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Original Research Article

A Community Based Study of Association of Body Mass Index with Co-Morbid Conditions in an Urban Population of Delhi

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Abstract

Background: Overweight and obesity are associated with a significant burden of co-morbidities like hypertension, osteoarthritis(OA), sleep apnea (SA), type 2 diabetes mellitus, asthma, heartburn, etc. There is a paucity of well-dispersed studies to assess the prevalence of overweight and obesity in India.

Aims and objectives: To find out the prevalence of overweight, obesity, and various co-morbid conditions in relation to body mass index (BMI), waist hip ratio (WHR), waist circumference (WC), and hip circumference (HC).

Materials and methods: This community-based cross-sectional study was conducted on a population consisting of all the adults between 18 and 60 years of age residing in Gokulpuri, located in the eastern part of Delhi. Pre-tested, pre-coded, semi structure questionnaire was used to collect data regarding socio demographic and anthropometric measurements.

Results: A total of 530 subjects were included as per our inclusion and exclusion criteria. The mean age ± SD of the study subjects was 36.84 ± 12.54 years. This study shows that obesity, measured either as BMI, WC, or percentage body fat, is associated with various co-morbidities, but the association was stronger in the case of BMI. The association of WC was also better appreciated than WHR in the case of most of the co-morbidities. The association between overweight and obesity was strong in cases of hypertension, OA-knee, gastroesophageal reflux disease (GERD), DM type II, and OSA. However, the association of obesity with other co-morbidities like asthma, gallbladder stones, and cholecystitis could not be established statistically.

Conclusion: BMI has come out as a better indicator of the risks of co-morbidities associated with overweight or obesity. It is also noted that BMI correlates better with the number of comorbidities compared to other indices. Measurement of BMI is hence recommended in such a community setting to find out the magnitude of overweight or obesity and the related health problems. However, as far as type 2 diabetes mellitus is concerned, WC is a better indicator of risk. Hence, measurement of waist circumference is worth consideration in the risk estimation of type II DM.

Key words: Obesity, Body mass index, Waist circumference, Co-morbidities.

Introduction

Obesity prevalence and obesity-related disease burdens are increasing worldwide [1]. Recent studies have reported that globally, more than 1.9 billion adults are overweight and 650 million are obese [2]. There is evidence to suggest that obesity leads to disease clustering, frailty, and poor health-related quality of life [3]. According to large observational studies, obesity is associated with a reduction in disease-free life of 3–8 years and with an approximately 1·3 times excess risk of premature death compared with people with healthy weight [4,5]. In addition, overweight and obesity predispose people to a large array of clinical conditions, including cardiovascular disease, type 2 diabetes, osteoarthritis, chronic kidney disease, site-specific cancers, musculoskeletal disorders, etc. [6, 7]. Due to the consumption of energy-dense food (i.e., unhealthy food habits), sedentary lifestyles, a lack of health care services, and financial support, developing countries are facing a high risk of obesity and its adverse consequences. However, it is unclear whether these diseases are distributed across all people with obesity or cluster in smaller groups of individuals with obesity-related multimorbidity.

In India, more than 135 million individuals were affected by obesity [8]. The prevalence of obesity in

India varies due to age, gender, geographical environment, socio-economic status, etc. According to the 2015 ICMR- INDIAB study, the prevalence rates of obesity and central obesity vary from 11.8% to 31.3% and 16.9% to 36.3%, respectively [9]. In India, abdominal obesity is one of the major risk factors for cardiovascular disease (CVD). Various studies have shown that the prevalence of obesity among women is significantly higher as compared to men [8]. Obesity is one of the main medical and financial burdens for the government. In India, obesity has been considered a major public health problem. Alarmed by reports that India will become the global diabetes capital by 2050, the Ministry of Health, Government of India, has reduced the diagnostic cut-offs for BMI and WC to fight the battle against obesity. There is a paucity of well-dispersed studies to assess the prevalence of overweight and obesity in India. Studies based on measurements of waist and hip circumference are also lacking. Though there are studies showing a correlation between BMI and separate morbidities, few studies demonstrate the association of different morbid conditions with obesity. Therefore, the current study was carried out with the objective of finding out the prevalence of overweight and obesity and associated co-morbid conditions in an urban community in East Delhi.

Materials and methods:

This community-based cross-sectional study was carried out on a population consisting of all the adults between 18 and 60 years of age residing in Gokulpuri, New Delhi.

A pre-designed, pre-tested, pre-coded, semi-structured, investigator-administered questionnaire was used to col lect information on sociodemographic characteristics and morbidities. The purpose of the study was explained to the subjects in local language, and the investigator interviewed the eligible candidates who agreed to participate in the study after getting written informed consent. BMI was calculated in kg/m2 and distributed as per Asian criteria (<18.5: lean; 18.5-22.9: normal; 23.0-27.4: overweight; >27.5: obese). WC (cm) >90 in males and >85 in females was considered obese. WHR ≥0.96 in males and ≥0.83 in females was considered obese. Body fat percentage was distributed as <20.0, 20.0–24.9, and >25.0. The body fat percentage >25 was considered obese. Proportion and the Chi Square test were applied for analysis using suitable statistical software.

Results:

In this cross-sectional study, a total of 530 subjects were included as per our inclusion and exclusion criteria. The mean age ± SD of the study subjects was 36.84 ± 12.54 years. The mean age of females was 37.83 ± 12 years, which was higher than that of males, 35.74 ± 13.08 years. The t-test for independent variables showed no significant difference between the mean ages of male and female study subjects (t = 1.92, p > 0.05) (Table 1).

Table 1: Sociodemographic characteristics of our study population.

Sociodemographic characteristics		Male (N=251)		Female(N=279)		Total (N=530)	
		N	%	N	%	N	%
Age	18-25	69	(27.5)	51	(18.3)	120	(22.6)
	25-35	72	(28.8)	83	(29.7)	155	(29.3)
	35-45	44	(17.5)	69	(24.7)	113	(21.3)
	45-55	33	(13.1)	46	(16.5)	79	(14.9)
	55-59	33	(13.1)	30	(10.8)	63	(11.9)
Educational status*	Illiterate	31	(12.4)	123	(44.1)	154	(29.1)
	Primary/Just literate	16	(06.4)	36	(12.9)	52	(09.8)
	Middle school	60	(232.8)	65	(23.3)	125	(23.6)
	High school	77	(30.7)	33	(11.8)	110	(20.7)
	Intermediate/Post	33	(13.1)	11	(03.9)	44	(08.3)
	Graduate	28	(11.2)	10	(03.6)	38	(07.2)
	PG/Professional	6	(02.4)	1	(00.4)	7	(01.3)
Religion	Hindus	217	(86.5)	250	(89.6)	467	(88.1)
	Muslims	33	(13.1)	28	(10.0)	61	(11.5)
	Sikhs	1	(00.4)	1	(00.4)	2	(00.4)
SES*	Lower	53	(21.1)	22	(07.9)	75	(14.2)
	UL	65	(25.9)	55	(19.7)	120	(22.6)
	LM	125	(49.8)	175	(62.7)	300	(56.6)
	UM	8	(03.2)	27	(09.7)	35	(06.6)
Marital status	Married	192	(76.5)	240	(86.0)	432	(81.5)
	Unmarried	57	(22.7)	23	(08.2)	80	(15.1)
	Others	2	(00.8)	16	(05.8)	18	(03.4)
Family type	Nuclear	137	(54.6)	168	(60.2)	305	(57.6)
	Joint	102	(40.6)	97	(34.7)	199	(37.5)
	Extended	12	(04.8)	14	(05.1)	26	(04.9)
Nature of work	Sedentary	108	(43.0)	213	76.3)	321	(60.5)
	Non-sedentary	143	(56.9)	66	(23.6)	209	(39.4)

The overall prevalence of only overweight (BMI 23.0-27.4 kg/m2) was 29.6%; however, based on the WHO definition (BMI 25-29.9 kg/m2), it was 26.4%. Among the study subjects, 28.7% men and 30.5% women were overweight. Gender-wise differences in the prevalence of overweight were not statistically significant (p = 0.71). Obese subjects (BMI ≥27.5 kg/m2) comprised 23.0% of the study subjects. The overall prevalence of obesity according to WHO criteria was 11.1%. Obesity was more prevalent in females, i.e., 29.7%, as compared to males, 15.5% (p<0.001) (Table 2).

Table 2: Anthropometric measurements of our study subjects.

Anthropometric measurements		Male (N=251)		Female (N=279)		P value
		N	%	N	%	
Body mass index (Asian)	<18.5[a]	36	(14.3)	38	(13.6)	0.001
	18.5-22.9[b]	104	(41.4)	73	(26.2)	
	23.0-27.4[c]	72	(28.7)	85	(30.5)	
	≥27.5[d]	39	(15.5)	83	(29.7)	
Waist circumference	Normal	153	(61.0)	132	(47.3)	0.001
	Obese	98	(39.0)	147	(52.7)	
Waist hip ratio	Normal	132	(52.6)	45	(16.1)	0.00
	Obese	119	(47.4)	234	(83.9)	
Body fat percentage	<20.0	184	(73.3)	52	(18.6)	0.00
	20.0-24.9	50	(19.9)	95	(34.1)	
	≥25.0	17	(06.8)	132	(47.3)	

a: Lean; b: normal; c: overweight; d: obese.

Prevalence of co-morbidities among the study subjects

In this study, hypertensive subjects comprised 21.1% of the total population. There was no significant gender-wise difference in hypertension prevalence. A similar proportion of subjects had osteoarthritis, i.e., 21.1%. Almost 90% complained of bilateral osteoarthritis of the knees. Gastroesophageal reflux disease was diagnosed in 20.4% of the subjects. A higher proportion of females (20.4% had GERD as compared to males (13.9%. This difference was statistically highly significant. (p <0.001) (Table 3). Only seven cases of heart attacks and two cases of strokes were reported. There were 13 documented cases of kidney stones and 9 cases of inguinal hernias among the study subjects.

Table 3: The prevalence of Prevalence of Co-Morbidities among the study subjects.

Co-Morbidities	Total (N=530)		Male (N=251)		Female (N=279)	
	N	%	N	%	N	%
Hypertension	112	21.1	55	21.9	57	20.4
Osteoarthritis (Knee)	112	21.1	33	13.1	79	28.9
Gastro Esophageal Reflux Disease (GERD)	108	20.4	35	13.9	73	26.2
Diabetes Mellitus type-II	78	14.7	30	12.0	48	17.2
Asthma	72	13.6	38	15.1	34	12.2
Obstructive Sleep Apnea	49	9.2	21	08.4	28	10.0
Gall Bladder Stone	48	9.1	18	07.2	30	10.8
Hypothyroidism	41	7.7	14	05.6	27	09.7
Cholecystitis	25	4.7	8	03.2	17	06.1
Low backache	260	49.1	84	33.5	176	63.1

Out of a total of 530 subjects, 43% were free from any morbidity; 26% of the subjects had just one or other morbidity. The rest of the study subjects had more than one type of morbidity (Figure 3). The mean BMI for the subjects with different numbers of co-morbidities has been plotted in the graph (Fig. 4). The gradual increase in the mean BMI with an increase in the number of co-morbidities can be appreciated in the diagram. The mean BMI at zero morbidity is significantly different from other mean BMIs. Similarly, the mean BMI of subjects with one morbidity differs significantly from that of subjects with four or more morbidities.

There is a significant positive association between hypertension and BMI ≥ 23 kg/m2 (p<0.001). Overweight subjects (BMI ≥ 23 kg/m2) were at 1.8 (95% CI; 1.0–6.7) times greater risk for hypertension as compared to subjects whose BMI was between 18.5-22.9 kg/m2. The risk was much higher (3.7, 95% CI: 2.0–6.7)} at a BMI ≥ 27 kg/m2. Overweight females were at a greater risk (OR: 3.15) for hypertension as compared to males (OR: 1.6) (Table 4).

Table 4: Association of BMI with Hypertension in our study subjects.

Hyper-tension	MALE		FEMALE		TOTAL	
BMI (Asia)	N (%)	OR; [95%CI]	N (%)	OR; [95%CI]	N (%)	OR; [95%CI]
<18.5	3	0.4	5	2.0	8	0.77
	(8.3)	[0.1-1.6]	(13.2)	[0.5-8.9]	(10.8)	[0.3-1.9]
18.5-22.9	19	1	5	1	24	1
	(18.3)		(6.8)		(23.6)	
23.0-27.4	19	1.6	16	3.15	35	1.8
	(26.4)	[0.7-3.5]	(18.8)	[1.0-10.4]	(22.3)	[1.0-3.3]
≥ 27.5	14	2.5	31	8.11	45	3.7
	(35.9)	[1.02-6.16]	(37.3)	[2.7-25.6]	(36.9)	[2.0-6.8]

Osteoarthritis of the knee was significantly associated with BMI ≥ 23 kg/m2 (x2 = 30.23, P<0.001) in both sexes. However, BMI ≥ 27 kg/m2 posed a greater risk for the condition {OR: 3.9 (95% CI: 2.1–7.2). In our study, males are at greater risk for osteoarthritis at a BMI > 23 kg/m2 (OR: 3.3) as compared to females (OR: 1.2) (Table 5).

Table 5 Association of BMI with Osteoarthritis-knee in the study subjects.

Osteo - Arthritis	MALE		FEMALE		TOTAL	
BMI (Asia)	N (%)	OR; [95%CI]	N (%)	OR; [95%CI]	N (%)	OR; [95%CI]
<18.5	4	1.3	4	0.4	8	0.8
	(11.1)	[0.2-6.0]	(10.5)	[01.-1.4]	(10.8)	[0.3-2.0]
18.5-22.9	7	1	16	1	23	1
	(6.7)		(21.9)		(13.0)	
23.0-27.4	14	3.3	22	1.2	36	1.9
	(19.4)	[1.2-9.8]	(25.9)	[0.6-2.7]	(22.9)	[1.0-2.8]
≥27.5	8	3.6	37	2.9	45	3.9
	(20.5)	[1.0-12.1]	(44.6)	[1.3-6.1]		[2.1-7.2]

The association between BMI and GERD among the subjects was statistically significant (P<0.001). The overall association was stronger in males as compared to females. But the risk was higher in overweight females (OR: 2.5, 95% CI: 1.0–4.9) as compared to males (OR: 1.2, 95% CI: 0.5–3.3). However, in obese males, the risk of GERD was higher (OR: 3.4) than in obese females (2.7) (Table 6).

Table 6: Association of BMI with Gastro-Esophageal Reflux Disease in our study subjects

GERD	MALE		FEMALE		TOTAL	
BMI (Asia)	N (%)	OR; [95%CI]	N (%)	OR; [95%CI]	N (%)	OR; [95%CI]
<18.5	1	0.2	9	1.7	10	1.1
	(2.8)	[0.01-1.73]	(23.7)	[0.6-5.2]	(13.5)	[0.4-2.8]
18.5-22.9	12	1	11	1	23	1
	(11.5)		(15.1)		(13.0)	
23.0-27.4	10	1.2	26	2.5	6	2
	(13.9)	[0.5-3.3]	(30.6)	[1.0-5.9]	(22.9)	[1.0-3.6]
≥27.5	12	3.4	27	2.7	39	3.1
	(30.8)	[1.3-9.3]	(32.5)	[1.1-6.4]	(32.0)	[1.7-5.8]

The association between diabetes mellitus type II and BMI has been shown by an independent Chi-square test (x2 = 10.45, P = 0.01). Findings suggest that with an increase in BMI, the proportion of subjects with diabetes mellitus type II also increases. The diabetes prevalence was 10.2%, 15.2%, and 23.0% in those with a BMI of 18.5-22.9 kg/m2, 23.0-27.4 kg/m2, and >= 27.5 kg/m2. The results further show that those who are obese (BMI >27.5 kg/m2) have a risk 2.6 (95% CI: 1.3-5.2) times greater than those whose BMI is within normal values (18.5-22.9 kg/m2) of having the disease. The risk is comparable for both sexes.

Table 7: Association of BMI with Diabetes Mellitus type II in the study subjects

DM-type II	MALE		FEMALE		TOTAL	
BMI (Asia)	N (%)	OR; [95%CI]	N (%)	OR; [95%CI]	N (%)	OR; [95%CI]
<18.5	3	1.1	5	0.9	8	1.0
	8.0	0.2-4.9	13.2	0.3-3.4	10.8	0.4-2.7
18.5-22.9	8	1	10	1	18	1
	7.7		13.7		10.2	
23.0-27.4	13	2.6	11	0.9	24	1.53
	18.1	09-7.5	12.9	0.3-2.6	15.2	0.75-3.2
≥27.5	6	2.2	22	2.3	28	2.6
	15.4	0.6-7.6	26.5	0.9-5.6	23.0	1.3-5.2

Obstructive sleep apnea is associated with BMI (x^2 =16.84, P = 0.001), but the prevalence of OSA does not increase uniformly with an increase in BMI. The risk increases considerably after a BMI cutoff of 23 kg/m². The odd ratio is as high as 5.3 and 5.9 for the overweight and obese categories, respectively. The study did not show an association between bronchial asthma and BMI (P = 0.59).

We found a significant association between BMI and hypothyroidism. (P= 0.003). The association was statistically significant in females (P = 0.012). The risk of hypothyroidism is increasing almost four times from a normal BMI to a BMI in the obese range (≥27.5 kg/m²).

Analysis of the data does not show an association between occurrences of gall bladder stones and BMI (P = 0.60). The study also fails to establish an association between BMI and co-morbidity, like cholecystitis. The result does not show a statistically significant association between low back pain and BMI (P = 0.19).

Unlike BMI, the association of co-morbidities with obesity by waist circumference criteria is displayed in **Table 8**. The table clearly shows the morbidities, such as hypertension, osteoarthritis, and diabetes mellitus type II, which were significantly associated with waist circumference (P< 0.001).

Table 8: Association of Co-morbidities with Obesity according to Waist Circumference in the study subjects.

Co-morbidities	Males		Females		Total	
	Waist >90cm		Waist >85cm		Obese	
	(N=98)		(N=147)		(N=245)	
	N (%)	OR; [95% CI]	N (%)	OR; [95% CI]	N (%)	OR ; [95% CI]
Hypertension *	34	3.39	48	6.6	82	402
	(34.7)	[1.8-6.2]	(32.7)	[3.1-14.2]	(33.5)	[2.7-6.7]
Osteo-arthritis Knee*	19	3.2	35	3.1	78	3.5
	(19.4)	[1.5-6.8]	(23.8)	[1.8-5.6]	(31.8)	[2.2-5.4]
GERD*	19	2.05	50	2.4	69	2.5
	(19.4)	[1.0.2]	(34)	[1.4-4.3]	(28.2)	[1.6-3.8]
DM type II*	21	3.1	57	2.8	54	3
	(21.4)	[1.4-6.8]	(38.8)	[1.4-5.7]	(22)	[1.3-5.1]
Asthma	17	1.3	24	2.3	41	1.6
	(17.3)	[0.6-2.6]	(16.3)	[1.0-5.1]	(16.7)	[0.9-2.7]
OSA*	15	4.4	22	3.6	37	4
	(15.3)	[1.6-11.8]	(15)	[1.4-9.2]	(15.1)	[2.0-7.9]
GBS	6	0.8	21	2.3	27	1.6
	(6.1)	[0.3-2.1]	(14.3)	[1.0-5.2]	(11)	[0.8-2.8]
Chole-cystitis	4	1.6	13	3.1	17	2.6
	(4.1)	[0.4-6.5]	(8.8)	[0.9-9.7]	(6.9)	[1.0-6.0]
Low-Backache	36	3.3	104	6.6	140	1.8
	(36.7)	[1.8-62]	(70.7)	[3.1-14.1]	(57.1)	[1.3-2.5]
Hypothyroidism	8	2.2	17	1.6	25	1.9
	(8.2)	[0.7-6.5]	(11.6)	[0.7-3.6]	(10.2)	[0.9-3.7]

*Morbidities with significant association with obesity

Association of Co-morbidities with Obesity according to Waist Hip Ratio in our study subject shown in Table 9.

Table 9: Association of Co-morbidities with Obesity according to Waist Hip Ratio in the study subject

Co-morbidities	Males (WHR >0.95) (N=119)		Females (WHR >0.83) (N=234)		Total Obese (N=353)	
	N (%)	OR; [95% CI]	N (%)	OR; [95% CI]	N (%)	OR; [95% CI]
Hypertension *	37	2.86	52	2.3	89	2.3
	(31.1)	[1.5-5.6]	(22.2)	[0.8-6.9]	(25.2)	[1.3-3.7]
Osteo-arthritis Knee*	24	3.4	68	1.3	92	2.8
	(20.2)	[1.4-8.4]	(29.1)	[0.6-2.8]	(26.1)	[1.6-4.7]
GERD*	24	2.8	62	1.1	86	2.3
	(20.2)	[1.2-4.7]	(26.5)	[0.5-2.5]	(24.4)	[1.4-3.7]
DM type II*	20	2.5	41	1.1	61	1.9
	(16.8)	[1.0-4.5]	(17.5)	[05-3.0]	(17.3)	[1.1-3.5]
Asthma	29	1.5	29	1.1	50	1.1
	(12.4)	[0.7-3.0]	(12.4)	[0.4-3.6]	(14.2)	[0.7-1.9]
OSA*	18	7.6	23	0.9	41	2.7
	(15.1)	[2.0-33.7]	(9.8)	[0.3-2.8]	(11.6)	[1.2-6.0]
GBS	7	0.7	27	1.8	34	1.2
	(5.9)	[0.2-2.0]	(11.5)	[0.5-7.9]	(9.6)	[0.6-2.3]
Chole-cystitis	5	1.8	16	3.2	21	2.7
	(4.2)	[0.4-9.8]	(6.8)	[0.4-66.9]	(5.9)	[0.9-8.0]
Hypothyroidism	10	2.9	23	1.1	33	2.2
	(8.4)	[0.9-9.6]	(9.8)	[0.4-3.4]	(9.3)	[0.98-4.8]
Low-Backache	46	1.6	150	1.3	196	2.2
	(38.7)	[0.9-2.7]	(64.1)	[0.6-2.6]	(55.5)	[1.5-3.1]

* Morbidities with significant association with obesity

According to body fat percentage criteria, there were 67 obese males and 227 obese females. The association with various co- morbid conditions are shown in Table 10

Table 10: Association of Co-morbidities with Obesity according to Body fat percentages in the study subjects

Co-morbidities	Obese (Males) N =67		Obese (Females) N =227		Total N=294	
	N (%)	OR [95% CI]	N (%)	OR [95% CI]	N (%)	OR [95% CI]
Hypertension *	28	4.1	51	2.2	79	2.2
	41.8	2.1-8.3	22.5	0.8-6.1	26.9	1.4-3.5
Osteo-arthritis Knee*	14	2.2	73	3.6	87	3.5
	10.9	1.0-5.2	32.2	1.4-9.9	29.6	2.1-5.7
GERD*	15	2.3	64	1.8	79	2.6
	22.4	1.0-5.2	28.2	0.8-4.4	26.9	1.6-4.1
DM type II*	16	3.8	44	2.9	60	3.1
	23.9	1.6-8.9	19.4	0.9-9.9	20.4	1.8-5.4
Asthma	11	1.1	30	1.8	41	1
	16.4	0.5-2.6	13.2	0.6-6.4	13.9	0.6-1.7
OSA*	13	5.3	24	1.4	37	2.7
	19.4	1.9-14.8	10.6	0.4-5.0	12.6	1.4-5.8
GBS	5	1.0	26	1.5	31	1.5
	7.5	0.3-3.3	11.5	0.5-5.5	10.5	0.8-2.8
Chole-cystitis	1	0.4	16	3.9	17	1.7
	1.5	0.0-3.1	7	0.5-79.9	5.8	0.7-4.1
Hypothyroidism	6	2.6.51	23	1.35	29	2
	9	0.1-	10.1	0.4-4.0	9.9	1.0-4.0
Low-Backache	23	1	146	1.3	169	2.1
	34.2	0.6-1.9	64.3	0.7-2.5	57.5	1.5-3.0

* Morbidities with significant association with obesity

In multi-logistic regression analysis, it was noted that age greater than 25 years poses a significant risk factor for hypertension (adjusted odds = 3.55, 95% CI: 1.34–9.43). The risk is almost ten times greater when the age is more than 45 years. (Adjusted Odds = 9.56, 95% CI: 3.52–25.99) When other factors like WHR and body fat percentage are controlled, subjects with a BMI >27.5 experience almost three times greater risk (adjusted odds: 2.95, 95% CI: 1.57–5.54) for hypertension as compared to subjects with a BMI lower than that ($p<0.001$).

It is also observed that BMI > 27.5 is a significant risk factor for the osteoarthritis knee (adjusted odds = 2.57, 95% CI: 1.35–4.87, p = 0.004). Similarly, age factor has come out as a significant determining factor for osteoarthritis knee. Age groups between 25 and 45 experience 2.7 times the risk, and age groups 45 and 59' experience 9.55 times the risk of the condition as compared to subjects in the age group of 18 to 25.

Discussion

Over the past two to three decades, obesity has shown a fast-rising trend. However, due to the paucity of population-based studies given the magnitude of obesity, this baseline cross-sectional study was conducted in an urban resettlement colony in east India. The purpose of the survey also included the study of the association between various co-morbid conditions of obesity and overweight.

The age group of 18 to 60 years was chosen so as to exclude the effect of aging on co-morbid conditions. Subjects of both sexes were fairly distributed across the ages, and the mean ages of females (37.83 + 12 years) and males (35.74 + 13 years) were comparable.

Almost four-fifths of the study subjects were from the lower middle class, and more than three-fourths of females were involved in a sedentary type of physical activity. They were mostly involved in household activities. It is also noted that one-quarter of the male population remained unemployed. This level of physical activity is low as compared to what has been reported by a study from Haryana, which reported half (52.4%) of the females and about a quarter (23.2%) of the males to be sedentary [10]. Similar findings are reported in another multi-centric study by Mishra et al. in India, which reports that 48% of urban women lead a sedentary lifestyle [11].

Even though the economic condition was not so good, the literacy rate was quite higher than the national average. It could be attributed to the better educational setup in Delhi. The literacy rates of males (87.6%) and females (55.9%) were significantly different, but the results are consistent with the findings of NFHS-3 data for males (90%) in Delhi. The lower female literacy level in the present study as compared to the NFHS-3 report (79%) could be due to the inclusion of females older than 49 years, who could be less educated, and also because the study was carried out in a lower middle-class locality of Delhi [12].

While comparing the present data with other studies from India, it is apparent that the prevalence of overweight or obesity in the present study is in line with other Indian studies, which have also shown a high prevalence of overweight or obesity in urban populations [13, 14].

Accordingly, the overall prevalence of overweight was 27.4%. The prevalence of obesity in males and females was calculated to be 6.8% and 47.3%, respectively. Our study results were in concordance with the previous study report from the rural-urban migrant population of north Delhi. In this study, 10.6% of males and 40.2% of females were classified as obese [15].

According to the present study, every fifth person in the population is hypertensive (DBP > 90 or SBP > 140 mm Hg), and almost every other person is pre-hypertensive or at risk of developing hypertension (DBP 80–89 or SBP 120–139 mm Hg). The present study reported a lower prevalence than that reported in other studies from different geographical parts of India [16–18]. However, our study results are comparable with the previous study reports [19–21].

The significant positive association between hypertension and different BMI categories could be seen in the present study subjects. ($X2=29.11$, $P<0.001$). The association was stronger for females as compared to males. Overweight subjects (BMI ≥ 23 kg/m2) were at 1.8 times greater risk for hypertension as compared to subjects whose BMI was between 18.5 and 22.9 kg/m2. The risk was almost four times higher at a BMI ≥27 kg/m2, especially in females. This association has also been studied in another study by **Tuomilehto** et al. on female nurses in a cohort study [22].

We found 112 (21.1%) cases of clinical osteoarthritis (OA) of the knee in the study population. Our result could be explained by a previous study by Pingle et al. in urban slums, giving the prevalence of OA as 36.2% and with the assumption that OA-Knee is the common form of OA present in India [23].

The association was significant at BMI ≥23 kg/m2 for both sexes, but the odds obtained at BMI ≥27 kg/m2 were greater for males, unlike in the study by Chong et al. [24]

This could be because most of the male population in our study were masons, shoemakers, or weavers by profession, which involves prolonged sitting or squatting posture. In such postures, the knees bear more burden.

GERD was one of the most common (20.4%) co-morbidities in the present study. Higher prevalence in females may be due to high sensitivity and a lower threshold in females for the symptoms as shown in other studies, or the inclusion of more young males in the present study. But the overall association was stronger in males as compared to females. The risk of GERD in obese males (BMI≥27.5 kg/m2) was also higher (OR: 3.4) than obese females (2.7).

The remarkably high prevalence of diabetes mellitus type 2 {14.7% [95% CI; 8.0-16.0]} is of particular note despite their low socio-economic strata. Previous studies show almost similar results. In large cities in north and south India, diabetes prevalence among adults (≥20 years) has ranged from 8–15% [25–28]. Our study figure is also consistent with the results (11.6%) of the Diabetes Epidemiology Study Group in India (DESI) and also with the most recent study conducted by Misra A et al. in urban slums on 532 subjects, giving the figure as 11.2% [15].

Unlike previous studies, our result shows a high prevalence of diabetes in females (17.2% vs. 12.0% in males). But there is a significant increase in the prevalence of DM with BMI in both men and women. In the present study, the association of DM with waist circumference is also very evident.[29]

The prevalence of asthma is found to be 13.6% in the present study, which is similar to a study in Mumbai showing the prevalence to be 17% by working definition as compared to 3.5% by physician diagnosis.

However, a statistical association between BMI and asthma has not been established. Contrary to the review literature, more of the males (15.1%) had asthma as compared to females (12.2%). This could have been confounded by the higher level of exposure to outdoor pollution in east Delhi in the case of male subjects. There are not enough studies to analyze the association between obesity, WC, and asthma in females, as obtained in this study. However, the association between BMI and asthma in females has been shown by previous studies [30].

Subjects with Obstructive Sleep Apnea (OSA) constituted 9.2% of the whole sample. In females, 10.0% and in males, 8.4% had sleep apnea. Unfortunately, there are no studies on the prevalence of OSA in India at the community level. But our result matches the prevalence of 9.0% as shown in Singaporean children in the year 2000 [31].

Obstructive sleep apnea is associated with BMI (X2 = 16.84, P = 0.001). The risk increases considerably after a BMI cutoff of 23 kg/m2. The odds ratio is as high as 5.3 and 5.9 for the overweight and obese categories, respectively. The level of association with obesity by the WC criterion was also high, and more so in males. Results also show that study subjects faced almost four and a half times greater risk for OSA as compared to normal subjects by WC criteria, whereas the risk was only threefold by WHR or % body fat criteria.

In the present study, the prevalence of hypothyroidism was found to be 7.7%. More females (9.7%) were hypothyroid as compared to males (5.6%), as per the medical records available with the subjects. This finding is consistent with the findings of a survey conducted in Chennai on 420 subjects by Unnikrishnan et al. in the years 2003–2008 [32].

They have measured all the blood parameters in the community and found out that subclinical hypothyroidism was present in 6.6% of subjects, and another 2.2% of subjects were overtly hypothyroid. The findings of the study suggest a significant association of BMI with hypothyroidism. (X2 = 20.24, P = 0.003) The association is statistically significant for females. This finding is also supported by the observations in a study conducted by Deshmukh et al., where they found females to be associated with hypothyroidism and metabolic syndrome [33].

It is also seen in the study that the risk of hypothyroidism is increasing almost four times from a normal BMI to a BMI in the obese range (≥27.5 kg/m2). However, obesity may have resulted from hypothyroidism.

The prevalence of gallstones is 9.1% in the present study population. This prevalence is higher than what has been reported (4.3%) by Unisa et al. in two decades before (1998) [34]. This could be explained by the rising prevalence of obesity and the strong association of obesity with GBS shown in other studies. However, this prevalence is lower than that of American Indians, as reported by Everhart et al. [35].

In the present study, GBS is more prevalent among females. But analysis of the data does not show a statistically significant association between occurrences of gall bladder stones and BMI. This could be due to an inadequate sample size as far as GBS prevalence is considered.

Among the study subjects, 4.7% reported having been diagnosed with cholecystitis. Unfortunately, there is a scarcity of community-based data to comment on the prevalence of this condition. However, the prevalence of acute and chronic cholecystitis in north India is reported to be high. In this study, we did not see an association between BMI and cholecystitis.

Common surrogate measures of abdominal obesity are WC,HC, and body fat percentages (BF). Our study also showed a significant correlation between BMI and other indices of obesity like WC, HC, and BF percentages estimated from the skin fold

thickness. The level of significance was high for the three indices. (p value <0.001). However, BMI was found to be linearly associated with WHR in the present study. Besides, estimation of WHR is difficult because measurement of the hip may not always be possible as it requires disrobing, which is a difficult task in India.

Conclusion: Among the various surrogates of obesity tested in this study, like WC, HC, WHR, and body fat percentage, BMI has come out as a better indicator of the risks for co-morbidities associated with overweight or obesity. It is also noted that BMI correlates better with the number of comorbidities compared to other indices. Measurement of BMI is hence recommended in such a community setting to find out the magnitude of overweight or obesity and the related health problems. However, as far as type 2 diabetes mellitus is concerned, WC is a better indicator of risk. Hence, measurement of waist circumference is worth consideration in the risk estimation of type II DM. The high prevalence of co-morbidities like osteoarthritis knee, obstructive sleep apnea, and gastroesophageal reflux disease in the community needs further research.

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