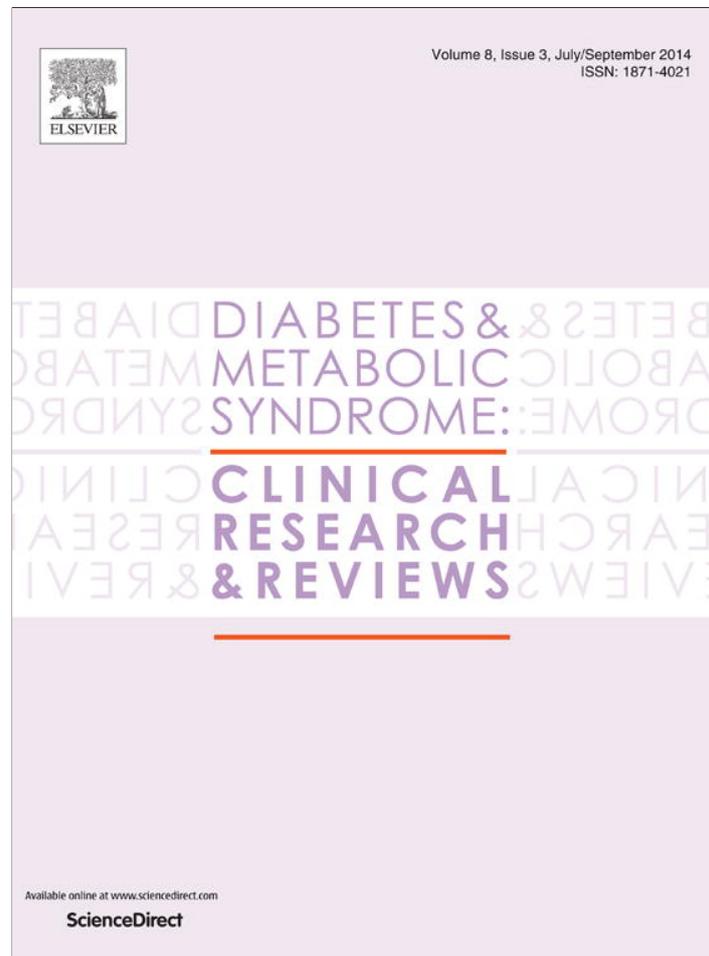


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## Original Article

## High prevalence of metabolic syndrome among urban subjects in India: A multisite study



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## A B S T R A C T

**Objective:** Metabolic syndrome is an important cardiovascular risk factor. To determine its prevalence among urban subjects in India we performed a multisite study.

**Methods:** The study was performed at eleven cities using cluster sampling. 6198 subjects (men 3426, women 2772, response 62%, age  $48 \pm 10$  years) were evaluated for socio-demographic, lifestyle, anthropometric and biochemical factors. Prevalence of metabolic syndrome was determined using harmonized Asian-specific criteria. Significant socioeconomic and lifestyle associations were determined.

**Results:** Age adjusted prevalence (%; 95% confidence intervals) of metabolic syndrome in men and women was 33.3 (31.7–34.9) and 40.4 (38.6–42.2) (harmonized criteria), 23.9 (22.4–26.4) and 34.5 (32.0–36.1) (modified Adult Treatment Panel-3, ATP-3) and 17.2 (15.3–19.1) and 22.8 (20.1–24.2) (ATP-3). Individual components of metabolic syndrome in men and women, respectively, were: high waist circumference 35.7 (34.1–37.3) and 57.5 (55.6–59.3), high blood pressure 50.6 (48.9–52.3) and 46.3 (44.4–48.1), impaired fasting glucose/diabetes 29.0 (27.5–30.5) and 28.0 (26.3–29.7), low HDL cholesterol 34.1 (32.5–35.7) and 52.8 (50.9–54.7) and high triglycerides 41.2 (39.5–42.8) and 31.5 (29.7–33.2) percent. Prevalence of metabolic syndrome was significantly greater in subjects with highest vs. lowest categories of education (45 vs. 26%), occupation (46 vs. 40%), fat intake (52 vs. 45%), sedentary lifestyle (47 vs. 38%) and body mass index (66 vs. 29%) ( $p < 0.05$ ).

**Conclusion:** There is high prevalence of metabolic syndrome in urban Indian subjects. Socioeconomic (high educational and occupational status) and lifestyle (high fat diet, low physical activity, overweight and obesity) factors are important.

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### 1. Introduction

Metabolic syndrome is an important diabetes and cardiovascular disease (CVD) risk factor [1]. It is a constellation of multiple cardiometabolic abnormalities including truncal (central) obesity, borderline and high blood pressure, high fasting glucose, high triglycerides and low high density lipoprotein (HDL) cholesterol [2–4]. Although the concept of combination of CVD risk factors is not new [5], the syndrome was initially defined in the third report of US National Cholesterol Education Program (ATP-3) [2]. Prevalence of the metabolic syndrome using initial definition varied from 20% to 30% among adults in high-income countries of

Europe and North America and was lower in middle and low income countries [6]. It was soon realized that this definition excluded many high risk diabetes and CVD subjects in East and South Asia [7]. Thereafter, the diagnostic criteria were revised for Asian subjects [3,4]. Studies that used the revised criteria reported greater prevalence of the metabolic syndrome in most Asian and other middle income countries (30–50%) [8].

It has been proposed that the metabolic syndrome is a sum of its components and determinants of the components are important in its genesis [9]. Various risk factors for metabolic syndrome are ethnicity, maternal and fetal undernutrition, early childhood nutrition, transition from under- to over-nutrition, life-course change in body fat distribution, physical inactivity, dietary factors such as high intake of carbohydrates, fats and trans-fats, stress, alcohol abuse, menopause and hormone replacement therapy, and obesity [6]. There are multiple studies from India and other low and lower middle income countries that have reported prevalence

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of metabolic syndrome but none have focused on its risk factors or associations [10]. Therefore to determine the prevalence of the metabolic syndrome and its components among urban Indian populations and to identify significant lifestyle and anthropometric associations we performed an epidemiological study among middle-class urban populations in India. The study evaluated risk factors among the urban middle class which is the biggest subset of Indian population. This group of apparently homogenous subjects provides unique opportunity to identify influence of lifestyles on cardiovascular risk factors [11] including metabolic syndrome.

## 2. Methods

A multisite study to identify prevalence of cardiovascular risk factors and their socio-demographic determinants was organized among urban subjects in India. Rationale for the study has been reported [11]. Protocol was approved by the institutional ethics committee of the national coordinating center. Written informed consent was obtained from each participant. The study case report form was developed according to recommendations of the World Health Organization [12]. We planned the study to identify prevalence of cardiometabolic risk factors and their determinants in urban subjects in India. For this, medium sized cities were identified in each of the large states of India and investigators who had a track record of research in cardiovascular or diabetes epidemiology were invited for participation in the study. We invited 20 investigators from all regions of the country, 15 participated in the steering committee meeting and finally 11 investigators in 11 cities finally performed the survey.

### 2.1. Sampling

The study data were collected in the years 2006–2010 at various locations. Simple cluster sampling was performed at each site. A middle-class location was identified at each city according to methodology reported earlier [13]. A sample size of about 250 men and 250 women ( $n = 500$ ) at each site is considered adequate by the WHO to identify 20% difference in mean level of biophysical and biochemical risk factors [12]. We invited 800–1000 subjects in each location to ensure participation of at least 500 subjects at each site estimating a response of 70% as reported in previous studies at similar locations [13]. At each site a uniform protocol of recruitment was followed. Accordingly, a locality within the urban area of the city was identified on ad hoc basis by each investigator, houses enumerated, number of subjects  $\geq 20$  years living in each house determined and all these individuals were invited to a local community center or healthcare facility (clinic, dispensary) for examination and blood investigations. This procedure ensured participation of consecutive members of the locality and was representative even if the survey was prematurely abandoned at a particular location. The surveys were preceded by meetings with community leaders to ensure good participation. Subjects were invited in fasting state to a community center or medical center within each locality either twice or thrice a week depending upon the investigator's schedule.

### 2.2. Measurements

The study case report form was filled by the research worker employed by the site investigator after details were inquired from the subject. Apart from demographic history, details of socioeconomic status based on educational status, occupational class and self-assessed socioeconomic status, history of known hypertension, diabetes, lipid abnormalities and cardiovascular disease were inquired. Smoking details were inquired for type of smoking or tobacco use, number of cigarettes or bidis smoked and years of

smoking. Intake of alcohol was assessed as drink per week. Dietary fat was assessed using questions about type of cooking oil used and estimated visible fat intake (g) daily. The total dietary fat intake per family per month was inquired and was divided by days of a month and number of adolescents and adults in the family to determine individual intake in g/day. Fruits and vegetables intake were assessed by a question that inquired number of servings (medium portions) of either fruits or green leafy vegetables. Details of physical activity were assessed by questions for exact daily duration (minutes) of work related, commute related and leisure time physical activity. Height was measured using stadiometer, weight using calibrated spring weighing machines, and waist and hip circumference was measured using WHO guidelines [12]. Sitting blood pressure measured after at least 5 min rest using standardized instruments. Three readings were obtained and were averaged for the data analysis. Fasting blood sample was obtained from all individuals after at least 10 h fast. The blood samples were obtained at community centers by technicians from an accredited national laboratory – Thyrocare Technologies Ltd., Mumbai, India ([www.thyrocare.com](http://www.thyrocare.com)). Blood glucose was measured at the local biochemistry facility of these laboratories. Blood for cholesterol, cholesterol lipoproteins and triglycerides estimation was transported under dry ice to the national referral laboratory at Mumbai, India. All the blood samples were analyzed at a single laboratory and a uniform protocol was used for measurements. Cholesterol, high density lipoprotein (HDL) cholesterol and triglyceride levels were measured using enzyme-based assays with internal and external quality control ([www.thyrocare.com](http://www.thyrocare.com)). Values of low density lipoprotein (LDL) cholesterol were calculated using Friedwald's formula (LDL cholesterol = [total cholesterol – (HDL cholesterol + triglycerides/5)]).

### 2.3. Diagnostic criteria

Metabolic syndrome has been diagnosed using harmonized Asian criteria, revised ATP-3 criteria as well as standard ATP-3 criteria [2–4]. The harmonized definition with Asian criteria is presence of any three of the following five criteria – waist size  $>90$  cm men,  $>80$  cm women; BP systolic  $\geq 130$  and/or diastolic  $\geq 85$  mm Hg; fasting triglycerides  $\geq 150$  mg/dl; HDL cholesterol  $<40$  mg/dl men,  $<50$  mg/dl women; and fasting blood glucose  $\geq 100$  mg/dl or known diabetes – were present [4]. Educational status was used as marker of socioeconomic status and categorized according to the number of years of formal education into three groups: less than 10 years (illiterates and less than secondary), 10–15 years (secondary to graduate) and more than 15 years (postgraduate education). Details of stress were inquired using INTERHEART study methods [14]. Smokers included subjects who smoked cigarettes, bidis, or other smoked forms of tobacco daily, past smokers were subjects who had smoked for at least 1 year and had stopped more than a year ago. Users of other forms of tobacco (oral, nasal, etc.) were classified as smokeless tobacco use. The diagnostic criteria for tobacco use as well as other coronary risk factors have been advised by the WHO [12]. Subjects consuming  $\geq 20$  g visible fat daily were categorized as high fat intake. This corresponds to total fat intake of  $>40$  g/day reported in previous studies from India [15] and corresponds to percent energy intake from fat (fat en%) of  $>30\%$  which is considered cutoff for high fat intake as suggested by WHO and other international guidelines [16]. Those involved in any significant physical activity were classified as active and with  $>30$  min of work-, leisure-, or commute-related physical activity were classified as moderately active as in earlier studies [13]. Hypertension was diagnosed when systolic blood pressure was  $\geq 140$  mm Hg and/or diastolic  $\geq 90$  mm Hg or a person was a known hypertensive [17]. Overweight was defined as body mass index  $\geq 25$  kg/m<sup>2</sup> and obesity defined by

**Table 1**  
Prevalence of metabolic syndrome using Asian specific criteria in various age-groups.

Age groups	Male (N=3426)	Female (N=2772)	Total (N=6198)
<30	41 (16.1)	48 (23.4)	89 (19.4)
30–39	185 (32.3)	201 (35.4)	386 (33.8)
40–49	396 (43.3)	371 (47.2)	767 (45.1)
50–59	413 (47.0)	383 (60.0)	796 (52.5)
60–69	277 (51.4)	277 (61.9)	554 (56.2)
≥70	127 (47.7)	74 (57.8)	201 (51.0)
Age-adjusted (95% CI)	33.3 (31.7–34.9)	40.4 (38.6–42.2)	36.1 (35.1–37.5)

body mass index ≥30 kg/m<sup>2</sup>. Truncal obesity was diagnosed when waist-hip ratio was >0.9 in men and >0.8 in women or waist circumference was >90 cm in men and >80 cm in women according to the harmonized guidelines [4]. Dyslipidemia was defined by the presence of high total cholesterol (≥200 mg/dl), high LDL cholesterol (≥130 mg/dl), low HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women) or high triglycerides (≥150 mg/dl), or if the individual was on treatment with cholesterol-lowering drugs [2]. Diabetes was diagnosed on the basis of either history of known diabetes on treatment or fasting glucose ≥126 mg/dl.

2.4. Statistical analyses

All the data were entered into SPSS database (Version 10.0, SPSS Inc., Chicago). In more than 90% subjects data for various variables were available and in about 85% data for all the variables were available. Values for men and women have been analyzed separately. Numerical variables are reported as means ± 1 SD and categorical variables as percent. Descriptive statistics are presented. Age-adjustment was performed using direct method with 2001 Indian census population as standard. Prevalence of risk factors in the study population and in various groups is reported as percent and 95% confidence intervals (CI). Intergroup comparisons were performed using  $\chi^2$  test. Logistic regression was performed to perform age-adjustments. Mantel-Haenszel  $\chi^2$  was used to determine trends in categorical variables.  $p < 0.05$  was considered significant.

3. Results

The study was performed at 11 cities located in all geographic regions of India. 6198 subjects (men 3426, women 2772) of the targeted 9900 subjects were evaluated (response 62%). Recruitment at individual sites and data for social and demographic characteristics has been reported [18]. Prevalence of the metabolic syndrome using Asian-specific criteria in men is 33.3% (95% CI 31.7–34.9%) and women 40.4% (CI 38.6–42.2%). Prevalence

according to modified ATP-3 criteria is 23.9% (CI 22.4–26.4%) in men and 34.5% (CI 32.0–36.1%) in women while according to standard ATP-3 criteria is 17.2% (CI 15.3–19.1%) in men and 22.8% (CI 20.1–24.2%) in women. Age-specific prevalence of metabolic syndrome is reported in Table 1 and shows a significant increase with age (Mantel-Haenszel  $\chi^2$  for trend,  $p < 0.05$ ).

Prevalence of individual components of the metabolic syndrome is shown in Table 2. An age-associated increase in observed in all the component factors of the metabolic syndrome. However, in the age-group ≥70 years there is lower prevalence of most of the components in men as well as women. Greater prevalence in women vs. men is observed for high waist circumference (57.5 vs. 35.7%) and low HDL cholesterol (53.1 vs. 34.1%) while prevalence of borderline and high blood pressure (46.3 vs. 50.6%), impaired fasting glucose or diabetes (28.0 vs. 29.0%) and high triglycerides (31.5 vs. 41.2%) is greater in men.

Age-adjusted prevalence of metabolic syndrome (Asian-specific) in various socioeconomic and lifestyle risk factor groups is shown in Table 3. With increasing educational status, occupational classes, dietary fat intake, physical inactivity and BMI there is significant increase in its prevalence (Mantel-Haenszel  $\chi^2$  for trend,  $p < 0.05$ ). Association of metabolic syndrome with smoking and/or tobacco use, depression and stress of various kinds is not clear. The trends are more prominent in men as compared to women (Table 3).

4. Discussion

This study shows a moderately high prevalence of metabolic syndrome in urban middle-class Asian Indian subjects. The prevalence is greater in women as compared to men. Men and women with better educational and occupational status, greater fat intake, lower physical activity and higher body mass index have significantly greater prevalence of the metabolic syndrome.

Large variations in the prevalence of metabolic syndrome have been reported from studies in different regions of the world [6,8,10]. Using the older ATP-3 definition the prevalence was reported as varying from 10% to 30% [19,20]. Using ATP-3 and data from Third National Health and Nutrition Evaluation Study (NHANES-3), Ford et al. [21] reported metabolic syndrome in 21.8% men and 23.2% women in USA. Comparison of NHANES data from 1999/2000 to 2009/2010 has reported that the prevalence has decreased from 25.5% to 22.9% [22]. During this period prevalence of hypertriglyceridemia and high blood pressure decreased while hyperglycemia and high waist circumference increased. The present study shows that prevalence of metabolic syndrome in India is lower when ATP-3 criteria are used for diagnosis but is greater when harmonized criteria are used. Our prevalence rates are similar to other regions of Asia [8] but lower than NHANES reports [22]. We cannot comment on the changing trends, although a serial study from India has reported increasing

**Table 2**  
Age-group specific prevalence of various components of the metabolic syndrome (Asian-specific criteria).

Age groups	Waist circumference >90/80 cm		Blood pressure ≥130/85 mm Hg		Fasting blood glucose ≥100 mg/dl or known diabetes		High density lipoprotein cholesterol <40/50 mg/dl		Triglycerides ≥150 mg/dl	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
<30	59(23.2)	89(43.4)	94(37.0)	58(28.2)	41(16.1)	29(14.1)	88(34.6)	127(61.9)	77(30.3)	46(22.4)
30–39	237(41.3)	352(61.9)	246(42.9)	197(34.7)	152(26.5)	155(27.3)	230(40.1)	325(57.2)	260(45.3)	160(28.2)
40–49	482(52.6)	571(72.6)	500(54.6)	429(54.6)	368(40.2)	263(33.4)	298(32.5)	380(48.3)	480(52.4)	307(39.0)
50–59	491(55.8)	475(74.4)	583(66.3)	433(67.8)	398(45.2)	305(47.8)	268(30.5)	291(45.6)	391(44.5)	275(43.1)
60–69	282(52.3)	332(74.3)	422(78.3)	352(78.7)	280(51.9)	231(51.7)	131(24.3)	176(39.4)	211(39.1)	194(43.4)
≥70	141(50.9)	90(70.3)	215(80.8)	112(87.5)	149(56.0)	73(57.0)	50(18.8)	35(27.3)	98(36.8)	46(35.9)
Age-adjusted (95% CI)	35.7 (34.1–37.3)	57.5 (55.6–59.3)	50.6 (48.9–52.3)	46.3 (44.4–48.1)	29.0 (27.5–30.5)	28.0 (26.3–29.7)	34.1 (32.5–35.7)	52.8 (50.9–54.7)	41.2 (39.5–42.8)	31.5 (29.7–33.2)

**Table 3**

Age-adjusted prevalence (95% confidence intervals) of metabolic syndrome in various risk factor groups in men, women and overall cohort.

Variable	Number	Total	Men	Women
Educational status				
• Illiteracy/primary	272	25.7(20.5–30.9)	22.9(11.0–34.8)	26.3(20.5–32.1)
• High school	2293	42.8(40.8–44.8)	36.9(34.0–39.8)	47.9(45.1–50.7)
• Some college	3005	45.3(43.5–47.1) <sup>a</sup>	44.6(42.4–46.7) <sup>a</sup>	47.0(43.8–50.1) <sup>a</sup>
Occupational status				
• Low class V–VI	1287	39.5(36.8–42.2)	28.5(24.2–32.8)	44.8(41.5–48.1)
• Middle class III–IV	1676	48.0(45.6–50.4)	36.4(33.4–39.4)	64.4(60.8–68.0)
• Upper class I–II	3017	46.2(44.4–47.9) <sup>a</sup>	47.7(45.6–50.4) <sup>a</sup>	43.7(40.8–46.6)
Dietary fat intake				
• <20 g/day	1575	45.4(42.9–47.8)	40.9(37.4–44.3)	49.9(46.4–53.4)
• 20–39 g/day	2525	42.8(40.8–44.7)	38.7(36.2–41.2)	48.4(45.4–51.4)
• >40 g/day	834	52.3(48.9–55.7) <sup>a</sup>	52.4(48.0–56.8) <sup>a</sup>	52.0(46.7–57.3) <sup>a</sup>
Physical activity levels				
• Sedentary/low	2368	47.2(45.2–49.2)	43.9(41.0–46.7)	50.5(47.7–53.3)
• Mild	3404	42.5(40.8–44.1)	37.9(35.7–40.1)	48.5(46.0–51.0)
• Moderate	1285	46.5(43.8–49.2)	40.9(37.2–44.6)	52.9(48.9–56.9)
• Vigorous	110	38.2(29.1–47.3) <sup>a</sup>	41.1(29.8–52.4) <sup>a</sup>	32.4(17.3–47.5) <sup>a</sup>
Smoking/Tobacco				
• Non-smoker	4790	47.5(46.1–48.9)	43.2(41.2–45.2)	51.7(49.7–53.7)
• Ex smoker	196	53.6(46.6–60.6)	50.8(43.3–58.2)	73.9(55.9–91.8)
• Current smoker	457	43.1(38.5–47.6)	44.3(39.6–48.9)	15.8(0.6–32.2)
Alcohol abuse	678	44.1(40.3–47.8)	45.8(41.8–49.7)	31.9(20.9–42.9)
Depression				
• No	3976	44.7(43.1–46.2)	41.9(39.8–43.9)	48.0(45.7–50.3)
• Yes	1258	43.5(40.7–46.2)	38.5(34.8–42.1)	49.6(45.5–53.7)
Overweight/obesity				
• BMI <23	1752	29.3(27.2–31.4)	28.2(25.4–31.0)	30.6(27.4–33.8)
• BMI 23–24.9	1236	47.2(44.4–50.0)	47.1(43.5–50.6)	47.5(43.0–52.0)
• BMI 25–29.9	2263	49.5(47.4–51.5)	45.5(42.8–48.2)	55.1(51.9–58.2)
• BMI ≥30	829	66.4(53.2–69.6) <sup>a</sup>	62.1(56.9–67.3) <sup>a</sup>	69.3(65.2–73.3) <sup>a</sup>

<sup>a</sup> Mantel–Haenszel test,  $p < 0.05$ ; BMI, body mass index kg/m<sup>2</sup>.

prevalence of multiple cardiometabolic risk factors in urban subjects [23].

There have been a number of studies of metabolic syndrome in India [24–45]. Initial studies used the standard ATP-3 or modified ATP-3 criteria for diagnosis and reported prevalence of 18–35% in urban subjects [24–27]. Recent studies have used harmonized criteria and Asian-specific guidelines and have reported a higher prevalence, 25–50%, with large inter-study variations [28–41]. The prevalence of metabolic syndrome is significantly lower in rural subjects [29,42–45] and varies from 9% to 12% although a study in rural South India [42] has reported a greater prevalence. The present study shows a high prevalence of metabolic syndrome in Indian urban populations which is almost three times the rural prevalence. Although, this is the largest study of metabolic syndrome in India, there is need for more studies using uniform sampling to identify national prevalence of this syndrome as this conglomeration of cardiovascular risks is the most important risk-driver for premature CHD in India [46]. This study also shows a high prevalence of certain components of the metabolic syndrome among the urban subjects in India. High prevalence of hypertension and central obesity is noteworthy. Both are associated with a significantly greater cardiovascular risk as shown in cross sectional and prospective studies especially in setting of the metabolic syndrome [46]. Prevalence of diabetes is also high and similar to many previous studies from urban India [47]. Prevalence of obesity defined by BMI  $\geq 30$  kg/m<sup>2</sup> is low. This syndrome of normal weight central obesity is an important cardiovascular risk marker [48] and shows a high propensity of Indian urban subjects to develop cardiovascular diseases at lower thresholds of risk factors.

There is significant association of various lifestyle factors with prevalence of metabolic syndrome. In India, and other low-income

and lower middle-income countries, a few cardiometabolic risk factors (obesity and diabetes) are greater in higher socioeconomic strata although many risk factors such as smoking, low fruit and vegetable intake, leisure-time physical inactivity and low HDL cholesterol are greater in the low socioeconomic status persons [49]. Significant association of metabolic syndrome with lower physical activity, greater fat intake and high BMI are well known [6] and the present study shows that risk factors for the metabolic syndrome are universal.

The study has several limitations. We did not study populations in all the large Indian states but inclusion of all regions of the country is unique to our study. Sampling confined to urban locations in middle-level cities could be criticized for selection bias, however, such urban locations now represent the heart of India and are fertile grounds for cardiovascular epidemic. Moreover, rapidly increasing urbanization in the country shall lead to more than 60% of the population in similar locations within the next 20–30 years. The study, therefore, illustrates the need to create more healthy cities for control of multiple metabolic cardiovascular abnormalities. Thirdly, the data from middle-class locations in urban areas may not be generalizable to the whole country when almost 30% of Indian population live in urban slums and more than 65% dwell in rural locations. However, the study does provide a snapshot on more than 300 million Indians who are middle class and provides a glimpse into the future of the country. Fourthly, selection of the cities, locations and participants could be criticized as biased due to convenience sampling. The best epidemiological approach would have been to perform a stratified sampling using the whole country as sampling frame. We did not randomize the whole cities into strata based on locations and amenities but chose middle class locations as classified by the

government and then performed consecutive household survey or simple cluster sampling at all the locations. This method has been recommended by the WHO as alternate strategy to stratified random sampling [12]. Fifthly, the study has low response rates (62%) which is an important limitation. However, the response rate is similar to many previous studies from India [11]. Some studies from Western Europe and America have reported response rates as low as 35–40% [50]. It has been opined that response rate of >60% be considered as threshold of acceptability and has face validity as a measure of survey quality [50]. The study has several strengths. It has highlighted a high prevalence of cardiometabolic risks in the country. This study also shows that poor lifestyles (low physical activity, high fat diet, obesity) have significant association with increased cardiometabolic risk. Other strengths of the study include inclusion of almost all regions of the country; evaluation of risk factors in urban locations that are known to have high burden of cardiovascular disease and use of uniform methodology and measurements, especially biochemical.

In conclusion, this study shows a high prevalence of the metabolic syndrome in urban Asian Indians and also shows that it is more prevalent in subjects with higher socioeconomic status, sedentary lifestyle, high fat diet and obesity. These data highlight the urgent need for control of upstream causes of obesity (excessive caloric intake, poor dietary habits and physical inactivity) to control the rapidly increasing epidemic of diabetes and coronary heart disease in India.

### Conflict of interest

None declared

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