Original article

Effect of obesity on cardiometabolic risk factors in Asian Indians

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ABSTRACT

Objectives: To determine the prevalence of overweight and obesity and their effects on cardiometabolic risk factors in a representative sample of urban population in Eastern India.

Materials and methods: A population-based survey was conducted among a randomly selected study population aged 20–80 years in an urban population of Berhampur city of Eastern India. Both anthropometric and biochemical information were collected, in addition to detailed information on classical cardiometabolic risk factors. Both descriptive and inferential statistical analyses were performed. Obesity and overweight were defined based on the revised Asian–Pacific population criteria (Body mass index [BMI] ≥ 25 kg/m² and ≥ 23 kg/m², respectively).

Results: The age-standardized rates of obesity and overweight are 36.8% (Males: 33.2%; Females: 40.8%) and 17.6%, (Males: 20.4%; Females: 15.1%) respectively, i.e., over half are either obese or overweight in this study population. Compared to the World Health Organization (WHO) standard cutoff criteria of overweight [BMI ≥ 25 kg/m²] and obesity [BMI ≥ 30 kg/m²], the cardiometabolic risk factors studied showed a significant incremental rise even with the lower cutoffs of the revised Asia–Pacific criteria. Older age, female gender, family history of diabetes, being hypertensive, hypertriglyceridemia, hypercholesterolemia, physical inactivity and middle to higher socioeconomic status significantly contributed to increased obesity risk among this urban population.

Conclusion: One-third of the urban populations are obese in Eastern India – an underestimate compared to the standard BMI cutoff criteria. Nevertheless, significant associations of the classical cardiometabolic risk factors with obesity were observed using the revised Asia–Pacific criteria clearly indicating a more aggressive cardiovascular prevention strategy for Asian Indians.

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1. Introduction

Obesity is a well-recognized cardiovascular risk factor that exerts effects on the heart and circulation both directly and indirectly through its influence on known risk factors such as hyperlipidemia, hypertension, hyperglycemia, prothrombotic state and proinflammatory mediators.¹ There are also some unrecognized mechanisms of obesity-related cardiovascular risk. Overweight and obesity together predispose to long-term cardiovascular disorders (CVD) such as coronary heart disease, heart failure, and sudden death.¹ Distinct regional and ethnic patterns in obesity associated cardiometabolic disorders are also reported.²

Impaired cardiovascular fitness is commonly associated with obesity in physically inactive individuals contributing to additional cardiovascular risk independent of the degree of obesity. Thus both “fatness” and “fitness” are important independent and modifiable risk factors for heart disease.³ Obesity – as an independent cardiometabolic risk factor is unclear. Methodological issues, such as variations both in the measurement and definition of obesity add further challenges in proving the validity of this apparent relationship. Obesity often occurs in a cluster with established cardiometabolic risk factors and, thereby making it more difficult to establish whether the presence and pattern of obesity is an independent cardiometabolic risk factor or not.

Relationship of cardiometabolic risk factors with Body mass index (BMI) has been studied in multiple populations across European, North American and Asian–Pacific countries.^{4–7} These studies have shown that the risk of cardiovascular disease increases continuously with increasing BMI. But few comparable prospective

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data are currently available for South Asian region, even though South Asians are at a higher risk than White Caucasians for the development of obesity and obesity-related cardiometabolic disorders for the same level of increase in BMI levels.^{8,9} They also seem to have a peculiar body phenotype known as South Asian Phenotype, predisposing them to increased cardiometabolic risk. There could also be unique genetic markers which make South Asians more susceptible to diabetes.^{8–10}

Data from various mortality statistics and morbidity surveys indicate significant regional variations in cardiovascular risk factors prevalence across Indian subcontinent.¹¹ Furthermore, data from the Registrar General of India reported greater age-adjusted cardiovascular mortality in southern and eastern states of the country.¹¹ But regrettably, accurate recent data on a national scale are not available in India.^{12,13} Earlier we reported that the state of Orissa, one of the poorest states of Eastern India bordering a prosperous state of Andhra Pradesh of Southern India, showed interesting variations in classical coronary risk factors among an urban population.^{14–16} Such a distinctive geographic location opens up to cultural and socio-economic interactions. Obesity is a lifestyle disease and factors contributing to changing patterns in obesity prevalence in this geographic region may provide significant insights into tackling the ever-rising burden of obesity and its effect on cardiovascular risk factors in South Asians. The present study aims at updating on changing patterns of obesity in this urban Eastern Indian population and quantifying factors significantly contributing to any observed underlying pattern. Increased BMI has been shown to be associated with increased cardiometabolic risk in urban Indian populations from North and South India.^{17–20} Likewise to correlate BMI with multiple cardiometabolic risk factors in Eastern India we analyzed data using regression-based statistical techniques.

2. Materials and methods

2.1. Study design and setting

The present study was a population-based survey of cohort under Berhampur Municipal corporation with an estimated population of 307,724 in 2001, in Orissa one of the poorest states of Eastern India bordering a prosperous state of Andhra Pradesh of Southern India. So the residents here are diverse mix of socioeconomic class, language, faith and customs.

2.2. Sampling design and sample size

The urban population of Berhampur city of Eastern India spread across 37 electoral wards constituted the sampling frame. Thirty wards were selected randomly to identify the sampling unit, a household. Each ward of the city is divided into 12–14 streets and each street is spread in two rows of households. Two rows of households were randomly selected and the sampling unit household was selected by simple random sampling to enroll approximately 40 subjects who are ≥ 20 years of age from each ward. A total of 1178 subjects who are ≥ 20 years of age out of 1200 eligible subjects finally participated in the study. These details of sampling design have been published earlier.¹⁴

2.3. Survey methods

Demographic, socioeconomic status as per modified Kuppuswamy scale,²¹ and self-reported behavioral information (smoking, alcohol, physical activity, fruit intake and diet), objective measures of anthropometry (height, weight, waist and hip circumferences), biochemical (plasma glucose, total cholesterol, triglycerides, High density lipoprotein cholesterol [HDL-c] levels), and

electrocardiographic data were collected from all study participants. Detailed interviews were performed through a previously validated questionnaire based on the guidelines of World Health Organization (WHO).²² History of any chronic illness, in the participant as well as in the family, including diabetes mellitus, hypertension, cerebrovascular accident and coronary heart disease were recorded. Details of study methodology have been published elsewhere.¹⁴

2.4. Ethical approval

Institutional ethical committee approval was obtained prior to the start of study and informed consent was taken from all the study subjects.²³

2.5. Definitions of cardiovascular risk factors

Definition and diagnosis of diabetes mellitus and intermediate hyperglycemia was based on a Report of a World Health Organization (WHO)/International diabetes Federation (IDF) Consultation, Geneva: World Health Organization; 2006.²⁴

Diabetes was defined as individuals diagnosed by a physician and on glucose-lowering medications (self-reported) and/or those who had a fasting plasma glucose level of 126 mg/dl (≥ 7.0 mmol/l) or 2 h plasma glucose ≥ 200 mg/dl (11.1 mmol/l).²⁴

Impaired fasting glucose (IFG) as fasting plasma glucose level of 100–125 mg/dl (5.6–6.9 mmol/l). **Impaired glucose tolerance (IGT)** as fasting plasma glucose level of 110–125 mg/dl (5.6–6.9 mmol/l) or 2 h post-glucose load plasma glucose level of 140–199 mg/dl (7.8–11.1 mmol/l).²⁴

Obesity and overweight was based on the revised criteria specific for Asian–Pacific populations.²⁵ Value of BMI ≥ 23 kg/m² was used to define overweight and ≥ 25 kg/m² were used to define obese.

Hypertension definition was based on the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.²⁶

Dyslipidemia was based on the third report of the National Cholesterol Education Program (NCEP).²⁷

2.6. Metabolic syndrome

We followed a unified definition of the metabolic syndrome by joint interim statement of five major scientific organizations – the International Diabetes Federation, the National Heart, Lung, and Blood Institute, the American Heart Association, the World Heart Federation, the International Atherosclerosis Society, and the International Association of the Study of Obesity.²⁸

2.7. Anthropometric profile

Body weight and height were measured with the subject bare-foot and wearing light clothing. BMI was calculated as weight in kilograms over height in meters squared. Waist circumference was measured at the mid point between the lower limit of the rib cage and upper border of iliac crest.

Blood pressure was recorded in a sitting position of the right arm to the nearest 2 mmHg using mercury sphygmomanometer. Two readings were taken 5 min apart and the mean was taken as the blood pressure.

2.8. Biochemical analysis

A fasting blood sample was collected after an overnight fast of at least 10 h for biochemical investigations. In addition, venous

Table 1
Clinical and demographic characteristics of study subjects.

Variable	Non-obese (n = 662)	Obese (n = 516)	P value
	Mean (SD)	Mean (SD)	
Age (years)	43.6 (14.7)	48.7 (12.3)	0.000**
Sex			
Male	356 (60.3)	234 (39.7)	0.004*
Female	306 (52.0)	282 (48.0)	
Education			
Illiterate	95 (14.4)	38 (7.4)	0.000**
Elementary	176 (26.6)	118 (22.9)	
High school	174 (26.3)	137 (26.6)	
College	217 (32.8)	223 (43.2)	
Family history of hypertension	197 (29.8)	182 (35.3)	0.044*
Family history of diabetes	116 (17.5)	167 (32.4)	0.000**
Socioeconomic status			
Lower	135 (20.4)	46 (8.9)	0.000**
Middle	470 (71.0)	412 (79.8)	
Upper	57 (8.6)	58 (11.2)	
Physical inactivity	169 (25.5)	231 (44.8)	0.000**
Hypertension	126 (19.0)	188 (36.4)	0.000**
Diabetes	53 (8.0)	83 (16.1)	0.000**
Central obesity	153 (23.1)	423 (82.0)	0.000**
Hypercholesterolemia ≥ 200 mg/dl	122 (18.4)	151 (29.3)	0.000**
Hypertriglyceridemia ≥ 150 mg/dl	200 (30.2)	244 (47.3)	0.000**
High LDL ≥ 130 mg/dl	143 (21.6)	122 (23.6)	0.405
Low HDL (males < 40 mg/dl, females < 50 mg/dl)	291 (44.0)	262 (50.8)	0.020*

Numbers in parenthesis indicate percentages.

* $P < 0.05$, ** $P < 0.01$.

plasma glucose 2 h after ingestion of oral glucose load in all subjects except in known diabetics, who underwent 2 h postprandial plasma glucose estimation. All biochemical parameters were performed using enzymatic kits.^{29–33} Details of methodology have been published elsewhere.¹⁴

2.9. Statistical analysis

Significant differences in proportions of several covariates studied across two groups of general obesity status were tested using Pearson's Chi-Square test [Table 1].

To test significant differences in means of each individual risk factor studied across three different samples (classified by BMI categories), multi-way ANOVA (Analysis of Variance) tests were employed [Tables 3 and 4].

Univariate logistic regression and multivariable logistic regression analyses were performed using SAS software (9.1.2, NC, Cary, United States) to predict potential significant predictors of obesity employing backward elimination modeling technique.

2.10. Method of age standardization

Age-standardized prevalence was estimated by direct standardization method using population of Orissa, India for respective

populations ≥ 20 years of age. 95% confidence intervals (CI) were calculated for the prevalence. The details of statistical methodology are published in our earlier studies for direct age-standardized prevalence estimation of Diabetes mellitus/IGT and Metabolic Syndrome in the same urban population setting of Orissa state of Eastern India.¹⁶ The following formula was used to estimate age-standardized rates.

Formula – Direct method.

$$SR = \frac{\sum (r_i P_i)}{\sum P_i}$$

where, SR is the age-standardized rate for the population being studied r_i is the age-group specific rate for age-group i in the population being studied P_i is the population of age group i in the standard population.

3. Results

A total of 1178 subjects participated in the study. Of them 516 were obese; 217 were overweight. The general characteristics of our study outcomes are summarized below.

3.1. Demographic and clinical profile of subjects with and without obesity

The sex distribution in this study was almost equal. The age of the subjects ranged from 20 to 80 years, with a mean age of 47 years in males (SD = 14.46) and 44.21 years in females (SD = 13.26). Detailed clinical and demographic characteristics of study population are shown in Table 1.

3.2. Prevalence of obesity/overweight

Table 2 shows age-standardized rates (with 95% CI) of both obesity and overweight. The prevalence rates of obesity and overweight are 36.82% and 17.65%, respectively. Obesity is significantly more prevalent in females, i.e., 40.79% compared to 33.17% in males. But overweight is more common in males (20.36%) compared to females (15.09) [Table 2].

3.3. Anthropometric and biochemical parameters according to body mass index

They are summarized in Table 3. In general, there is a linear incremental increase in the levels of all anthropometric and biochemical parameters studied – relatively lower levels for the normal weight individuals (18.5–22.9 kg/m²) while relatively higher levels for obese individuals (≥ 25 kg/m²). Females showed significantly lower levels of cardiometabolic risk factors compared to males across all three different categories of BMI except for HDL. The mean age of subjects within each category of BMI also varied – the obese individuals were relatively older in age. All the within group comparisons are statistically significant ($P < 0.05$).

Table 2
Age-standardized prevalence of subjects as per body mass index.

BMI	Male (n = 590)			Female (n = 588)			Total (1178)		
	Age std prev. (%)	95% Confidence interval		Age std. prev. (%)	95% Confidence interval		Age std. prev. (%)	95% Confidence interval	
< 18.5 (n = 84)	9.52	6.36	12.67	10.40	7.31	13.49	10.15	7.91	12.38
18.5–22.9 (n = 361)	36.95	32.35	41.55	33.72	29.38	38.06	35.39	32.21	38.57
23.0–24.99 (n = 217)	20.36	16.61	24.12	15.09	12.03	18.14	17.65	15.20	20.09
≥ 25.0 (n = 516)	33.17	29.25	37.09	40.79	36.80	44.78	36.82	34.00	39.64

Table 3

Anthropometric and biochemical parameters of the study subjects according to body mass index.

Gender wise	Group I (n = 361)			Group II (n = 217)			Group III (n = 516)		
	BMI 18.5–22.9 kg/m ²			BMI 23–24.9 kg/m ²			BMI ≥ 25 kg/m ²		
	Male	Female	Overall	Male	Female	Overall	Male	Female	Overall
Numbers	194	167	361	126	91	217	234	282	516
Age (years)	46.5 ± 15.7	39.2 ± 12.7	43.1 ± 14.9	48.0 ± 14.0	45.0 ± 12.8	46.7 ± 13.6	49.9 ± 12.4**	47.8 ± 12.2**	48.7 ± 12.3**
Weight (kg)	55.7 ± 5.7	47.9 ± 4.8	52.1 ± 6.6	64.6 ± 5.4	54.6 ± 4.7	60.4 ± 7.1	73.4 ± 8.7**	64.8 ± 8.3**	68.7 ± 9.5*
Waist cir (cm)	78.6 ± 8.1	72.6 ± 7.7	75.8 ± 8.5	87.3 ± 6.6	79.6 ± 8.1	84.1 ± 8.2	95.0 ± 9.1**	89.4 ± 9.9**	92.0 ± 9.9*
SBP (mm Hg)	130.3 ± 12.0	125.0 ± 13.1	127.8 ± 12.8	133.5 ± 13.8	131.0 ± 16.2	132.4 ± 14.8	137.5 ± 15.1**	134.8 ± 13.6**	136.0 ± 14.3*
DBP (mm Hg)	82.4 ± 7.0	80.4 ± 7.0	81.5 ± 7.1	85.0 ± 7.7	83.6 ± 9.5	84.4 ± 8.5	86.9 ± 8.9**	85.9 ± 8.7**	86.4 ± 8.8*
FBS (mg/dl)	92.7 ± 30.4	87.4 ± 32.1	90.2 ± 31.3	100.0 ± 37.5	91.4 ± 24.8	96.4 ± 33.0	102.7 ± 29.8*	104.0 ± 38.5**	103.4 ± 34.8*
PGBS (mg/dl)	132.0 ± 51.9	121.8 ± 47.0	127.3 ± 49.9	141.1 ± 58.7	126.7 ± 39.6	135.1 ± 52.0	147.6 ± 54.9*	147.1 ± 61.4**	147.3 ± 58.5*
CHOL (mg/dl)	176.6 ± 33.6	173.3 ± 34.7	175.0 ± 34.1	186.9 ± 33.5	177.0 ± 30.8	182.7 ± 32.7	185.5 ± 32.9*	89.6 ± 36.7**	187.7 ± 35.0*
TG (mg/dl)	149.4 ± 64.0	140.8 ± 48.3	145.4 ± 57.4	172.6 ± 72.3	143.4 ± 39.3	160.3 ± 62.3	170.7 ± 62.0*	168.0 ± 55.0**	169.2 ± 58.2*
HDL (mg/dl)	46.7 ± 5.0	47.2 ± 4.5	46.9 ± 4.8	45.3 ± 4.1	46.4 ± 4.1	45.8 ± 4.1	45.6 ± 4.2*	45.7 ± 4.3**	45.6 ± 4.2*
LDL (mg/dl)	99.3 ± 30.3	97.4 ± 30.7	98.4 ± 30.4	107.9 ± 30.4	101.8 ± 28.7	105.3 ± 29.8	105.5 ± 28.8*	109.9 ± 31.9**	107.9 ± 30.6*

Data are shown as mean ± SD, ***P* < 0.000, **P* < 0.05, ANOVA test of significance between three groups, Waist Cir: waist circumference, SBP: systolic blood pressure, DBP: diastolic blood pressure, FBS: fasting blood sugar, PGBS: post-glucose blood sugar, CHOL: blood cholesterol, TG: triglycerides, HDL: high density lipoprotein cholesterol, LDL: low-density lipoprotein cholesterol.

3.4. Prevalence of cardiometabolic risk factors in obese

They are summarized in Table 4. Obese individuals (BMI ≥ 25) have relatively a higher rate of cardiometabolic risk factors compared to those considered having normal BMI levels (18.5–22.9). Except for metabolic syndrome rates, females showed relatively lower rates in all the cardiovascular risk factors studied. Almost one in four of the obese individuals are considered pre-diabetics, as opposed to only one in ten among the normal weight individuals. Diabetes rates doubled from 10% in normal weight individuals to >20% among obese individuals. Likewise, half of the obese individuals are reported to be hypertensive, while only quarter of the normal weight individuals are hypertensive. All the within group comparisons are statistically significant (*P* < 0.05).

3.5. Significant risk factors for obesity

Detailed correlates of obesity in univariate analysis for the base model in Table 5 and the final model of multivariate logistic regression method showing significant predictors of obesity are summarized in Table 6.

Older age, hypertriglyceridemic and hypercholesterolemic individuals have about one and half times higher risk for obesity. Individuals with family history of diabetes mellitus, middle to higher socioeconomic status, physical inactivity were more than two fold increased risk of developing obesity. Likewise, female gender and hypertensives were almost twice as likely to be at-risk of obesity.

4. Discussion

This cross-sectional study of adequate statistical power and representativeness (*n* = 1178) was conducted among an apparently urban healthy population in Eastern India, a region with distinctive lifestyles and culture. A very high age-standardized prevalence of obesity and overweight at 36.82% and 17.65% were observed in this study population. Higher the BMI levels greater the levels and rates of the several cardiometabolic risk factors were noted. Females in general showed relatively both lower levels and rates across all the cardiometabolic risk factors studied except a higher rate of metabolic syndrome compared to males. On multivariable analyses, older age, female gender, family history of diabetes, being hypertensive, hypertriglyceridemia, hypercholesterolemia, physical inactivity and middle to higher socioeconomic status significantly contributed to increased obesity risk among this urban population.

The prevalence of obesity is increasing exponentially in India, both in the urban and rural areas. Obesity in childhood and adolescence is attaining an alarming and epidemic proportion in India with about 15–20% of the population being affected.^{34,35} Similarly, about 30–65% of adult urban Indians are either overweight or obese or have central adiposity.³⁶ Indian National Family Health Surveys reported a rapid increase in BMI and prevalence of obesity in the country.³⁷ Similar findings are observed from rest of South Asia.^{38–40} Increasing urbanization with associated dietary and physical activity transitions are aggravating the obesity epidemic in South Asian region.^{38–41}

Though the prevalence of obesity in South Asians is lower than whites, blacks and Hispanics, the health risks related with obesity

Table 4

Prevalence of cardiometabolic risk factors according to body mass index (BMI).

Variables	Group I			Group II			Group III		
	BMI (18.5–22.9 kg/m ²)			BMI (23–24.9 kg/m ²)			BMI (>25 kg/m ²)		
Gender wise numbers	Male (n = 194)	Female (n = 167)	Total (n = 361)	Male (n = 126)	Female (n = 91)	Total (n = 217)	Male (n = 234)	Female (n = 282)	Total (n = 516)
Impaired fasting glucose	26 (13.4) ^{a,b}	15 (9.0) ^b	36 (11.4) ^{a,b}	23 (18.3) ^c	15 (16.5) ^c	38 (17.5) ^c	66 (28.2)	72 (25.5)	138 (26.7)
Impaired glucose tolerance	22 (11.3) ^{a,b}	11 (6.6) ^{a,b}	33 (9.1) ^{a,b}	24 (19.0) ^c	10 (11.0) ^c	34 (15.7) ^c	55 (23.5)	63 (22.3)	118 (22.9)
Diabetes	27 (13.9) ^{a,b}	9 (5.4) ^{a,b}	36 (10.0) ^{a,b}	24 (19.0)	10 (11.0) ^c	34 (15.7) ^c	52 (22.2)	60 (21.3)	112 (21.7)
Hypertension	55 (28.4) ^{a,b}	32 (19.2) ^a	87 (24.1) ^{a,b}	51 (40.5) ^c	30 (33.0) ^c	81 (37.3) ^c	114 (48.7)	135 (47.9)	249 (48.3)
Metabolic syndrome	29 (14.9) ^{a,b}	39 (23.4) ^{a,b}	68 (18.8) ^{a,b}	45 (35.7) ^c	49 (53.8) ^c	94 (43.3) ^c	127 (54.3)	214 (75.9)	341 (66.1)

Values are shown as no (%).

^a Group I versus II; statistical significance at the *P* < 0.05 level.

^b Group I versus III; all statistical significant (*P* < 0.05).

^c Group II versus III statistical significance (*P* < 0.05).

Table 5
Correlates of obesity (body mass index ≥ 25) univariate analysis-base model.

	n (%)	General obesity odds ratio (95% CI)	P
Gender			
Male	234 (39.7)	1	0.004
Female	282 (48.0)	1.40 (1.11–1.76)	
Physical activity			
No (n = 400)	231 (57.8)	2.36 (1.84–3.02)	0.000
Yes (n = 778)	285 (36.6)	1	
Socioeconomic status			
Lower (n = 181)	46 (25.4)	1	
Middle (n = 882)	412 (46.7)	2.57 (1.79–3.68)	0.000
High (n = 115)	58 (50.4)	2.98 (1.81–4.90)	0.000
Age			
<45 years (n = 560)	198 (35.4)	1	
45–64 years (n = 481)	252 (52.4)	2.01 (1.56–2.58)	0.000
>64 years (n = 137)	66 (48.2)	1.70 (1.16–2.47)	0.006
Family history of hypertension			
Present	182 (48.0)	1.28 (1.00–1.64)	0.044
Absent	334 (41.8)	1	
Family history of diabetes			
Present	167 (59.0)	2.25 (1.71–2.95)	0.000
Absent	349 (39.0)	1	
Hypertension			
Yes (n = 431)	249 (57.8)	2.46 (1.92–3.13)	0.000
No (n = 747)	267 (35.7)	1	
Diabetes			
Yes (n = 185)	112 (60.5)	2.23 (1.62–3.08)	0.000
No (n = 993)	404 (40.7)	1	
Hypercholesterolemia			
Yes (n = 273)	151 (55.3)	1.83 (1.39–2.40)	0.000
No (n = 905)	265 (40.3)	1	
Hypertriglyceridemia			
Yes (n = 444)	244 (55.0)	2.07 (1.63–2.63)	0.000
No (n = 734)	272 (37.1)	1	
High LDL			
Yes (n = 265)	122 (46.0)	1.12 (0.85–1.47)	0.405
No (n = 913)	394 (43.2)	1	
Low HDL			
Yes (n = 553)	262 (47.4)	1.31 (1.04–1.65)	0.020
No (n = 625)	254 (40.6)	1	

crop up at a lower BMI in South Asians.³⁶ These observations strongly indicate that the current WHO criteria to define overweight and obesity may not be suitable for Asian populace in general and South Asians in particular. Thus, a new criterion to define overweight and obesity in the Asia–Pacific and South Asian Region was proposed recently.²⁵

The magnitude of the effect of BMI on cardiometabolic risk factors is clearly shown in this study. The study reports higher values for both systolic and diastolic blood pressure, blood sugar status, cholesterol, triglyceride and low-density lipoprotein cholesterol (LDL-C) in both overweight and obese groups. Further, lower levels of HDL-c were found in these groups, indicating the

Table 6
Correlates of obesity (body mass index ≥ 25) (backward elimination logistic regression modeling).

Variables	Adjusted odds ratios (AOR)	95% Confidence intervals (CI)
Female gender	1.77	1.37–2.29
Age (45–64)	1.44	1.10–1.87
Family history diabetes	2.09	1.56–2.81
Hypertension	1.92	1.46–2.51
SES-middle	2.38	1.62–3.52
SES-high	2.31	1.34–3.97
Hypertriglyceridemia	1.42	1.07–1.89
Physical inactivity	2.07	1.58–2.71
Hypercholesterolemia	1.44	1.05–1.99

SES = Socioeconomic status.

possibility of an increased susceptibility for atherosclerotic diseases.

Diabetes and glucose intolerance is significantly associated with overweight and obesity. The current study also showed a substantial increase in IFG and IGT according to BMI maintaining consistency with other studies.^{42,43} Numerous epidemiological studies have shown that BMI is a powerful predictor of type 2 diabetes, hypertension, hypercholesterolemia and heart disease.^{1,43,44}

Metabolic syndrome, which constitutes the clustering of cardiometabolic risk factors, is considered to be a major risk factor for cardiometabolic disorders.⁴⁵ Our study has reported an increasing trend in prevalence of metabolic syndrome according to BMI. Metabolic syndrome was present in 18.8% of normal weight, 43.3% of overweight and 66.1% of obese subjects. Further it was mostly seen in females. Similar observations are seen in rest of South Asia.^{39,46}

Another observation from the study reinforces that physical activity levels are decreasing in South Asians. The present study reveals 44.8% of the subjects with obesity are physically inactive and these physically inactive individuals are twice as likely to become obese.

In summary increased BMI has been shown to be associated with increased cardiovascular risk and cardiometabolic risk factors worsen continuously across the spectrum of BMI in Asian Indians. Similar relationship of cardiometabolic risk factors with BMI has been studied in multiple populations in Europe, north America and Asia–Pacific.^{4–7}

The BMI was significantly and linearly associated with blood pressure, glucose levels, lipids and was inversely and linearly associated with HDL-c In the Framingham Offspring Study.⁴⁷ US National Health Surveys – also reported a linear relationship of multiple cardiovascular risk factors with BMI.⁴⁸

Our study has several strengths and limitations. Recall bias of the self-reported measures for behavioral risk factors is a possibility. The study is confined to urban populace and may not be truly representative of the general population. However, since the obesity, diabetes and cardiovascular disorders in India are essentially an urban phenomenon such findings are clearly relevant to comparable urban population settings.²⁰ A small sample size in comparison to large prospective epidemiological studies in USA, Europe, and Asia–Pacific^{4–7} is a limitation. However, this is not a prospective study but a cross-sectional study evaluating significant risk factors of obesity associated with continuous variables such as blood pressure, glucose and lipids. For such analyses, the present sample size is considered adequate. Further the study is an observational study and therefore no causal inferences can be made. We have not evaluated association of cardiovascular risk factors with other measures of obesity such as Waist circumferences and Waist hip ratios in the present study.

Strengths of this study include a large population-based sample, representative sampling methodology and the use of standardized data collection protocols and in-depth assessment of multiple cardiometabolic risk factors. Furthermore the survey had a high response rate (98.16%).

5. Conclusion

More than one-third of the urban population studied was found to be obese in this study – higher than several past and recent estimates in similar population settings elsewhere. We also quantified several cardiovascular risk factors significantly being associated with obesity which are known modifiable classical risk factors. Such findings are timely and are considered useful as a major source of information for planning primary prevention strategies to prevent and control obesity.

Although, longitudinal studies play a crucial role in defining the important risk factors and guide evidence base for interventions, observational studies as the present one provides knowledge regarding broad risk factors, such as high BMI and obesity, that could be targeted for early intervention toward prevention and control of anticipated epidemic of CVD. Our study in this Asian Indian population reveals cluster of multiple risk factors with increasing BMI, i.e., Normal, overweight and obesity. This study highlights the fact that cardiovascular risk increases even within normal BMI range as well and there is a linear increase in multiple cardiometabolic risk factors.

In conclusion, the observed high prevalence of obesity and associated cardiometabolic risk factors in this urban populace of Eastern India reinforces the need for a more aggressive preventive and management strategy targeting South Asians in particular for an optimum cardiometabolic health in a cost effective manner. Nevertheless, lower cutoffs of obesity levels for South Asians may help clinicians identify at-risk individuals better, thus providing effective preventive measures on cardiometabolic disorders.

Conflicts of interest

All authors have none to declare.

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