Original Article

Prevalence of and Risk Factors for Diabesity in Urban Chennai

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Abstract

Background: A large number of epidemiologic studies across the world indicate a growing link between obesity and diabetes. The metropolitan city of Chennai in South India is experiencing an alarming increase in diabetes and obesity. **Aim:** The aim of this study was to determine the prevalence of and risk factors for diabetes and obesity together termed as "diabesity" among adults in urban Chennai. **Materials and Methods:** This was a community-based cross-sectional door-to-door study done as part of a large National Institute of Health and Care Research (NIHR)—a funded project aimed to understand patterns and determinants of health in South Asia. Of the 200 wards in Chennai, 34 wards were surveyed in the main project and two wards were selected randomly for this substudy. Five community enumeration blocks were selected using a systematic sampling technique. Participants aged ≥18 years were selected using a consecutive sampling method. **Results:** Of the 1138 participants studied, the prevalence of diabesity was found to be 34.3%(n = 390). Of the study participants, 74.8% had obesity (61.9%—generalized obesity; 68.5%—abdominal obesity) and 43.0% had diabetes. As age increased, the diabesity risk also increased gradually from 30 to 39 years (odds ratio [OR]: 3.6[95%, confidence interval [CI]: 1.4–8.9]) to 50–59 years (OR: 5.4[95%, CI: 2.2–13.2]), whereas there was a slight decrease in risk after 60 years (OR: 5.1[95%, CI: 2.1–12.3]). Females had nearly twice the risk of diabesity compared to men (OR: 1.8, $P < 0.001$), and physically inactive individuals had 1.7 times increased risk ($P < 0.001$). **Conclusion:** We report in this study that the prevalence of the dual metabolic defect (diabesity) is alarmingly high in urban Chennai. This study was an attempt to understand the epidemiology of diabesity.

Keywords: Diabesity, epidemiology, risk factors, urban

Introduction

Obesity and diabetes are considered to be major public health issues globally.[1] Current available literature indicates a parallel increase in both obesity and diabetes.[1-3] Diabetes prevalence is increasing across the globe at a significant rate, according to the International Diabetes Federation (IDF), confirming diabetes as a major burden on individuals, families, and societies.[4] Type 2 diabetes mellitus (T2DM) accounts for 90% of all diabetes cases.[5] Globally, adults (20–79 years) with diabetes account for 537 million people and it is estimated to increase to 643 million by 2030 and 783 million by 2045.[4] Among the IDF regions, the South-East Asian region ranks second with 90 million people with diabetes, of which 82% (74 million) reside in India.[6] Similarly, the World Obesity Federation reports that in 2020, 764 million were living with obesity, a significant risk factor for T2DM, and predicts that by 2030 there will be one billion obese people worldwide, with the highest number of people living in developing countries like India.[7]

The term "diabesity," which is defined as a coexistence of T2DM and obesity was first coined by Sims *et al*.[8] in 1973. Diabesity has substantial health consequences, including long-term diabetes complications, impairment

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in health-related functions, lowered quality of life, and reduced longevity.[3] A study conducted by Schnurr *et al*.[9] concluded that obesity raises the risk of developing T2DM 6-fold, regardless of genetic disposition. To curb this evolving epidemic of diabesity, screening, prevention, and early treatment are vital.[2] Several studies have emphasized the importance of reporting diabesity and recommended research in developing countries to understand the epidemiology of diabesity, its health burden, and its associated risk factors.[1-3,10] Hence, this study aims to estimate the prevalence of "diabesity" and associated risk factors among the adult population in Chennai, south India.

Materials and Methods

This is a community-based cross-sectional study which is part of a large health surveillance study to understand the patterns and determinants of health in South Asian people, carried out in four countries namely; India, Pakistan, Bangladesh, and Sri Lanka, funded by the National Institute for Health and Care Research. In India, there were two sites: Delhi and Chennai. In Delhi, the survey was conducted by Max Healthcare. In Chennai, the survey was conducted by the Madras Diabetes Research Foundation (MDRF). For this sub-study, the data from the Chennai site was used. The health surveillance study was carried out on a representative population of Chennai between May 2018 and September 2021. Chennai city has 15 zones and 200 wards, out of which 34 wards were systematically selected for the surveillance study, and two wards were randomly selected for this study. Five community enumeration blocks (CEBs) per ward were selected using simple random sampling techniques and were completely enumerated. Adults (men and women) aged ≥18 years living at their residence for more than 12 months were included in the study. Participants with severe mental or psychiatric illness, pregnant or breastfeeding, or other serious illness and subjects who do not give written consent were excluded from the study. Participants in the study were interviewed using structured and pretested health and lifestyle questionnaires that collected demographic, socioeconomic, medical, and family history of diabetes and heart disease, tobacco use, alcohol consumption, and fruit and vegetable consumption.

Physical activity was also captured using WHO STEP Global Physical activity questionnaire (GPAQ). To assess physical activity, metabolic equivalent (MET) scores were calculated separately for individual domains and subdomains, adopting existing guidelines. MET is the ratio of a person's working metabolic rate to calorie expenditure. When calculating a person's overall energy expenditure using GPAQ data, 4 METs were assigned to the time spent in moderate activities, and 8 METs to the time spent in vigorous activities.[11,12]

Using standardized techniques, the following anthropometric measurements were collected from all participants: weight, height, and waist. Height was measured using (SECA Model 213, Hamburg, Deutschland) stadiometer. A bio-impedance machine, (Omron BF511, Omron Healthcare Group, Kyoto, Japan), was used to measure body mass index (BMI) and waist circumference was measured using a nonstretchable measuring tape.

Fasting venous blood samples were obtained the next day morning after participants observed a minimum of 8–10 h of fasting overnight. The venous blood samples were collected by trained technicians. Fasting plasma glucose (FPG) level was measured using AINA mini-Glucose meter (point-of-care device), Jana care, Inc., Boston, USA. HbA1c was measured using the Variant II Turbo machine, Bio-Rad Laboratories, Inc., USA.

This study was approved by the Institutional Ethics Committee of the MDRF, Chennai. Written informed consent was obtained from all subjects.

Definitions

Obesity

Generalized obesity (GO) was defined as BMI ≥25 kg/m^2 for both sexes or abdominal obesity (AO), defined as waist circumference ≥90 cm for males and ≥80 cm for females.[13]

Diabetes

FPG ≥126 mg/dl[14] or HbA1c ≥6.5 or participants taking diabetes drugs.[15]

Diabesity

Individuals with both obesity and diabetes.

Physical activity

Individuals were classified based on MET-minutes into three groups as: inactive/low (<600 MET-minutes), active (600–1200 MET-minutes), and highly active (>1200 MET-minutes). In this study, the active and highly active groups were clubbed as an active group (≥600 MET-minutes).

Hypertension

Diagnosed in individuals who were on antihypertensive medications or had a systolic blood pressure (SBP) ≥140 mmHg and/or a diastolic blood pressure (DBP) ≥90 mmHg.[16]

Current smoking

Defined as self-reported smoking of tobacco products daily or on some days in the past 12 months.

Current alcohol use

Defined as self-reported use of alcohol daily or on some days in the past 12 months.

Statistical analysis

Statistical analysis was performed using SPSS statistical package version 24. Continuous variables were expressed as a mean and standard deviation whereas categorical variables were expressed as frequencies and percentages. Student's *t*-test was used to compare means for continuous variables and the chi-square test was used for comparing proportions between two groups. Furthermore, univariate and multivariate logistic regression analyses were performed to examine the association using diabesity as a dependent variable while potential risk factors as independent variables. *P* value <0.05 was considered significant.

Results

This study included 1138 individuals (male: n = 455 and females: n = 683) among whom, 26.3% had FPG levels ≥126 mg/dl, 25.6% had HbA1c ≥6.5%, 68.5% had abdominal obesity and 61.9% had generalized obesity. The prevalence of diabetes (FPG or HbA1c) and obesity (AO or GO) was 43, and 74.8%, respectively, and that of diabesity was 34.3% [Figure 1].

[Table 1] presents the demographic and biochemical characteristics of the study population. The mean age of the study population was 51 ± 13 years. Compared to men, women had significantly higher prevalence of diabesity (65.1%). In this study, overall, 59.3% of participants belonged to the middle-income group, who had a family income between 10,000 and 20,000 Indian Rupees, and 46.6% had a primary school education or less. Of the individuals with diabesity, 4.4% were smokers, 8.7% consumed alcohol, and 1.8% had five servings of fruits and vegetables per day. Physical inactivity was significantly higher among those with diabesity compared to those without (69 vs. 61.5%; *P* = 0.013).

[Figure 2] presents age-specific distributions of diabetes, obesity, and diabesity. The prevalence of obesity increased significantly from 53.4% in the age group 18–29 years to 80.6% in the 30–39 years age group and gradually reduced thereafter. A similar observation was seen with diabesity, which increased from 10.3% (18–29 years) to 29.4% (30–39 years). While, the prevalence of diabetes significantly increased from 24.1% in the age group, 18–29 years to 50.5% in the age group ≥ 60 years.

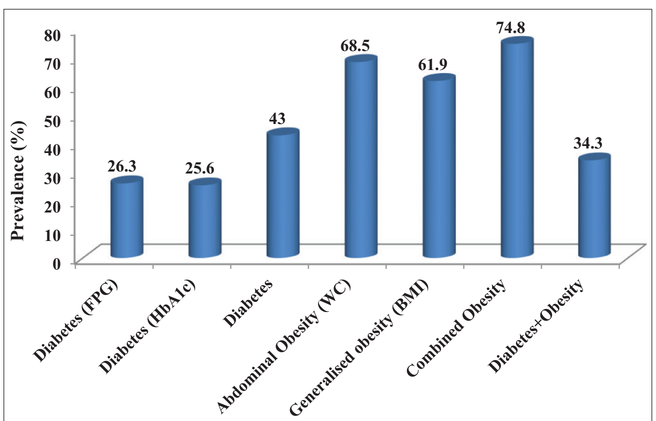

Figure 1: Prevalence of diabetes, obesity, and diabesity

[Figure 3] shows the distribution of diabetes, obesity, and diabesity by sex. The prevalence of obesity (82 vs. 64%, *P* < 0.001) and diabesity (37.2 vs. 29.9%, *P* < 0.01) was higher in females compared to males, respectively. There was no significant difference in the prevalence of diabetes among males (43.1%) and females (42.9%).

[Table 2] presents the univariate and multivariate logistic regression analysis with diabesity as the dependent variable, and variables associated with it in univariate analysis were used as the independent variables in the multivariate model. As age increased the diabesity risk also increased from 30 to 59 years (*P* < 0.05). However, there was a slight decrease in diabetes risk >60 years. Females had a higher risk of diabesity compared to men, the unadjusted odds for females was [odds ratio: 1.4 (95% confidence interval: 1.1–1.8)]. Considering the physically active group as a reference, the odds for developing diabesity was higher in individuals who were physically inactive. There was no significant association with fruit and vegetable intake, hypertension, and education levels. In the multivariate analysis, age, female gender, and physical inactivity were significantly associated with diabesity.

Discussion

Diabesity, which refers to the coexistence of diabetes and obesity, is a major public health problem. To our knowledge, this is one of the few studies from India to assess the prevalence and risk factors of diabesity in a community-based study. The main findings of this study are as follows (i) the prevalence of diabesity was 34.3% among adults in urban Chennai; (ii) the prevalence of diabesity was significantly higher in females and with increasing age; and (iii) additionally physical inactivity was an independent predictor of diabesity.

Over the last few decades, both type 2 diabetes and obesity have increased rapidly worldwide, especially in developing countries like India, mainly due to growing urbanization and changes in human behavior, especially sedentary lifestyles (mechanical transportation, television watching, and lack of exercise, etc.,) and the influence of the western diet (increased availability of processed and fast food, consuming more "energy-dense, nutrient-poor" foods, etc.,).[17-20] Asian Indians are more likely to develop AO and accumulate abdominal fat, which is referred to as the "Asian Indian phenotype".[21,22] As reported by the Indian

Table 1: Demographic and biochemical characteristics of study population

	Overall (*n* = 1138)	Without diabesity (n = 748)	With diabesity (n = 390)	*P*-value
Age (years)	51±13	50±14	53±12	0.028
Female n (%)	683 (60)	429 (57.4)	254 (65.1)	0.011
Weight (kg)	63±13	62±13	67±13	0.028
Height (cms)	156±9	156±9	156±9	0.949
BMI (kg/m^2)	26.1±4.7	25.4±4.8	27.8±4.2	0.027
Waist circumference				
Male (*n* = 455)	91±11	89±11	97±8	0.038
Female (*n* = 683)	88±11	86±12	92±9	0.033
SBP (mmHg)	129±19	128±20	131±19	0.318
DBP (mmHg)	82±11	82±11	83±11	0.466
HbA1c	6.3±1.6	5.8±1.2	7.3±1.9	0.027
FPG (mgl/dl)	119±54	100±37	154±64	0.028
Hypertension (≥140/≥90)	377 (33.1)	238 (31.8)	139 (35.6)	0.193
Abdominal obesity n (%)				
Male (*n* = 455)	246 (54.1)	127 (39.8)	119 (87.5)	<0.001
Female (*n* = 683)	533 (78)	286 (66.7)	247 (97.2)	<0.001
Generalized obesity n (%)				
Male (*n* = 455)	237 (52.1)	131 (41.1)	106 (77.9)	<0.001
Female (*n* = 683)	467 (68.4)	265 (61.8)	202 (79.5)	<0.001
Smoking n (%)	54 (4.7)	37 (4.9)	17 (4.4)	0.658
Alcohol n (%)	102 (9)	68 (9.1)	34 (8.7)	0.834
Family income (INR)				
<10000	284 (25)	182 (24.3)	102 (26.2)	0.241
10000–20000	675 (59.3)	451 (60.3)	224 (57.4)	0.172
>20000	179 (15.7)	115 (15.4)	64 (16.4)	0.330
Education				
Less than primary school	530 (46.6)	358 (47.9)	172 (44.1)	0.111
Primary school completed	252 (22.1)	160 (21.4)	92 (23.6)	0.187
Secondary and High school completed	260 (22.8)	163 (21.8)	97 (24.9)	0.118
College completed	96 (8.4)	67 (9)	29 (7.4)	0.178
Physically Inactive	729 (64.1)	460 (61.5)	269 (69)	0.013
Diet				
Fruit servings ≥2 servings/day	369 (32.4)	250 (33.4)	119 (30.5)	0.320
Vegetable ≥3 servings/day	182 (16)	127 (17)	55 (14.1)	0.209
Fruits and vegetables combined (5 servings/day)	29 (2.5)	22 (2.9)	7 (1.8)	0.244

DBP, diastolic blood pressure; INR, Indian Rupees; FPG, fasting plasma glucose; SBP, systolic blood pressure
$p < 0.05$ is considered significant

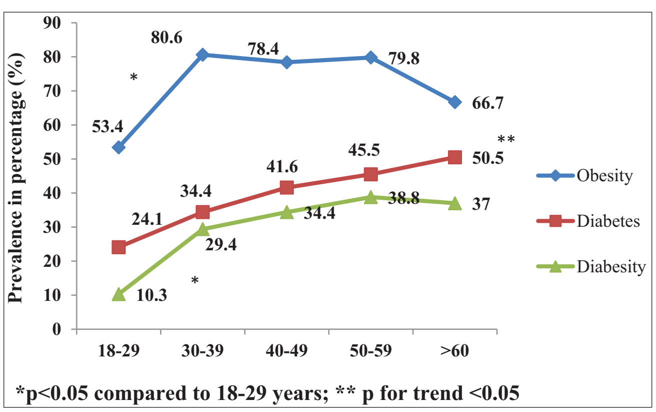

Figure 2: Age-wise distribution of obesity, diabetes, and diabesity. **P* < 0.05 compared to 18–29 years; ** *P* for trend <0.05

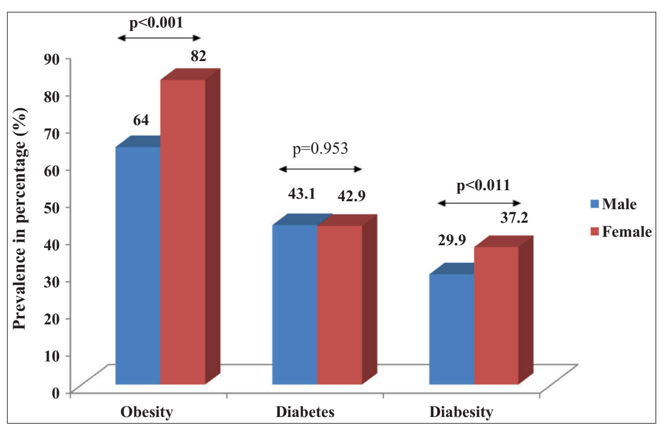

Figure 3: Gender-wise distribution of obesity, diabetes, and diabesity

Table 2: Association of risk factors with diabesity

	Odds ratio (95% CI)	*P*-value
Univariate association		
Age group (years)		
18–29	1.00 (Ref)	
30–39	3.6 (1.4–8.9)	0.005
40–49	4.5 (1.8–10.9)	0.001
50–59	5.4 (2.2–13.2)	<0.001
≥60	5.1 (2.1–12.3)	<0.001
Sex		
Male	1.00 (Ref)	
Female	1.4 (1.1–1.8)	0.011
Physical activity		
Active	1.00 (Ref)	
Inactive	1.4 (1.1–1.8)	0.013
Diet (fruit and vegetable)		
≥5 servings of fruits and vegetable	1.00 (Ref)	
<5 servings of fruits and vegetable	1.6 (0.7–3.9)	0.249
Education		
College completed	1.00 (Ref)	
Less than primary school	1.1 (0.7–1.8)	0.665
Primary school completed	1.3 (0.8–2.2)	0.271
Secondary and High school completed	1.4 (0.8–2.3)	0.215
Multivariate association		
Age (Years)	1.2 (1.1-1.4)	<0.001
Sex (Female)	1.7 (1.3-2.2)	<0.001
Physically inactive	1.7 (1.29-2.3)	<0.001

CI, confidence interval

$p < 0.05$ is considered significant

Council of Medical Research (ICMR) - India Diabetes (INDIAB) study, in Tamil Nadu the prevalence rates for GO, AO, and combined obesity were 24.6%, 26.6%, and 19.3%, respectively.[23] Several studies have shown that women in India have a higher prevalence of obesity[23,24] particularly in urban areas.[25] This could be attributed to the consumption of more saturated fats, have less physical activity, and dependency on mechanical transportation.[18] Menopause is considered to be one of the contributing factors to obesity among women.[26] The prevalence of AO [current study: 78% vs. National Family Health Survey 5 (NFHS-5): 59.5%] and GO (current study: 68.4% vs. NFHS-5: 41.9%) among females, were higher in the current study compared to that reported in the NFHS-5.[27] This might be due to the fact that NFHS-5 was conducted in the representative population of Chennai and this study was carried out in two selected wards.

As per the IDF, diabetes prevalence has increased in India over the past decade from 61.3 million in 2011[28] to 74.2 million in 2021.[4] According to the Global Burden of Disease Study, the number of people with diabetes increased from 26 million to 65 million between 1990 and 2016 in India, with the highest prevalence reported in Tamil Nadu.[29] The ICMR-INDIAB study conducted between 2008 and 2010 reported that the prevalence of diabetes in Tamil Nadu was 10.4%.[30] According to NFHS-5 conducted between 2019 and 2021, the prevalence of diabetes in Tamil Nadu was 20.7% in females and 22.1% in males, and the prevalence of obesity was reported to be 40.4% and 37.0% among females and males, respectively.[27]

The Center for cArdio-metabolic Risk Reduction in South Asia (CARRS) study conducted in Chennai in 2015 reported that the prevalence of diabetes was 22.8%.[31] The diabetes prevalence in Chennai was 27.2% for females and 22.1% for males, according to the NFHS-5.[27] In the current study, the diabetes prevalence was high (43%) compared to CARRS and NFHS-5. The NFHS-5 used random blood glucose values to identify diabetes, whereas the CARRS study used FPG or HbA1c or people taking diabetes medication, similar to this study.

A growing number of people have obesity or diabetes, leading to shorter life-span, reduced productivity, and significant economic losses.[30,32-34] It is predicted that a 10% increase in overweight and obesity causes an increment of 4.7% in diabetes.[35] According to the Chennai Urban Rural Epidemiological Study (CURES), abdominal obesity contributes to diabetes incidence by 1.63 times.[36] The Global Burden of Disease Study reported that adults with a BMI ≥25 kg/m², increased from 9.0% to 20.4% between 1990 and 2016 and that in 2016, for every 100 adults with a BMI ≥25 kg/m² in India, there were 38 adults with diabetes, compared with the global average of 19 adults.[29] Very few studies have assessed the prevalence of diabesity. According to a study conducted in an urban Primary Health Center at Pondicherry, obesity prevalence in T2DM patients (diabesity) was reported to be 66.9%,[37] whereas another study conducted in Belagavi in Karnataka reported that the prevalence of obesity in T2DM patients was 53.4%.[38] Perhaps the higher prevalence of diabesity compared to the current study may be due to the studies being carried out in individuals with diabetes, rather than a general population.

Unhealthy diets, physical inactivity, and low income are considered the major risk factors for obesity.[23,35] However, WHO and the IDF recommend that addressing obesity in the early stages can prevent future T2DM.[39] Therefore, obesity has been categorized as a major diabetes risk factor. Population growth, aging, urbanization, behavioral factors such as sedentary lifestyle and consuming calorie-rich diet, and environmental factors such as availability and accessibility of physical activity area and food outlet contribute to the increased prevalence of diabetes and obesity "diabesity".[40-42]

In the past decade, several studies have reported physical inactivity to be common in developed and developing countries.[43-46] Global trend in physical inactivity from 2001 to 2016, a pooled analysis from 358 population-based survey reported that the prevalence of insufficient physical activity over time increased from 31.6% in 2001 to 36.8% in the year 2016 in high-income countries whereas 16% in 2001 to 16.2% in the year 2016 in low-income countries.[47] The ICMR-INDIAB study conducted in four regions of India, including Tamil Nadu, assessed physical activity pattern using the GPAQ, reported that 54.4% of the population were inactive (urban 65% vs. rural 50%).[11] Our study findings show that 64% of the study population were physically inactive or follow a sedentary lifestyle, which is similar to the figures reported in the urban areas of India. According to the Global Burden of Disease Study (2016), among the risk factors contributing to diabetes, high BMI and low physical activity were associated with diabetes Daily Adjusted life years in India.[29]

This study has few limitations. In this study, causal inferences and generalizability of results are precluded due to its cross-sectional design. Another limitation is the relatively small sample drawn from a single city in India. Several studies have reported a significant relationship between diabetes, obesity, and diet, but this study did not thoroughly examine the dietary pattern in the study population. One of the strengths is that it is one of the few to examine diabesity prevalence in India and its associated risk factors from a community perspective. Diabesity studies so far have focused mostly on obesity prevalence in type 2 diabetes patients, mostly conducted in hospitals.

Conclusion

In light of the rapid emergence of urban obesogenic environments across the country, diabetes prevention should be an urgent national priority. The current study found that the prevalence of dual metabolic defects (diabesity) to be alarmingly high in urban Chennai. This study made an effort to understand the epidemiology of diabesity which will help policymakers to design health programs to curb the rise of diabesity. More research studies are highly recommended in developing countries to identify the epidemiology of diabesity and its associated risk factors, for future prevention and intervention strategies.

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Ethical clearance

This study was approved by Madras Diabetes Research Foundation Institutional Ethics Committee (Ref no: MDRF/NCT/06-01-2018).

Author disclosure statement

No competing financial interests exist.

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Conflicts of interest

There are no conflicts of interest.

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