Prevalence and Factors Influencing Diabesity among Persons with Type 2 Diabetes Mellitus in Urban Puducherry: A Cross-Sectional Analytical Study

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Abstract

Background: The risk for cardiovascular diseases (CVDs) increase exponentially when type 2 diabetes mellitus (T2DM) and obesity coexist. Objective: To estimate the proportion of people with diabesity and assess the sociodemographic, dietary, and morbidity related factors associated with diabesity. Methods: A hospital-based cross-sectional analytical study was conducted in 2018 among persons with T2DM attending an urban Primary Health Centre in Puducherry using a structured questionnaire. Results: The mean (standard deviation) age of 151 study participants was 58.2 (11.8) years with 66% (n = 100), 77% (n = 116) and 40% (n = 60) being females, sedentary workers and belonging to lower socioeconomic status, respectively. Of total, 71% (n = 107) had hypertension, 66% (n = 99) had uncontrolled fasting blood sugar (FBS) level and 74% (n = 111) did not consume fruits daily. The proportion of diabesity was found to be 66.9% (95% CI 58.8–74.3). After adjusting for other factors, obesity was significantly high among T2DM patients aged 50 years and less (adjusted prevalence ratio– (aPR) 1.4; (95% confidence interval [CI]: 1.07–1.83) compared to >60 years. Having uncontrolled FBS values (aPR 1.28; [95% CI: 1.01–1.64]), deficient in calorie intake (aPR 1.66; [95% CI: 1.25–2.22]), deficient in fruits intake (aPR 1.45; [95% CI: 1.07–1.97]), and high fat consumption (aPR 1.26; [95% CI: 1.02–1.57]) had significant association with diabesity. Conclusion: Considering the rising burden of diabetes associated with obesity, vigilant strategy to reduce modifiable risk factors for CVD needs further emphasis at primary care settings.

Keywords: Diabetes, obesity, prevalence, risk factors, type 2 diabetes mellitus, urban Puducherry

Introduction

Cardiovascular diseases (CVDs) are one of the major causes of deaths worldwide and have fueled the already escalating costs of health care.[1] Dawning with the Framingham Heart Study, risk factors for the development of CVDs have gained importance in clinical as well as in the public health practice.[2] Further, the risk of CVDs and its mortality increases exponentially when diabetes mellitus (DM) and obesity coexist.[3]

Around one-tenth of the world’s adult population is suffering from type 2 DM (T2DM), and 80% of these patients belong to the low-and middle-income countries (“LMIC”).[4,5] On the other hand, the prevalence of obesity has tripled since 1975–13% worldwide in 2016 with the major increase in “LMIC” s.[6,7] Eventually, the prevalence of diabetes and obesity in India was 10% and 13%, respectively, in 2017.[8,9] Therefore, in a steady pace, these two epidemics with or without the presence of other comorbidities such as dyslipidemia or hypertension have gained its ground in India.[10,11] More so in South India, as the prevalence of both diabetes and obesity is higher in Tamil Nadu—higher in the urban compared to rural.[12] The term diabesity was first coined by Sims et al. in 1973 after the frequent coexistence of both the conditions in the developed nations.[13] The pathophysiology of obesity causing...
diabetes was well understood as diminished physical activity, and excessive calorie-dense food spurs the incidence of obesity, which further leads to insulin resistance and T2DM. One of the major risk factors for diabesity was found to be an unhealthy diet[14]. However, there is a paucity of literature regarding other determinants for diabesity that needs to be explored. Hence, the present study was done to estimate the proportion of people with obesity and assess the sociodemographic, dietary, and morbidity-related factors associated with it among persons with T2DM attending an urban Primary Health Centre in Puducherry.

Methods

Study design
A hospital based cross-sectional analytical study among T2DM patients registered for care.

Study setting
T2DM individuals were recruited from the service area of an urban health center of a tertiary care institute in the southern part of India. The health center provided noncommunicable disease (NCD), antenatal, under-five, and adolescent clinics apart from general outpatient services to a population of about 8200 with its 1680 households spread across four adjoining wards along the coastal areas of Puducherry. The four wards had similar socio-demographic, socio-cultural, and health-seeking behavior practices.[15] All the services, including routine medical consultation, laboratory services, treatment for minor ailments, and counseling were provided free of cost to the public. Fasting blood sugar (FBS) and postprandial blood sugar (PPBS) tests were done for all patients using a portable digital glucometer. If FBS >125 mg/dL or PPBS >200 mg/dL were found for any patient, then they were monitored every month or else blood sugar tests were done once in 3 months. Every month, during the NCD clinics, patients were given medicines and health education regarding nutrition, drug adherence, foot care, and physical activity. The yoga instructor was also posted to give training for those interested in Yoga exercises. Patients were started on oral hypoglycemic agents such as tablet Metformin 500 mg or Glibenclamide 5 mg or Glimepiride 2 mg provided by the clinic’s pharmacy. If blood sugar values were found uncontrolled, drug adherence was checked before referring the patients to the tertiary care institute for further evaluation and management.

Study population
We included all the adult (>18 years) T2DM patients registered in the health center and attending the clinic in February 2018. Those patients who did not attend the clinic for the previous two consecutive months were excluded.

Sample size and sampling technique
Considering the prevalence of obesity co-existing with T2DM as 39%, the relative precision of 20%, and nonresponse rate of 5%, the sample size was calculated as 151.[16,17] Since there were 174 patients registered with the NCD clinic, every T2DM patient was approached for enrollment.

Data variables, sources of data, and data collection
Around 45 individuals were enrolled from the NCD clinic every week. A structured questionnaire was administered, which had three parts. First section comprised the socio-demography details. Updated modified B. G. Prasad’s scale was used to estimate the patient’s socioeconomic status.[18] Upper (Class I) and upper-middle (Class II) categories were clubbed like lower (Class V) and lower-middle (Class IV) categories for analysis purposes as the numbers were small. The occupation was classified into three categories based on the amount of physical activity.[19]

The second section had details related to the comorbidity of the participants. Total cholesterol level, which was measured using an auto analyzer in the health center within the past 6 months, and blood glucose values were recorded from the patients’ records. Any diabetic who was a known hypertensive or diagnosed based on Joint National Committee-7 guidelines was classified as having “hypertension.”[20,21] A cut off of 200 mg/dL of total cholesterol was kept for the diagnosis of hypercholesterolemia. Blood glucose control status was based on guidelines by the Indian Council of Medical Research 2018.[22] The diagnoses of coronary artery disease, retinopathy, and diabetic foot were obtained from the records. Anthropometric measurements were taken in the standing position, with the participants wearing light clothing and no shoes. Height was measured to the nearest 0.1 cm using a portable stadiometer, and weight was measured to the nearest 0.1 kg using an electronic scale that was calibrated before each measurement.

The third part comprised of dietary history: 24-h dietary recall method was used. Details of the first food item consumed after waking up in the morning till the last thing taken before waking up in the next morning were recorded.[23] The nutrient content of each food item was estimated, and the diet intake was expressed as excess or deficit if it was 20% more or less respectively based on the Recommended Dietary Allowances for Indians.[24,25] T2DM patients were diagnosed to have diabesity if they were obese.[26] Obesity definition was based on the WHO Asia Pacific Guidelines of body mass index >24.99 kg/m², with or without abdominal obesity.[27]

Data entry and statistical analysis
Data were entered in EpiData v 3.01 software (EpiData Association, Odense, Denmark) and analyzed using STATA 14 software (StataCorp LP, College Station, Texas, USA). The burden of diabesity was summarized as the proportion with 95% confidence interval (CI). Association of socio-demographic, dietary, and morbidity-related characteristics with diabesity was assessed using Chi-squared test and unadjusted prevalence ratio (PR) with 95% CI. Multivariable analysis using log-binomial model was done to calculate adjusted PR (aPR) with 95% CI. Variables with P < 0.1 in univariate analyses were included in the multivariable model. A P < 0.05 was considered statistically significant in the final model.
Ethical approval
The study was conducted as a part of the review of the services delivered by the urban health center. Clarification of any query was done during the consultation with the patient in the NCD clinic. Verbal consent was obtained from each patient regarding the usage of data from their health case record for scientific research and presentation. At the end of the interview, participants were briefed and counseled regarding the hazards of diabesity.

RESULTS
A total of 151 eligible T2DM patients were included. The mean (standard deviation) age was 58.2 (11.8) years with 66% (n = 100) being females and 77% (n = 116) involved in sedentary occupation. Of total, 40% of the participants belonged to lower socioeconomic status (Class V) (n = 60) followed by lower middle (Class IV) (32%, n = 49). Table 1 describes the morbidity characteristics. Out of total 151 participants, 71% (n = 107) had hypertension and 66% (n = 99) and 64% (n = 97) had uncontrolled FBS and PPBS, respectively. The dietary pattern in Table 2 shows 46% (n = 69) had deficit in calorie intake and 74% (n = 111) did not consume fruits daily.

Of 151 patients, 66.9% (n = 101, 95% CI: 58.8–74.3) had diabesity. Age, gender, FBS, daily calorie intake, and consumption of fat and fruits were associated with diabesity on the unadjusted analysis (P < 0.1) [Table 3]. On adjusting for all other variables, diabesity was significantly high among T2DM patients who were aged 50 years and less (aPR 1.4; 95% CI: 1.07–1.83) compared to individuals >60 years. Similarly, the disease was significantly associated among patients with uncontrolled FBS, deficit in calorie and fruit intake, and excess fat consumption [Table 3].

DISCUSSION
The overall prevalence of obesity was found to be 66.9% (95% CI: 58.8–74.3) among 151 persons with T2DM attending an urban Primary Health Centre in Puducherry in 2018. It was more common among T2DM patients who were aged <51 years, had uncontrolled FBS levels, and were consuming diet rich in fat but deficient in calorie and fruits.

The burden of obesity among T2DM patients was comparable to the finding in another study by Mohan where it was 54.1%.[11] In 2016 it was found that obesity contributed to 36% of the overall diabetes disability-adjusted life years in India,[28] making it evident that declining the incidence of obesity is the finest approach to scale down this diabetes “tumor.”

Although diabesity has been recognized for long, but few studies have been done to study the factors associated with it. Middle age group, uncontrolled FBS, and consumption of diet rich in fat and deficient in fruits were significantly associated with diabesity in hospital based cross-sectional studies worldwide.[30-31] A poor-quality diet like the above leads to the enhanced risk of gaining weight and developing obesity among T2DM patients. The higher prevalence of obesity among the age group <51 years may be attributed to sedentary occupation, work and family-related stress and unhealthy diet.

The present study also showed the prevalence of diabesity was 66% significantly more (aPR-1.66 [95% CI: 1.25–2.22]) among participants consuming calorie deficit food items. The most probable reason for this could be that an acute low-calorie diet decelerates metabolism through an advanced feedback loop between our brain and digestive system.[32] This operates the hormone system to acquire and sustain body fat securing in anticipation of subsequent undernourishment. Further studies need to be done to explore this association.

The major strengths of the study were the robust statistical analysis and reduced data entry errors, whereas the limitations were recall bias for dietary pattern and limited generalizability of the findings.

“Diabesity” raises the question whether weight management and diabetes should be targeted with combined treatment strategies. Diabesity is difficult to be cured but can be controlled.[30] Many of the anti-diabetic pharmaceutical agents, including insulin are associated with a risk of weight gain in patients with T2DM, theoretically worsening the diabesity status. Therefore, balancing adequate glycemic control and diabesity risk becomes a priority for clinicians in choosing

| Characteristics | Number (%)* |
|-----------------|-------------|
| Family history of type 2 diabetes mellitus, yes | 80 (53) |
| Hypertension, yes | 107 (71) |
| Hypercholesterolemia, yes | 54 (36) |
| History of coronary artery disease, yes | 10 (7) |
| History of retinopathy, yes | 3 (2) |
| Diabetic foot, yes | 3 (2) |
| Fasting blood sugar, controlled | 52 (34) |
| Post prandial blood sugar, controlled | 54 (36) |

*Column percentage, ‘24-h dietary recall method

| Characteristics | Number (%)* |
|-----------------|-------------|
| Daily calorie intake† | 69 (46) |
| Deficit | 42 (28) |
| Normal | 40 (26) |
| Daily protein intake† | 131 (87) |
| Excess | 20 (13) |
| Normal | 72 (48) |
| Daily fat intake† | 79 (52) |
| Excess | 72 (48) |
| Normal | 72 (48) |
| Daily fruit intake† | 40 (26) |
| Yes | 111 (74) |

*Column percentage, ‘24-h dietary recall method

Table 1: Morbidity characteristics of type 2 diabetes mellitus patients attending an urban Primary Health Centre in Puducherry, 2018 (n=151)

Table 2: Dietary pattern of type 2 diabetes mellitus patients attending an urban Primary Health Centre in Puducherry, 2018 (n=151)
Table 3: Multivariable analysis showing association of sociodemographic, morbidity and dietary characteristics with obesity among type 2 diabetes mellitus patients attending an urban Primary Health Centre in Puducherry, 2018 (n=151)

| Characteristics                          | Total | Diabesity, n (%)| 95% CI | Unadjusted PR | Adjusted PR* |
|------------------------------------------|-------|-----------------|--------|---------------|--------------|
| Total participants                       | 151   | 101 (67)        |        | -             |              |
| Age (years)                              |       |                 |        | -             |              |
| ≤50                                      | 40    | 35 (88)         | 1.56 (1.21-2.02) | 1.4 (1.07-1.83) |
| 51-60                                    | 52    | 33 (63)         | 1.13 (0.83-1.54) | 1.07 (0.8-1.44) |
| >60                                      | 59    | 33 (56)         | Reference | Reference      |
| Gender                                   |       |                 |        | -             |              |
| Male                                     | 51    | 34 (67)         | Reference | Reference      |
| Female                                   | 100   | 67 (67)         | 1 (0.79-1.27) | 0.91 (0.73-1.15) |
| Occupation category                      |       |                 |        | -             |              |
| Sedentary                                | 116   | 80 (69)         | 1.15 (0.85-1.55) | -             |
| Moderate and heavy                       | 35    | 21 (60)         | Reference | -              |
| Socioeconomic status§                    |       |                 |        | -             |              |
| Upper middle and upper                   | 14    | 10 (71)         | 1.33 (0.83-2.15) | -             |
| Middle                                   | 28    | 15 (54)         | Reference | -              |
| Lower and lower middle                   | 109   | 76 (70)         | 1.3 (0.9-1.88) | -              |
| Family history of DM                     |       |                 |        | -             |              |
| Yes                                      | 80    | 58 (73)         | 1.2 (0.95-1.51) | -             |
| No                                       | 71    | 43 (61)         | Reference | -              |
| Hypertension                             |       |                 |        | -             |              |
| Yes                                      | 107   | 72 (67)         | 1.02 (0.8-1.31) | -             |
| No                                       | 44    | 29 (66)         | Reference | -              |
| Hypercholesterolemia                     |       |                 |        | -             |              |
| Yes                                      | 54    | 36 (67)         | 0.99 (0.79-1.26) | -             |
| No                                       | 97    | 65 (67)         | Reference | -              |
| History of CAD                           |       |                 |        | -             |              |
| Yes                                      | 10    | 6 (60)          | 0.89 (0.53-1.5) | -             |
| No                                       | 141   | 95 (67)         | Reference | -              |
| History of retinopathy                   |       |                 |        | -             |              |
| Yes                                      | 3     | 2 (67)          | 1 (0.44-2.24) | -             |
| No                                       | 148   | 99 (67)         | Reference | -              |
| Diabetic foot                            |       |                 |        | -             |              |
| Yes                                      | 3     | 2 (67)          | 1 (0.44-2.24) | -             |
| No                                       | 148   | 99 (67)         | Reference | -              |
| Fasting blood sugar                      |       |                 |        | -             |              |
| Controlled                               | 52    | 29 (56)         | Reference | Reference      |
| Uncontrolled                             | 99    | 72 (73)         | 1.3 (1-1.71) | 1.28 (1.01-1.64) |
| Post prandial blood sugar                |       |                 |        | -             |              |
| Controlled                               | 54    | 35 (65)         | 0.95 (0.75-1.21) | -             |
| Uncontrolled                             | 97    | 66 (68)         | Reference | -              |
| Daily calorie intake                     |       |                 |        | -             |              |
| Deficit                                  | 69    | 57 (83)         | 1.57 (1.15-2.15) | 1.66 (1.25-2.22) |
| Excess                                   | 42    | 21 (53)         | 1.04 (0.7-1.56) | 1.28 (0.88-1.88) |
| Normal                                   | 40    | 23 (55)         | Reference | Reference      |
| Daily protein intake§                    |       |                 |        | -             |              |
| Excess                                   | 131   | 90 (69)         | 1.25 (0.83-1.89) | -             |
| Normal                                   | 20    | 11 (55)         | Reference | -              |
| Daily fat intake                         |       |                 |        | -             |              |
| Excess                                   | 72    | 55 (76)         | 1.31 (1.05-1.65) | 1.26 (1.02-1.57) |
| Normal                                   | 79    | 46 (58)         | Reference | Reference      |
| Daily fruit intake                       |       |                 |        | -             |              |
| Yes                                      | 40    | 20 (50)         | Reference | Reference      |
| No                                       | 111   | 81 (73)         | 1.46 (1.05-2.05) | 1.45 (1.07-1.97) |

*Based on log binomial model-included variables age, gender, fasting blood sugar, calorie intake, fat intake and fruit intake which had P<0.1 in univariate analysis, *Row percentage, †P<0.05, Modified BG Prasad's scale 2018, 24-h dietary recall method. PR: Prevalence ratio, CI: Confidence interval, DM: Diabetes mellitus, CAD: Coronary artery disease

the anti-diabetic drug regimens. A multi-prong, and an individualistic approach for setting immediate and long-term targets is thus mandatory in the successful management of diabesity. Multidisciplinary approach involving changes in diet, lifestyle, and pharmacotherapy should be devised by the healthcare professionals for a rational and scientific algorithm
design for patients with diabesity-taking age, co-morbidities, social and cultural aspects of individual cases into consideration.

Acute calorie deficit diet pattern was most prevalent among the diabesity participants followed by no fruit intake, middle-aged, uncontrolled FBS and T2DM patients consuming fat-rich diet. Hence, these are the target groups who should be streamlined for behavioral change and followed up periodically by health-care workers. More awareness needs to be generated regarding these factors even among the general population to start the early screening of diabesity. With the burden of diabesity increasing, it is the right time to make necessary steps to screen, diagnose, treat, and create awareness on diabesity risk factors. Understanding these factors could be useful in further expanding India’s NCD control program on the path to universal health coverage.

### Conclusion

Two third of the study participants had diabesity. Obesity was more common among middle aged T2DM patients with uncontrolled FBS levels and who were consuming diet rich in fat but deficient in calorie and fruits. Considering the rising burden of diabesity, there is a need for developing high risk-based screening strategy to identify and reduce modifiable risk factors for CVD.

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### Conflicts of interest

There are no conflicts of interest.

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