Prevalence of generalized & abdominal obesity in urban & rural India- the ICMR-INDIAB Study (Phase-I) [ICMR-INDIAB-3]

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Background & objectives: Overweight and obesity are rapidly increasing in countries like India. This study was aimed at determining the prevalence of generalized, abdominal and combined obesity in urban and rural India.

Methods: Phase I of the ICMR-INDIAB study was conducted in a representative population of three States [Tamil Nadu (TN), Maharashtra (MH) and Jharkhand (JH)] and one Union Territory (UT) [Chandigarh (CH)] of India. A stratified multi-stage sampling design was adopted and individuals ≥20 yr of age were included. WHO Asia Pacific guidelines were used to define overweight [body mass index (BMI) ≥23 kg/m^2 but <25 kg/m^2], generalized obesity (GO, BMI≥25kg/m^2), abdominal obesity (AO, waist circumference ≥90 cm for men and ≥80cm for women) and combined obesity (CO, GO plus AO). Of the 14,277 participants, 13,800 subjects (response rate, 96.7%) were included for the analysis (urban: n=4,063; rural: n=9737).

Results: The prevalence of GO was 24.6, 16.6, 11.8 and 31.3 per cent among residents of TN, MH, JH and CH, while the prevalence of AO was 26.6, 18.7, 16.9 and 36.1 per cent, respectively. CO was present in 19.3, 13.0, 9.8 and 26.6 per cent of the TN, MH, JH and CH population. The prevalence of GO, AO and CO were significantly higher among urban residents compared to rural residents in all the four regions studied. The prevalence of overweight was 15.2, 11.3, 7.8 and 15.9 per cent among residents of TN, MH, JH and CH, respectively. Multiple logistic regression analysis showed that female gender, hypertension, diabetes, higher socio-economic status, physical inactivity and urban residence were significantly associated with GO, AO and CO in all the four regions studied. Age was significantly associated with AO and CO, but not with GO.

Interpretation & conclusions: Prevalence of AO as well as of GO were high in India. Extrapolated to the whole country, 135, 153 and 107 million individuals will have GO, AO and CO, respectively. However, these figures have been estimated from three States and one UT of India and the results may be viewed in this light.

Key words Abdominal obesity - combined obesity - generalized obesity - INDIAB - India

According to the World Health Organization (WHO), obesity is one of the most common, yet among the most neglected, public health problems in both developed and developing countries[1]. According to the WHO World Health Statistics Report 2012, globally one in six adults is obese and nearly 2.8 million individuals die each year due to overweight or obesity[2]. Due to the increased risk of morbidity and mortality, obesity is now being recognized as a disease in its own right. Additionally, obesity is strongly associated with other metabolic disorders including diabetes, hypertension, dyslipidaemia, cardiovascular disease and even some cancers. The risk for these disorders appears to start[3] from a body mass index (BMI) of about 21 kg/m^2. Obesity is generally classified as generalized obesity (GO) and abdominal obesity (AO). Individuals with obesity have higher rates of mortality and morbidity compared to non obese individuals[4,5].

India, with 1.2 billion people is the second most populous country in the world and is currently experiencing rapid epidemiological transition. Undernutrition due to poverty which dominated in the past, is being rapidly replaced by obesity associated with affluence[6]. Industrialization and urbanization also contribute to increased prevalence of obesity. Studies from different parts of India have provided evidence of the rising prevalence of obesity[6-9]. However, most reports have been region specific (mostly from urban areas). Further, different studies have used different methodologies, definitions and cut-off points for defining obesity, making comparisons difficult. To date, there has been no nationally representative study on the prevalence of obesity in India. Here we present the prevalence of generalized and abdominal obesity in urban and rural India based on phase I of the Indian Council of Medical Research - India Diabetes (ICMR-INDIAB) Study, in which representative samples were obtained from three States and one Union Territory (UT) in different regions of India covering a population of 213 million.

Material & Methods

The ICMR-INDIAB study is an ongoing cross-sectional national study on the prevalence of diabetes and related disorders such as obesity and hypertension. Funded by the ICMR and the Department of Health Research (DHR), Government of India, the study plans to sample all the 28 States (now 29 States after the State of Andhra Pradesh was divided into Telangana and Andhra Pradesh) in India, 2 UTs namely Chandigarh and Puducherry and the National Capital Territory

(NCT) of Delhi. The detailed methodology of the study has been published separately[10]. Briefly, this is a door-to-door survey of individuals aged 20 yr and above. Due to the complex logistics involved, the study is being done in phases. Phase I of the ICMR-INDIAB study was conducted from November 2008 to April 2010, in three States randomly selected to represent the south (Tamil Nadu-TN; population- 67.4 million), west (Maharashtra-MH; population- 112.7 million) and east (Jharkhand-JH; population- 31.5 million) of India and one UT representing northern India (Chandigarh-CH; population-1.4 million).

The sample size was calculated separately for urban and rural areas, as previous studies showed large variations in urban and rural prevalence of type 2 diabetes mellitus (approximately 10 and 4%, respectively). Using a precision of 20 per cent and allowing for a non response rate of 20 per cent, the sample size was calculated to be 2800 individuals in rural areas and 1200 individuals in urban areas, with a total sample size of 4000 individuals per State. Thus the sample size for the entire study once completed will be 1,24,000 individuals (28 States including 2 UTs and 1 NCT). Thus, 16,000 individuals from the States of Tamil Nadu, Maharashtra and Jharkhand, and the Union Territory of Chandigarh (Phase I of the ICMR-INDIAB study) were included in this study to determine the prevalence of obesity.

Sampling strategy: A stratified multi-stage sampling design was adopted. The primary sampling units (PSUs) were villages in rural areas and census enumeration blocks (CEBs) in urban areas. Three-level stratification was done in both urban and rural areas, based on geography, population size and socio-economic status in order to obtain a representative sample of the region being studied. The estimation of the sampling error of the prevalence took into account both the multi-stage nature of the sampling design, and standardization to the age-sex composition of the 2001 Census population. A two-stage design was used in rural areas, while a three-stage design was adopted in urban areas. Ultimate stage units were households in both areas. In rural areas, the first stage of sampling involved selection of PSUs (villages) using the probability proportional to population size (PPS)**.** In the second stage, households (n=56) were selected by systematic sampling with a random start. In urban areas, due to the large population involved, a three-stage design was used**.** The first stage involved selection of wards by PPS method. In the next stage, one CEB was randomly selected from each

ward (the CEBs were of approximately the same size), and in the final stage, households (n=24) were selected from the CEBs by systemic sampling. In both rural and urban areas, only one individual was selected within each household using the World Health Organization (WHO) Kish method[11].

For Phase I, a total of 16,607 individuals (5,112 urban and 11,495 rural) were selected from 363 PSUs (188 urban and 175 rural) of whom 14,277 individuals responded (response rate, 86%). For the present study, 13,800 of the 14,277 subjects who participated in Phase I, for whom information on anthropometric measurements such as weight, height and waist was available, were included in the analysis (urban: n=4,063; rural=9,737). The study was approved by the Institutional Ethics Committee of the Madras Diabetes Research Foundation, Chennai, Tamil Nadu, India, and written informed consent was obtained from all the participants.

In all study participants, a structured questionnaire was administered by trained field investigators to obtain data on socio-demographic parameters and behavioural aspects. Anthropometric parameters were measured using standardized techniques[12]. Height (in centimeters) was measured using a stadiometer (SECA Model 214, Seca Gmbh Co, Hamburg, Germany). The individual was asked to stand upright without shoes with his/her back against the vertical back board, heels together and eyes directed forward. Weight (in kilograms) was measured with an electronic weighing scale (SECA Model 807, Seca Gmbh Co, Hamburg, Germany) that was kept on a firm horizontal flat surface. Subjects were asked to wear light clothing, and weight was recorded to the nearest 0.5 kg. Body mass index (BMI) was calculated using the formula weight (kg)/ height (m)^2.

Waist circumference (in centimeters) was measured using a non-stretchable measuring tape. Waist circumference was measured at the smallest horizontal girth between the costal margins and the iliac crest at the end of expiration.

Blood pressure was recorded in the sitting position in the right arm to the nearest 1 mmHg using the electronic OMRON machine (Omron Corporation, Tokyo, Japan). Two readings were taken five minutes apart and their mean was taken as the blood pressure.

Fasting capillary blood glucose (CBG) was determined using a One Touch Ultra glucose meter (Johnson & Johnson, Milpitas, CA, USA). Oral glucose (82.5 g, equivalent to 75 g of anhydrous glucose) was given and a 2 h post load CBG was collected. In individuals with self reported diabetes, only fasting CBG was measured.

Definitions

Overweight was defined as a BMI ≥23 kg/m^2 but <25 kg/m^2 for both genders (based on the World Health Organization Asia Pacific Guidelines) with or without abdominal obesity (AO)[12].

Generalized obesity (GO) was defined as a BMI ≥ 25 kg/m^2 for both genders (based on the World Health Organization Asia Pacific Guidelines) with or without abdominal obesity (AO)[12].

Abdominal obesity (AO) was defined as a waist circumference (WC) ≥ 90 cm for men and ≥ 80 cm for women with or without GO[13].

Isolated generalized obesity (IGO) was defined as a BMI ≥ 25 kg/m^2 with waist circumference of < 90 cm in men and < 80 cm in women.

Isolated abdominal obesity (IAO) was defined as a waist circumference of ≥ 90 cm in men or ≥ 80 cm in women with a BMI < 25 kg/m^2.

Combined obesity (CO): Individuals with both GO and AO.

Non obese subjects: Individuals without either GO or AO

Diabetes was defined by a physician diagnosis of diabetes and current use of medications for diabetes (insulin or oral hypoglycaemic agents) and/or fulfillment of criteria laid down by the WHO Consultation Group Report, *i.e.* a fasting CBG ≥7 mmol/l and/or a 2 h post glucose CBG value ≥12.2 mmol/l[14].

Hypertension was diagnosed in subjects who were on antihypertensive medications or had a systolic BP ≥140 mmHg and/or a diastolic BP ≥90 mmHg[15].

Statistical analysis: Statistical analyses were performed using SAS statistical package (version 9.0; SAS Institute, Inc., Cary, NC, USA). One-way ANOVA or Student's *t* test were used to compare groups for continuous variables and chi-square test was used to compare proportions between two groups. Multiple logistic regression analysis was used to examine the association between various exposures and outcomes. For projections, Government of India population projections for 2011 for the respective States/UT were used[16]. For national estimates, the prevalence of three

States was used (The UT was excluded as it is highly urbanized and may enormously inflate projections).

Results

Table I shows the clinical and biochemical characteristics of the study subjects. In all the four regions, urban residents had significantly higher weight, BMI, waist circumference, diastolic BP and fasting and 2 h post glucose CBG compared to rural participants. Overall, in both urban and rural areas, women had higher mean BMI values than men (Urban: women: 23.6 vs. men: 22.7 kg/m^2, $P<0.001$; Rural: women: 21.2 vs. men: 20.9, kg/m^2, $P<0.001$), but mean waist circumference values were higher in men than in women (Urban: women: 77.4 vs. men: 83.6 cm, $P<0.001$; Rural: women: 71.7 vs. men: 78.1 cm, $P<0.001$). Of the overall study population, 15.4 per cent smoked (males: 28.7 vs. females: 1.9%, $P<0.001$), while the alcohol consumption was 19.8 per cent (males: 36.3 vs. females: 3.1%, $P<0.001$).

Fig. 1 presents the prevalence of GO, AO and CO in all the four regions studied. In all four regions studied, urban residents had a significantly higher prevalence of GO, AO and CO compared with the respective rural population ($P<0.001$). The overall prevalence of GO was 24.6, 16.6, 11.8 and 31.3 per cent among residents of TN, MH, JH and CH, while the corresponding prevalence of AO was 26.6, 18.7, 16.9 and 36.1 per cent. The highest prevalence of CO was observed in CH (26.6%) followed by TN (19.3%), MH (13.0%) and JH (9.8%).

Age and gender-specific prevalence of combined obesity in the study population is shown in Fig. 2. Except in Tamil Nadu (in the 25-34 yr group) and in Chandigarh (in the 45-54 yr group), at every age interval, the prevalence of CO was higher in urban compared to the rural areas. Higher prevalence of CO was observed among women in Chandigarh and Tamil Nadu. Similar results were also obtained for GO and AO (data not shown). The overall prevalence of GO was highest in Chandigarh (women: 38.7 vs. men:24.2%, $P<0.001$), followed by Tamil Nadu (women: 28.4 vs. men: 20.6%, $P<0.001$), Maharashtra (women: 17.6 vs. men: 15.7%, $P=0.112$) and Jharkhand (women: 12.1 vs. men: 11.5%, $P=0.606$), respectively. The prevalence of AO was highest in Chandigarh (women: 44.5 vs. men: 28.0%, $P<0.001$), followed by Tamil Nadu (women: 32.3 vs. men: 20.5%, $P<0.001$), Jharkhand (women: 19.1 vs. men: 14.7%, $P=0.001$) and Maharashtra (women: 18.8 vs. men: 18.7%, $P=0.965$).

The prevalence of IGO was significantly higher among urban residents as compared to rural residents in CH (6.4 vs. 4.1%, $P<0.001$), TN (6.9 vs. 4.7%, $P<0.05$), JH (4.1 vs. 1.2%, $P<0.001$) and MH (5.9 vs. 2.5%, $P<0.001$). The prevalence of IAO was also significantly higher among urban residents of CH, TN, JH and MH compared to rural residents [12.6 vs. 8.3% ($P<0.001$); 8.6 vs. 6.7% ($P<0.05$); 11.0 vs. 5.6% ($P<0.001$); and 6.6 vs. 5.3% ($P<0.001$), respectively].

Overall prevalence of overweight was significantly higher among urban residents of CH, TN, JH and MH compared to rural residents [urban vs. rural: 18.9 vs. 14.8% ($P<0.05$); 16.5 vs. 14.6% ($P<0.05$); 12.4 vs. 5.7% ($P<0.001$); and 13.6 vs. 10.3% ($P<0.05$), respectively] (Fig. 3).

These figures, if projected to the whole country, would translate to 88 million individuals who are overweight, 135 million individuals with GO, 153 million individuals with AO and 107 million individuals with CO in India. However, these figures have been estimated from three regions and the results may be viewed in this light.

Table II describes various risk factors associated with obesity stratified by types of obesity in the study population. It was observed that obesity increased significantly with income, the proportion with GO being 11.4, 18.8 and 34.2 per cent; AO being 15.5, 20.7 and 38.7 per cent; and CO being 9.0, 14.7 and 28.6 per cent for the 1st, 2nd and 3rd income tertiles, respectively. An increasing trend in all three types of obesity was observed with increasing education status ($P<0.001$). Obesity was significantly higher among inactive subjects compared to active subjects and among those who consumed more wheat/rice compared to millets. An increasing trend in all three types of obesity was observed with glucose intolerance ($P<0.001$). The prevalence of obesity was also significantly higher in individuals with hypertension compared to those without.

Table III shows multiple logistic regression analysis using GO, AO and CO as the dependent variables and various risk factors as independent variables. Female gender, hypertension, diabetes, higher SES, physical inactivity and urban residence were significantly associated with generalized, abdominal and combined obesity in all four regions studied. Age was significantly associated with AO and CO, but not with GO.

Table I. Clinical and biochemical characteristics of rural and urban study subjects in the four regions

Variables	Chandigarh		Jharkhand		Maharashtra		Tamil Nadu	
	Urban (n=880)	Rural (n=2336)	Urban (n=921)	Rural (n=2286)	Urban (n=1215)	Rural (n=2594)	Urban (n=1047)	Rural (n=2521)
Age (yr)	39 ± 13	35 ± 12*	40 ± 14	40 ± 14	40 ± 14	42 ± 15*	41 ± 14	43 ± 15**
Male n (%)	430 (48.9)	1214 (52.0)	471 (51.1)	1164 (50.9)	617 (50.8)	1301 (50.2)	512 (48.9)	1235 (49.0)
Height (cm)	159 ± 10	159 ± 9**	157 ± 9	155 ± 9**	158 ± 10	157 ± 9*	157 ± 9	157 ± 9
Weight (kg)	62 ± 13	58 ± 12**	56 ± 13	47 ± 9**	55 ± 12	51 ± 11**	59 ± 13	54 ± 11**
BMI (kg/m^2)	24.4 ± 4.7	22.8 ± 4.5**	22.7 ± 4.6	19.2 ± 3.0**	22.2 ± 4.4	20.5 ± 3.8**	23.6 ± 4.6	21.7 ± 3.9**
Waist (cm)	83.9 ± 12.3	79.7 ± 12.5**	80.8 ± 13.6	71.3 ± 9.5**	77.3 ± 12.4	72.7 ± 12**	80.9 ± 12.2	76.2 ± 11.4**
SBP (mmHg)	130 ± 18	124 ± 16**	130 ± 19	127 ± 19**	128 ± 19	127 ± 18	130 ± 19	128 ± 19*
DBP (mmHg)	80 ± 11	77 ± 11**	78 ± 11	76 ± 11**	80 ± 12	78 ± 11**	81 ± 11	78 ± 11**
FBS (mmol/l)	5.9 ± 2.2	5.7 ± 1.9*	5.7 ± 2.3	5.1 ± 1.0**	5.7 ± 1.8	5.4 ± 1.5**	5.7 ± 2.0	5.3 ± 1.6**
2h PGBS (mmol/l)	7.1 ± 2.7	6.8 ± 2.2*	6.8 ± 2.3	6.3 ± 1.4**	6.9 ± 2.3	6.3 ± 1.9**	6.7 ± 2.5	6.3 ± 2.2**
Smoking % (SE)	13.6 (1.15)	17.7 (0.79)**	14.5 (1.16)	13.7 (0.72)	11.1 (0.90)	10.5 (0.60)	20.1 (1.23)	21 (0.81)
Alcohol % (SE)	16.4 (1.25)	17 (0.78)	18.1 (1.27)	33.6 (0.99)**	13.3 (0.97)	11.8 (0.63)	21.4 (1.27)	22.2 (0.83)
Diabetes % (SE)	14.2 (1.22)	8.4 (0.59)**	13.2 (1.18)	3.1 (0.39)**	10.4 (0.93)	6.3 (0.49)**	10.4 (0.93)	8 (0.55)**

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, fasting blood sugar; 2h PGBS, 2 hour post glucose blood sugar; SE, standard error; P*<0.05, **<0.001 compared with urban subjects
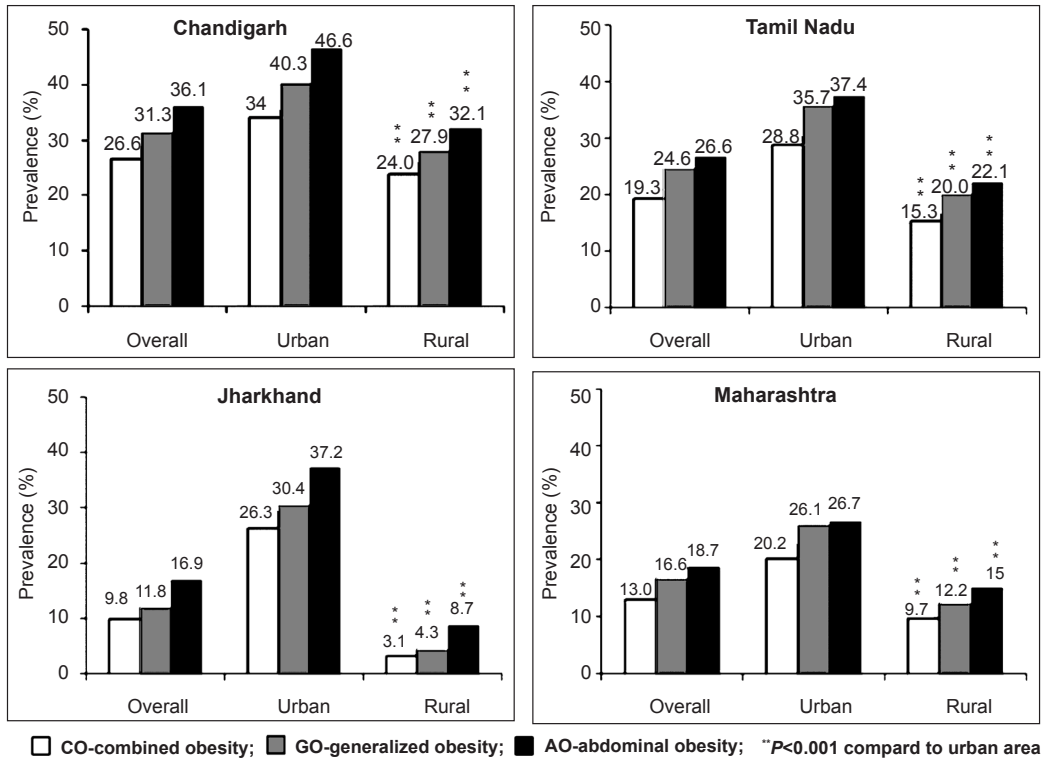
Fig. 1. Prevalence of generalized, abdominal and combined obesity in the four regions studied.
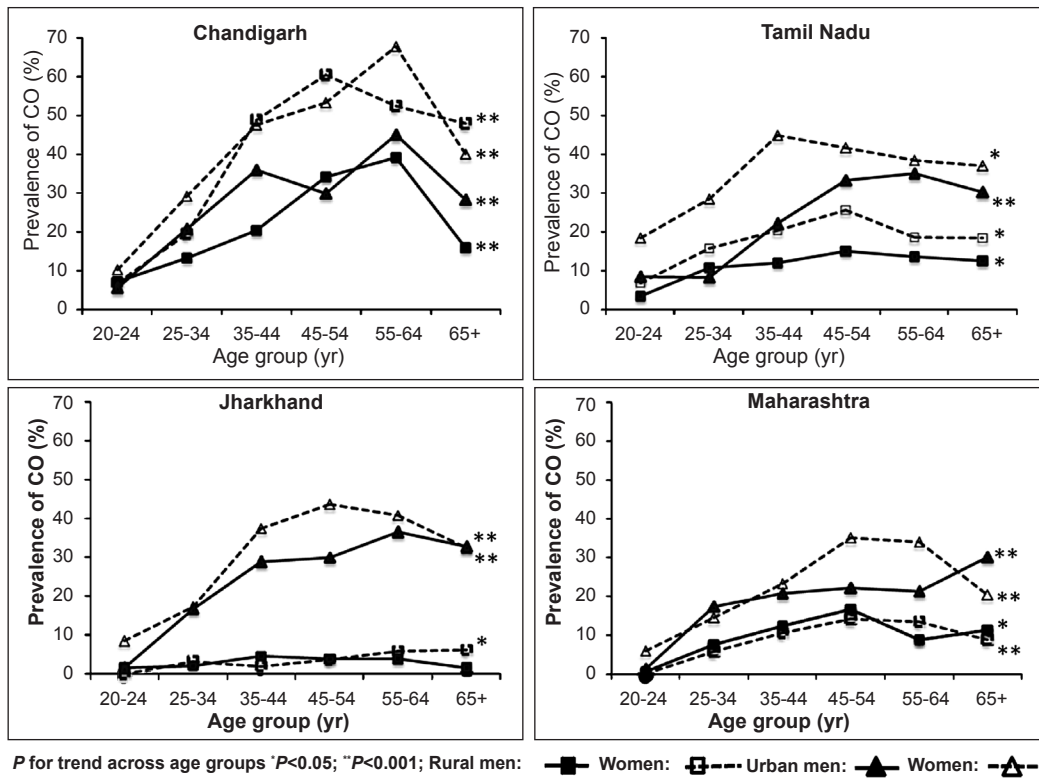
Fig. 2. Age- and gender-specific prevalence of combined obesity in the study population.

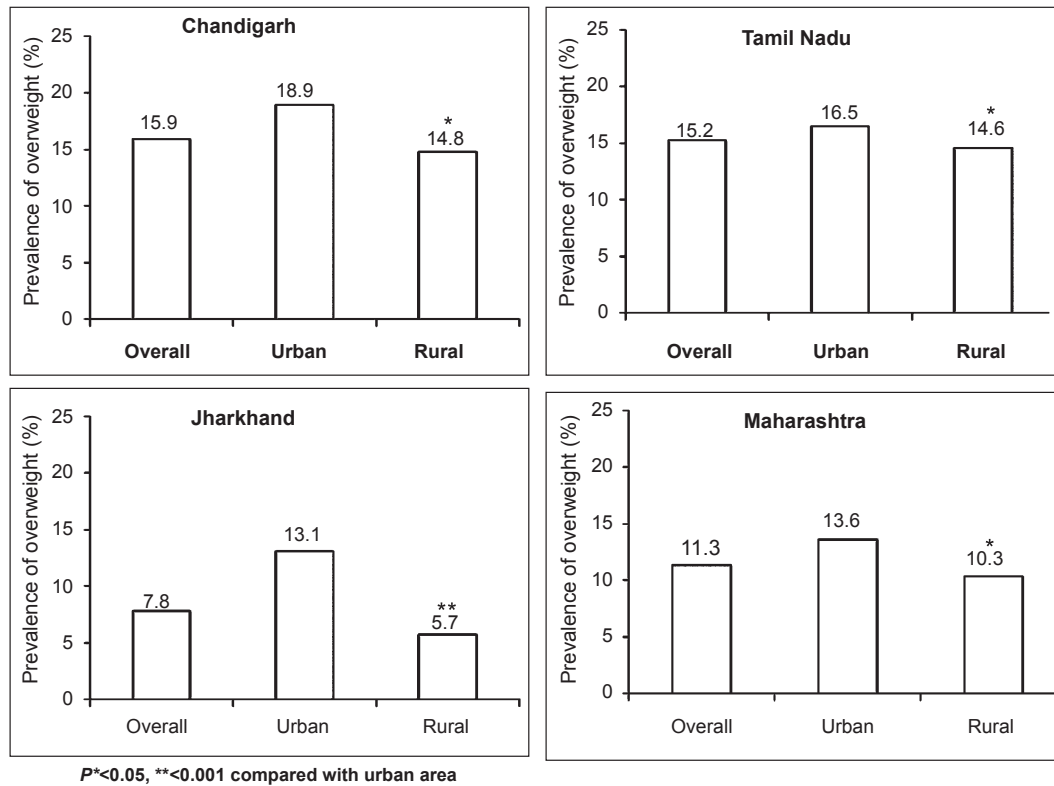**P*<0.05, **<0.001 compared with urban area**

Fig. 3. Prevalence of overweight in the four regions studied.

Discussion

The ICMR-INDIAB study is the first study from India to estimate the prevalence of obesity (generalized and abdominal) among urban and rural residents of States of India. This study showed the following results: the highest prevalence of both types of obesity (GO and AO) was found in Chandigarh followed by Tamil Nadu, Maharashtra and Jharkhand. This is not surprising as Chandigarh has the highest per capita income among all the four regions studied and is highly urbanized, consisting primarily of the city of Chandigarh and a few peri-urban clusters.

The prevalence of GO, AO and CO were significantly higher among urban residents compared to rural residents in all the four regions studied. The National Family Health Survey-3 (NFHS-3) also reported that in India, obesity (BMI $\geq$ 25 kg/m^2) was more prevalent in the urban areas and in higher socio-economic groups compared to the rural areas, especially among women (Men- urban: 15.9 vs. rural: 5.6%; Women- urban: 23.5 vs. rural: 7.2%)[17]. According to the NFHS-3 data, in the three States studied, the percentage of women who were obese

(BMI$\geq$ 25 kg/m^2) was highest in Tamil Nadu (24.4%), followed by Maharashtra (18.1%) and Jharkhand (5.9%) and a similar order was reported among men in the three States with 19.8, 15.9 and 5.3 per cent being obese respectively[17]. The Jaipur Heart Watch studies (I-IV) performed in India in rural and urban areas reported that generalized and abdominal obesity were significantly higher among the urban compared to rural population[18]. Another study conducted in adult population of urban Delhi and rural Ballabgarh (Haryana State), revealed that overweight was widely prevalent in the urban population (men : 35.1, women: 47.6%) compared to the rural population (men: 7.7, women: 11.3%)[19]. In a study conducted amongst middle-aged women in four urban and five rural locations in northern (Haryana), central (Jaipur), western (Pune), eastern (Kolkata), and southern (Kochi, Gandhigram) regions of India, age-adjusted prevalence of obesity in urban vs rural was reported to be 45.6 vs. 22.5 per cent and abdominal obesity to be 44.3 vs. 13.0 per cent, respectively[20].

Asian Indians have a greater predisposition to abdominal obesity and accumulation of visceral fat and

Risk factors	Total n	Generalized obesity (GO)	Abdominal obesity (AO)	Combined obesity (CO)
Income n (%, SE)[a]				
1st tertile	3909	444 (11.4, 0.51)	604 (15.5, 0.58)	353 (9.0, 0.46)
2nd tertile	4764	894 (18.8, 0.57)	986 (20.7, 0.59)	702 (14.7, 0.51)
3rd tertile	3961	1354 (34.2, 0.75)[##]	1532 (38.7, 0.77)[##]	1131 (28.6, 0.72)[##]
Occupation n (%, SE)				
Professional/Executive/ Big business/Clerical/Medium business	903	326 (36.1, 1.6)	355 (39.3, 1.61)	257 (28.5, 1.5)
Sales/Services/Skilled manual	2720	645 (23.7, 0.82)	732 (26.9, 0.85)	515 (18.9, 0.75)
Agriculture/Self-employed	2130	328 (4.1, 0.43)	413 (13.2, 0.73)	252 (8.1, 0.6)
Household & domestic work	243	58 (23.9, 2.74)	64 (26.3, 2.82)	49 (20.2, 2.5)
Unskilled manual	1347	141 (10.5, 0.84)	161 (12.0, 0.89)	107 (7.9, 0.73)
Do not work/Unemployed	5440	1397 (25.7, 0.59)	1637 (30.1, 0.62)	1171 (21.5, 0.56)[##]
Education n (%, SE)				
No formal schooling	4372	582 (13.3, 0.51)	768 (17.6, 0.58)	486 (11.1, 0.48)
School education	8308	1924 (23.2, 0.46)	2171 (26.1, 0.48)	1549 (18.6, 0.43)
Technical/College education	1109	389 (35.1, 1.43)[##]	422 (38.1, 1.46)[##]	316 (28.5, 1.36)[##]
Physical activity n (%, SE)				
Active	9330	1703 (18.3, 0.4)	1982 (21.2, 0.42)	1359 (14.6, 0.37)
Inactive	4420	1189 (26.9, 0.67)[**]	1373 (31.1, 0.7)[**]	990 (22.4, 0.63)[**]
Main staple food n (%, SE)				
Millets	1265	164 (13.0, 0.95)	196 (15.5, 1.01)	125 (9.9, 0.84)
Milled wheat/White rice	12518	2732 (21.8, 0.37)[**]	3166 (25.3, 0.39)[**]	2227 (17.8, 0.34)[**]
Fruits & vegetables (mean servings/day)	13800	2.97	2.97	2.3
Glucose intolerance n (%, SE)[$]				
Normal glucose tolerance	10289	1741 (16.9, 0.37)	1980 (19.2, 0.39)	1341 (13.0, 0.33)
Prediabetes	1376	452 (32.8, 1.27)	541 (39.3, 1.31)	392 (28.5, 1.22)
Diabetes	1065	517 (48.5, 1.53)[##]	617 (57.9, 1.51)[##]	475 (44.6, 1.52)[##]
Hypertension n (%, SE)				
No	7777	1094 (14.1, 0.39)	1266 (16.3, 0.41)	839 (10.8, 0.35)
Yes	5977	1793 (30.0, 0.59)[**]	2084 (34.9, 0.62)[**]	1508 (25.2, 0.56)[**]

Table II title: **Table II.** Association of the types of obesity with various factors in the study population

[**]$P<0.001$; [##]P for trend <0.001; [a]data available for income in 12634/13800 subjects:1st tertile – < ₹ 2000, 2nd tertile – ₹ 2000-3999, 3rd tertile – ≥ ₹ 4000/month; [$]diabetes screening done in 12,730/13,800 subjects

Table III. Multiple regression of type of obesity with various factors (For pooled data)			
Variables	Generalized obesity (GO)	Abdominal obesity (AO)	Combined obesity (CO)
	OR (95%CI) *P* value	OR (95%CI) *P* value	OR (95%CI) *P* value
Age (yr)	1.00 (0.99-1.01) 0.346	1.02 (1.02-1.02) <0.001	1.01 (1.00-1.01) <0.001
Gender (female)	1.77 (1.61-1.94) <0.001	1.93 (1.77-2.12) <0.001	1.88 (1.70-2.08) <0.001
Hypertension (yes)	2.47 (2.24-2.73) <0.001	2.30 (2.09-2.53) <0.001	2.49 (2.24-2.78) <0.001
Diabetes (yes)	2.63 (2.27-3.03) <0.001	2.95 (2.55-3.41) <0.001	2.84 (2.45-3.29) <0.001
Socio-economic status (high)	3.00 (2.64-3.42) <0.001	2.83 (2.51-3.20) <0.001	3.19 (2.76-3.68) <0.001
Physical inactivity (yes)	1.20 (1.06-1.28) <0.001	1.15 (1.04-1.26) <0.005	1.19 (1.07-1.32) <0.001
Urban residence (yes)	4.64 (4.08-5.27) <0.001	4.21 (3.73-4.74) <0.001	4.71 (4.09-5.42) <0.001
Region (State/UT) Jharkhand (Reference)			
Maharashtra	1.32 (1.13-1.54) <0.001	0.94 (0.81-1.08) 0.362	1.20 (1.02-1.42) 0.033
Tamil Nadu	2.19 (1.89-2.54) <0.001	1.49 (1.30-1.71) <0.001	1.90 (1.62-2.23) <0.001
Chandigarh	2.76 (2.37-3.21) <0.001	2.42 (2.11-2.79) <0.001	2.70 (2.30-3.18) <0.001
Included all variables with *P*<0.20 in univariate analysis			

this has been termed as "Asian Indian phenotype[21,22]. In a study conducted in urban north India (New Delhi), the overall prevalence of generalized obesity was 50.1 per cent, while that of abdominal obesity was 68.9 per cent[7]. The Chennai Urban Rural Epidemiology Study (CURES) conducted in Chennai city in Tamil Nadu reported age standardized prevalence of generalized obesity to be 45.9 per cent, while that of abdominal obesity was 46.6 per cent. Isolated generalized obesity was found in 9.1 per cent while isolated abdominal obesity was reported in 9.7 per cent[8]. The present study also showed a higher prevalence of isolated abdominal obesity than isolated generalized obesity in all four regions studied. The lower prevalence noted in the urban areas of Tamil Nadu in the present study compared to the CURES could be because CURES included only Chennai which is a highly urbanized metropolitan city whereas in INDIAB smaller towns in the State of Tamil Nadu, which are less urbanized were also included.

In countries like India, the rise in obesity prevalence could be attributed to the increasing urbanization, use of mechanized transport, increasing availability of processed and fast foods, increased television viewing, adoption of less physically active lifestyles and consumption of more "energy-dense, nutrient-poor" diets[23-25]. This is exemplified by the higher prevalence of both GO and AO in the urban population where the above factors are more common. Among the three States and one UT studied, the difference was striking in Jharkhand with almost three times higher prevalence of obesity in the urban compared to the rural population. In Tamil Nadu, Maharashtra and Chandigarh, the urban prevalence of obesity was nearly twice as that of the rural. This is in contrast to that seen in the developed countries, where the prevalence of obesity is higher in the rural areas compared to the urban areas, which may be attributed to different stages of epidemiological health transitions experienced by different countries[26].

Nearly 70 per cent of India's population resides in rural areas. Even a small increase in prevalence of obesity in rural areas could lead to a huge increase in the number of obese individuals in India. The present study showed a marked increase in BMI values in the rural areas compared to those reported in an earlier study by Ramachandran *et al*[27] in rural south India. The increase in prevalence of obesity among the rural population may be due to rapid changes in lifestyle in rural areas.

It is noteworthy that the alcohol consumption in the rural areas of Jharkhand is almost double that in urban areas (33.6 vs. 18.1%). This is partly because the alcohol consumption was significantly higher in women in rural Jharkhand compared to the other regions. However, the reported alcohol consumption was also higher among men in Jharkhand when compared to the other regions (Rural women : Jharkhand-16.2, Chandigarh- 0.0, Maharashtra-0.4, Tamil Nadu- 0.5%; and in rural men: Jharkhand- 50.4, Chandigarh- 32.8, Maharashtra- 23.2, Tamil Nadu- 44.8%). This may be due to the large tribal population in rural Jharkhand where alcohol intake is more culturally accepted even among women[28]. However, this does not seem to have affected the prevalence of obesity in an adverse manner as the prevalence of GO, AO and CO were lowest in Jharkhand.

Many studies in India have reported higher prevalence of obesity among women[20,22,29-32]. In a study conducted in four urban and five rural locations in India among women aged 35-70 yr, the age-adjusted prevalence of obesity (BMI $\geq$ 25 kg/m^2) in urban and rural areas was 45.6 and 22.5 per cent, respectively[20]. The NFHS-3 data which studied urban and rural residents (all women aged 15-49 and all men aged 15-54) in 28 States of India and the National Capital Territory of Delhi during the year 2005-2006, also showed a higher prevalence of overweight (BMI $\geq$ 25-29.9 kg/m^2) and obesity (BMI $\geq$ 30 kg/m^2) among females than males in all the States of India[17]. The prevalence of obesity observed in women in the three States included in our study was similar to that observed in NFHS-3, with the highest prevalence in Tamil Nadu (INDIAB: 24.6 vs. NFHS-3: 20.9%), followed by Maharashtra (INDIAB: 16.6 vs. NFHS-3: 14.5%) and Jharkhand (INDIAB: 11.8 vs. NFHS-3: 5.4%). The prevalence of obesity among Indian women has increased from 10.6 per cent (NFHS-2 in 1998-1999) to 12.6 per cent (NFHS-3 in 2005-2006), *i.e.* an increase by 24.52 per cent in a 7 year period[33].

Our study shows that it has now increased to 24.1 per cent representing a further increase by 91.3 per cent in a 5 year period and, on the whole, an increase by 127.4 per cent over a 12 year period. As obesity, particularly in young women, can have important consequences like infertility and development of polycystic ovary syndrome (PCOS), this is of great significance[34]. Higher prevalence of obesity in young women is also worrisome because it may increase the prevalence of gestational diabetes, type 2 diabetes, hypertension and cardiovascular disease later in the life.

The strengths of this study were that the study sample was truly representative of the regions studied in terms of geography, socio-economic status and population size and the sample size was large (n=13,800). This study was perhaps the first to look at the prevalence of GO, AO and CO by studying four regions of the country. Also, for the first time, data on the prevalence of GO, AO and CO have been obtained in urban as well as rural areas, in these States of the country.

The study also had a few limitations. First, the cross-sectional nature of the design did not allow for cause-effect relationships to be made. A second limitation was that the projections made here for obesity for the country as a whole were based on data in the three States only; these may be regarded as interim and may need to be revised after the entire study is completed.

In summary, our study showed that the prevalence of obesity (generalized and abdominal) was higher in India now compared to earlier studies. The prevalence of abdominal obesity was higher than the generalized obesity and urban residents had a higher prevalence of both forms of obesity than the rural residents. This study is of significance because it shows large increases in prevalence of obesity not only in urban areas but also in rural areas in India. With further urbanization, changing lifestyle and behaviour we may expect further increase in the incidence and prevalence of obesity in India.

Conflicts of interest: None.

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