ORIGINAL ARTICLE

# Prevalence of Diabetes Mellitus and Its Correlations with Body Mass Index, Neck Circumference, and Obstructive Sleep Apnea Risk among Adults in Kolkata, West Bengal

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## Abstract

Diabetes mellitus, a chronic metabolic disorder with the key feature of hyperglycemia, constitutes a significant global health threat due to the rising number of cases worldwide. This cross-sectional study was designed to examine the prevalence of diabetes mellitus and its connection with body mass index (BMI), neck circumference, and obstructive sleep apnea (OSA) risk among the adults of Kolkata, West Bengal.

The study included 1,016 adults between the ages of 41–70 years, with anthropometric measurements and fasting blood glucose levels recorded. The diabetes prevalence was 12.98% in males and 13.01% in females, which was highest in the age group of 51–60 years. A significant association was observed between BMI and diabetes, as higher prevalence rates were witnessed among overweight and obese individuals as opposed to those with normal or underweight BMIs. Moreover, neck circumference was positively correlated with the prevalence of diabetes. The larger the neck circumference, the higher the risk of diabetes. Besides, the prevalence of diabetes in high-risk subjects for OSA was higher than in low- and intermediate-risk participants, indicating a remarkable association between the risk for OSA and diabetes.

These findings draw attention to the need for public health interventions for the prevention and management of obesity, monitoring neck circumference, and addressing OSA in order to reduce the burden of diabetes in urban areas in India. Screening and intervention campaigns aimed at different age groups at high risk should focus on early detection and treatment of patients. The study overall helps in the understanding of the epidemiology in urban India, and such comprehensive approaches in diabetes management are also emphasized.


**Keywords:** Body mass index, Diabetes mellitus, Neck circumference, Obstructive sleep apnea, Urban India.

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## Introduction

Diabetes mellitus is a chronic metabolic disorder that arises from hyperglycemia due to insulin secretion defects, insulin action defects, or a combination of the two. It is one of the most significant global health risks that we have to face, and the cases have kept rising in the past few decades.[1] As per the International Diabetes Federation (IDF), the global prevalence of diabetes in 20–79 years old for 2021 was measured to be 10.5% (536.6 million people), which will continue to rise to 12.2% in the projection to 2045. The 2021 global health expenditures for diabetes-related diseases were about 966 billion USD and will be projected to grow to 1,054 billion USD by 2045. In India, there are 77 million people who are 18 years old and above and are diabetic (type 2), and almost 25 million people are others who are categorized as prediabetics (have a higher chance of developing diabetes soon).[2,3] One of the main characteristics of type 2 diabetes mellitus (T2DM) is obesity, which is noted by high body mass index (BMI). Excess deposition of adipose tissue is the main feature of obesity. It interferes with insulin metabolism, principally by making the body resistant to insulin, which means that T2DM is more likely to develop. The link between BMI and diabetes rates at population levels is well-known, pointing out a prevalent correlation between high BMIs and an increased risk of diabetes.[4]

Diabetes mellitus is common among adults, and it is essential to understand the relationship between its prevalence and BMI. This information can help in the development of public health planning and intervention programs to mitigate the burden of this chronic disease. The prevalence of diabetes and its association with BMI can be evaluated, which can later guide identifying high-risk populations, stimulating targeted prevention efforts, and improving optimal healthcare resource allocation.[5,6]

In India, particularly in cities like Kolkata in West Bengal, the diabetes burden is increasing exponentially, posing a formidable challenge to the healthcare sector and necessitating epidemiological studies for a comprehensive understanding of the disease prevalence and associated risk factors. The metropolitan city of Kolkata, famous for its rich heritage, culture, and busy landscapes, faces a double-edged sword of communicable and noncommunicable diseases, with diabetes being the major cause for the latter. Kolkata, like several other urban settings in India, has come under the spell of rapid urbanization and lifestyle transitions, which have changed food habits and physical activity levels and consequently affected the BMI distribution pattern among the adult population. Hence, looking into the link between BMI and diabetes along with other risk factors such as neck circumference and obstructive sleep apnea (OSA) in this vicinity is essential for designing helpful measures and promoting healthy lifestyles.[7–10]

In this context, the present study intends to assess the current prevalence of diabetes mellitus among the adults of Kolkata, West Bengal, and also study the correlations with BMI, neck circumference, and OSA risk levels in this population. This study is poised to contribute to the larger discussion on preventing and managing noncommunicable diseases in urban India.

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## Materials and Methods

This cross-sectional study was carried out among 1,016 adults, aged 41–70 years; of these, males and females were 524 and 492, respectively, from 2023, November 11 to 14. The participants were selected through a simple random technique from the Baguihati area of Kolkata, West Bengal, India.

The participants were divided into three different age groups with 10-year intervals each to study the age trend of diabetes. Anthropometric measurements, such as stature and body weight, were measured using standard instruments and techniques given by Weiner and Lourie.[11] Measurements were taken on the subjects wearing minimal and light apparel. BMI (weight/height$^2$) was calculated and classified according to the proposed criteria of the World Health Organization (WHO) Asian-Pacific cutoff points (underweight <18.5 kg/m$^2$, normal = 18.5–22.9 kg/m$^2$, overweight = 23.0–24.9 kg/m$^2$, and obese ≥25 kg/m$^2$.[12] Diabetes was taken as <126 mg/dL. A value of 100–125 mg/dL was classified as prediabetes. Nondiabetes was taken as >100 mg/dL.[13]

Neck circumference was measured with a standard nonelastic tape. Measurements were classified into two groups: <38 cm and ≥38 cm. To measure the OSA risk levels, participants were categorized into three groups: low, intermediate, and high. The OSA risk levels were determined by using a standard OSA risk assessment tool considering data such as age, BMI, neck circumference, and sleep apnea symptoms.

Statistical software MedCalc (Version:20) was used to carry out statistical analysis. Descriptive statistics of mean and standard deviation were used to examine the collected data. Besides descriptive statistics, to test the differences between the age groups and the association between BMI, neck circumference, OSA risk levels, and diabetes, *t*-test and correlation analysis were done, respectively. $p < 0.05$ was taken as statistically significant.

## Results

The significance of the sex difference between various parameters is evident from Table 1. Mean values of age, stature, body weight, BMI, neck circumference and FBG were found to be higher in males as compared with their female counterparts.

Table 2 shows the prevalence of diabetes according to age, sex, BMI categories, neck circumference and OSA risk levels among the study participants. A total of 1,016 suburban adults were included in this present study, of which 524 (51.57%) were males and 492 (48.43%) were females. The prevalence of diabetes among males and females is 12.98% (95% CI: 10.22–16.16) and 13.01% (95% CI: 10.16–16.31), respectively.

Of the total study population, the majority, 376 (37.01%), were in the age group 41–50 years, and the minimum number of participants was present in the age group 51–60 years (26.18%). The maximum prevalence (18.42%, 95% CI: 13.95–23.61) of diabetic adults was in the 51–60 years age group, whereas the minimum prevalence (7.75%, 95% CI: 5.25; 10.95) was in the 61–70 years age group.

Among the total study participants, 443 (43.61%) were overweight, and 56 (5.51%) were obese. The prevalence of diabetic adults with undernutrition and normal BMI category is 13.59% (95% CI: 7.63; 21.75) and 14.25% (95% CI: 11.03; 17.99), respectively. Besides this, the prevalence of diabetic adults with overweight and obese BMI categories is 12.64% (95% CI: 9.69; 16.10) and 5.36% (95% CI: 1.12; 14.87), respectively.

Furthermore, the study explored the neck circumference and the prevalence of diabetes among studied participants. It was notable that the mean neck circumference of the diabetic group (39.2 ± 3.5 cm) was significantly more than that of the nondiabetic group

**Table 1:** Significance of the sex difference between various parameters (*n* = 1016)

| *Parameters* | *Males (mean ± SD)* | *Females (mean ± SD)* |
|---|---|---|
| Age (years) | 56.35 ± 8.52 | 55.97 ± 8.68 |
| Stature (cm) | 156.97 ± 7.22 | 154.15 ± 7.07 |
| Weight (kg) | 55.19 ± 7.49 | 52.21 ± 8.02 |
| BMI (kg/m$^2$) | 22.42 ± 2.93 | 21.93 ± 2.87 |
| Neck circumference (cm) | 39.5 ± 3.7 | 37.8 ± 3.1 |
| FBG (mg/dL) | 105.41 ± 28.66 | 104.59 ± 23.01 |

**Table 2:** Prevalence of diabetes according to age, sex, BMI categories, neck circumference and OSA risk level (*n* = 1016)

| *Parameters* | *Number (%)* | *Diabetic (%)* | *Prevalence (%)* | *95% CI* | *p-value* |
|---|---|---|---|---|---|
| Sex | | | | | |
| Male | 524 (51.57) | 68 (51.52) | 12.98 | 10.22 to 16.16 | 0.9866 |
| Female | 492 (48.43) | 64 (48.48) | 13.01 | 10.16 to 16.31 | |
| Age group (years) | | | | | |
| 41–50 | 376 (37.01) | 54 (40.91) | 14.36 | 10.98 to 18.32 | 0.0002 |
| 51–60 | 266 (26.18) | 49 (37.12) | 18.42 | 13.95 to 23.61 | |
| 61–70 | 374 (36.81) | 29 (21.97) | 7.75 | 5.25 to 10.95 | |
| BMI | | | | | |
| Undernutrition | 103 (10.14) | 14 (10.61) | 13.59 | 7.63 to 21.75 | 0.2650 |
| Normal | 414 (40.74) | 59 (44.69) | 14.25 | 11.03 to 17.99 | |
| Overweight | 443 (43.61) | 56 (42.42) | 12.64 | 9.69 to 16.10 | |
| Obese | 56(5.51) | 3 (2.28) | 5.36 | 1.12 to 14.87 | |
| Neck circumference (cm) | | | | | |
| <38 | 668 (65.7) | 60 (45.45) | 8.98 | 6.84 to 11.91 | 0.0001 |
| >38 | 348(34.3) | 72 (54.55) | 20.69 | 17.13 to 24.52 | |
| OSA risk levels | | | | | |
| Low | 612 (60.2) | 59 (43.39) | 9.66 | 7.53 to 12.11 | 0.0003 |
| Intermediate | 286 (28.2) | 54 (39.13) | 18.88 | 14.58 to 24.28 | |
| High | 118 (11.6) | 19 (17.96) | 16.10 | 10.82 to 23.62 | |

**Table 3:** Correlation between body mass index, neck circumference, OSA risks and diabetes of participants ($n$ = 1016)

| *BMI categories* | *Diabetic n (%)* | *Glycemic status* | | *p-value* | *r-value* |
|---|---|---|---|---|---|
| | | *Prediabetic n (%)* | *Nondiabetic n (%)* | | |
| Undernutrition | 14 (10.61) | 41 (10.91) | 48 (9.45) | 0.009 | 0.99 |
| Normal | 59 (44.69) | 153 (40.69) | 202 (39.76) | | |
| Overweight | 56 (42.43) | 160 (42.55) | 227 (44.68) | | |
| Obese | 3 (2.27) | 22 (5.85) | 31 (6.11) | | |
| Neck circumference (cm) | | | | | |
| <38 | 60 (45.45) | 173 (46.01) | 435 (85.63) | 0.0001 | 0.52 |
| >38 | 72 (54.55) | 203 (53.99) | 73 (14.37) | | |
| OSA risk levels | | | | | |
| Low | 59 (43.39) | 154 (40.96) | 399 (78.57) | 0.0003 | 0.48 |
| Intermediate | 54 (39.13) | 141 (37.5) | 91 (17.91) | | |
| High | 19 (17.96) | 81 (21.54) | 18 (3.52) | | |

(37.8 ± 3.0 cm). Statistical analysis revealed a significant positive correlation ($r$ = 0.52, $p$ < 0.01) between neck circumference and prevalence of diabetes.

In addition, the association between obstructive sleep apnea (OSA) risk levels and prevalence of diabetes was analyzed. Participants were categorized into low risk, intermediate risk, and high risk for OSA. The analysis revealed that participants with high OSA risk levels had a higher prevalence of diabetes (16.10%, 95% CI: 10.82; 23.62) compared to those with low (9.66%, 95% CI: 7.53; 12.11) and intermediate (18.88%, 95% CI: 14.58; 24.28) risk levels. A statistically significant correlation ($r$ = 0.48, $p$ < 0.01) was observed between OSA risk levels and prevalence of diabetes among studied participants.

Table 3 shows the correlation between BMI, neck circumference, and the prevalence of diabetes among studied participants. A statistically significant correlation was observed between body mass index and diabetes. The r value shows a significant correlation between body mass index and diabetes. Similarly, a significant correlation was found between neck circumference and the prevalence of diabetes.

## Discussion

The findings of this cross-sectional study provide essential information on the existence of diabetes mellitus among adults in Kolkata, West Bengal, and their link with body mass index (BMI), neck circumference, and Obstructive Sleep Apnea (OSA) risk levels. The observed prevalence rates of diabetes in this population (12.98% in males and 13.01% in females) mirror the worldwide trend of the diabetes burden rising, especially in urban areas where lifestyles shift rapidly. These results reinforce the vital importance of implementing public health measures geared toward the prevention and management of diabetes in urban India, in particular, Kolkata.

The distribution of diabetes prevalence by age shows interesting trends; the greatest prevalence is registered in the age-group 51–60 years. The middle-aged group also included the highest proportion of participants, demonstrating that middle-aged adults are especially vulnerable to diabetes in this community. These results stress the need for targeted screening and intervention strategies that aim at different age groups, especially with the increasing prevalence of diabetes worldwide among the younger age cohorts.

This study provides evidence of the association between BMI and diabetes. Obesity was found to be related to diabetes in this study, confirming the role of obesity as an important risk factor for diabetes development. Diabetes was more common among people whose BMI was overweight or obese as compared to those with normal or underweight BMI categories. This is a testimony to the seriousness of obesity prevention and management strategies in solving the problem of diabetes in cities such as Kolkata.

The distribution of diabetic, prediabetic, and nondiabetic participants in various BMI categories reveals the importance of the need for targeted preventive measures. Programs aimed at promoting a healthy lifestyle that includes regular physical activity and balanced nutrition are the key to preventing obesity and diabetes in these people. Besides, the early identification of people who are prone to diabetes through routine screening using BMI will provide the chance for timely intervention and management, potentially avoiding the long-term complications associated with the disease.

Several studies have revealed that neck circumference is another important anthropometric measurement that is significantly associated with the prevalence of diabetes. The diabetic group showed greater neck circumference compared with their nondiabetic counterparts. This indicates that neck circumference can be one of the useful indicators for diabetes risk assessment, probably due to its association with upper body adiposity and insulin resistance.

This study further showed that there is a significant relationship between diabetes prevalence and the levels of OSA risk. The prevalence of diabetes among the participants at high risk for OSA was higher than among those either at low or intermediate risk. Such a correlation might indicate that OSA contributes to the development or worsening of diabetes risk via intermittent hypoxia and resultant metabolic disturbances. This strong positive association of risk between OSA and diabetes would, therefore, underline the imperative requirement for comprehensive screening and management strategies addressing the two conditions together.

In the context of prevention and management, it is not only weight management that will be important but also addressing sleep disorders to reduce the overall burden of diabetes. Public health interventions need to be age- and risk-profile-specific, with regular screening for diabetes and obesity, with OSA enabling early detection and effective management.

## Conclusion

In conclusion, the data in this research illustrate the prevalence of diabetes mellitus and its relation with BMI, neck circumference, and

OSA risk levels among adults in Kolkata, West Bengal. The results highlight the urgent need for multifaceted public health approaches that include diabetes prevention and management in urban India, focusing on lifestyle modifications to deal with obesity-related risk factors. Appropriate interventions targeted at different age groups and BMI categories should be instrumental in reducing the diabetes burden and overall population health in this setting.

Further research is required to identify the additional risk factors for diabetes and also evaluate various integrated intervention programs for their effectiveness. Multifactorial interventions will be required for combating the rising prevalence of diabetes and improving public health in urban India.

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