Original Article

Obstructive sleep apnea risk among adults with type 2 diabetes mellitus in an urban primary care setting of Mangalore, India

Anusha Narayan[1], Pracheth Raghuveer[2]

[1]Department of Anaesthesia, S Nijalingappa Medical College, Bagalkot, Karnataka, India, [2]Department of Epidemiology, National Institute of Mental Health and Neuro Sciences (NIMHANS), An Institute of National Importance, Bengaluru, Karnataka, India

Abstract

Background: Obstructive sleep apnea (OSA) is an under-evaluated and under-treated problem, particularly among individuals with type 2 diabetes mellitus (T2DM). Therefore, in this study, we aim to determine the risk of OSA among adults with T2DM residing in an urban area of Mangalore and to elucidate the determinants of OSA among the study participants. **Materials and Methods:** A cross-sectional study was conducted for a period of 2 months among adult patients (≥ 18 years) with T2DM seeking health care at a primary care setting located in an urban area of Mangalore. Face-to-face interviews were conducted using a semi-structured proforma. STOP-BANG questionnaire was used to assess the risk of OSA among the study participants. The measurements, such as height, weight, and neck circumference, were conducted using standard techniques. **Results:** The mean age of the study participants was 58.12 ± 11.60 years. The majority, (58.30%), were males, and 45.0% reported a family history of T2DM. A total of 108 (60.0%) experienced loud snoring while asleep, while 149 (82.80%) experienced tiredness during daytime. The mean body mass index (BMI) was 24.64 ± 4.9 kg/m^2, while a neck circumference of >40 cms was found in 28.90%. A total of 69 (38.30%) had a high risk of OSA with a STOP-BANG score ranging from 5 to 8, while 71 (39.40%) had a score ranging from 3 to 4 (intermediate risk). The statistically significant associations were found between age >50 years, male gender, and diabetes for ≥ 7 years and high risk of OSA ($P < 0.001$). **Conclusion:** More than a third of the study participants had a high risk of OSA. Age > 50 years, male gender, and diabetes for ≥7 years were the factors associated with OSA.

Keywords: Diabetes Mellitus, obstructive sleep apnea, primary care, sleep

Introduction

Sleep is a complex biological state characterized by changes in the behavioral, physiological, and electrophysiological parameters. Among the disorders of sleep, sleep-disordered breathing (SDB) events are an umbrella term for disorders that comprise a number of sleep-related breathing disturbances. Obstructive sleep apnea (OSA) is regarded as one such SDB problem. OSA is a prevalent medical problem affecting nearly 2–30% of individuals and may affect all age-groups.[1] OSA manifests as repeated complete or partial occlusion of the upper airway during sleep.[2] This causes hypoxia resulting in frequent arousals, which eventually result in sleep fragmentation and symptoms of excessive daytime sleepiness.[3] OSA is estimated to affect 936 million adults aged 30–69 years worldwide. Although the condition is simple to ignore, it can seriously harm the target organ.[4] It is currently recognized as an important health issue that can affect a variety of organs in the cardiovascular, neurologic, respiratory, and endocrine systems.

Address for correspondence: Dr. Pracheth Raghuveer, Department of Epidemiology, National Institute of Mental Health and Neuro Sciences (NIMHANS), An Institute of National Importance, Bengaluru, Karnataka, India.
E-mail: prach1986@gmail.com

Received: 20-01-2024 **Revised:** 20-03-2024
Accepted: 01-04-2024 **Published:** 26-07-2024

Access this article online

Quick Response Code:

Website: http://journals.lww.com/JFMPC

DOI: 10.4103/jfmpc.jfmpc_105_24

How to cite this article: Narayan A, Raghuveer P. Obstructive sleep apnea risk among adults with type 2 diabetes mellitus in an urban primary care setting of Mangalore, India. J Family Med Prim Care 2024;13:3264-9.

Research has shown that OSA, even if asymptomatic, may lead to increased morbidity and mortality.[5,6]

Diabetes mellitus (DM) is a chronic illness, which has been increasing in epidemic proportions worldwide. DM affects an estimated 10.5% of adults worldwide, and about 6.7 million deaths are attributed to DM annually of which type 2 diabetes mellitus (T2DM) constitutes up to 90% of all the deaths.[7] In India alone, the prevalence of T2DM is estimated to be around 70 million, which amounts to 8.7% of the population.[8] It has been found through studies that obesity, older age, and male gender are the significant risk factors which may contribute to the development of OSA.[9] T2DM is also known to be a pre-disposing factor for OSA with insulin resistance being the mechanism responsible for the association. Additionally, some studies also state that OSA and T2DM are bidirectional, that is, OSA can predispose to insulin resistance and T2DM as well.[10,11] Furthermore, research highlights effective treatment of OSA in individuals with T2DM.[12,13]

There is a growing body of evidence which establishes the link between OSA and T2DM.[10-14] However, OSA still remains an under-evaluated and under-treated problem, particularly among persons with T2DM. Besides, there exists a gap in research which addresses this association between OSA and T2DM, especially in Indian settings. Large discrepancies between expected and diagnosed cases of OSA in T2DM have been reported, suggesting that the majority of persons at risk for OSA are not being identified. Furthermore, the problem of OSA among persons with T2DM is relevant to family medicine and primary care practice. Primary care settings present an opportunity to screen persons who seek care for non-communicable diseases (NCDs), such as T2DM, for sleep disorders, such as OSA. Hence, we conducted this study to assess the prevalence and factors associated with OSA among adults with T2DM residing in an urban area of Mangalore, India.

Materials and Methods

This cross-sectional study was conducted for a period of 6 months (July 2017 to January 2018), in an Urban Health Training Center (UHTC) at Mangalore. The UHTC serves an underserved area named Bunder, which is inhabited by more than 3,200 families with a total population of 21,541 and 3,964 households. During the data collection period, a total of 4,680 patients sought health care at the UHTC, of which 348 (7.43%) were for T2DM.

Adults aged ≥18 years, residing in Bunder for ≥6 months with documented evidence of diagnosis and treatment prescribed for T2DM by a medical doctor, participated in the study after providing informed consent. Persons with other types of diabetes, such as type 1 diabetes mellitus (T1DM), secondary diabetes, and gestational diabetes, pregnant women, those with substance dependence, neurological disorders affecting sleep, severe intellectual difficulties, known psychiatric morbidity that interfered with their participation in the study, and persons who underwent neurosurgical procedures in the last 3 years were excluded. Convenience sampling was applied to select the study participants. The calculation of sample size was based on the formula: $n = Z^2*p*q/e^2$.[15] Here, n is the required sample size, and Z is the standard normal deviation, which is equal to 1.96 at 5% significance level. The prevalence of OSA among adults with T2DM, "p," was taken as 40.0%.[16] The permissible error in the estimate of p: "e" was set at 20%. Using this formula which considers 95% confidence limits and in addition to a 10% non-response error, the sample size was estimated to be 180 adults with T2DM. A pilot study was conducted among 20 persons with T2DM to assess the feasibility. Appropriate modifications were made in the study proforma based on the pilot study. The findings of the pilot study were not included in the main analysis.

Initially, a house-to-house survey was conducted in the study area to determine the number of adults with T2DM fulfilling the inclusion criteria. Those who fulfilled the eligibility criteria and gave consent were invited to participate in the study which was conducted in the UHTC located in the study area. This was because the data collection involved taking anthropometric measurements using standardized instruments present in the UHTC. It was not feasible for us to carry the instruments to the community. At the UHTC, the eligibility was reassessed and necessary exclusions were made.

A pre-designed, structured proforma was used to collect the appropriate information after validation by three research experts. The proforma contained details related to socio-demographic profile, such as age, gender, residence, education, working status, economic status, family type, information pertaining to duration of diabetes, medications used, presence of complications, and history of comorbid conditions, such as hypertension, dyslipidemia, ischemic heart disease, asthma, chronic bronchitis, and a family history of T2DM. The STOP-BANG questionnaire, which is a scoring model consisting of eight easily administered questions, starting with the acronym STOP-BANG, was used to predict OSA among the study participants.[17] The questionnaire consists of Yes/No answers, with a score of 1.0 for each Yes. Thus, the scores range from a value of 0 to 8. The accuracy of the STOP-BANG questionnaire has been validated by polysomnography (PSG)—the gold standard for diagnosing OSA.[18] Standard procedures were used to translate the proforma into the local language (Kannada). The weight and height of the study participants were measured using standard procedures and calibrated instruments (accuracy: up to 100 grams for weight and 0.1 cm for height) following which body mass index (BMI) was also calculated. As per the STOP-BANG, if the BMI > 35 kg/m^2, one point needs to be given while measuring the risk, and this was the basis for considering a participant as obese in this study.[18] Blood pressure was examined using an Aneroid Dial Type Sphygmomanometer. Before taking the measurements, the study participants were requested to sit quietly and rest for 5 minutes. Three readings of the systolic and diastolic blood

pressure were taken with 3-minute rest between each reading, and the means of second and third readings were used for analysis. If the difference between the two readings was greater than 10 mm Hg, the measurements were taken again. Conventional bladder cuff measuring 12–13 cm wide and 35 cm long was used. The arm and back were supported, while the cuff was positioned at the level of the heart. Phase I and V (sudden reduction/disappearance) Korotkoff sounds were used in auscultatory procedures to determine systolic and diastolic blood pressure, respectively.[19] Neck circumference was measured at the middle of the neck between the mid-cervical spine and the superior line of the cricothyroid membrane in standing position using a measuring tape.[20]

The student principal investigator who collected the data was trained by the guide/co-principal investigator and a subject expert, before the commencement of the study. Additionally, 10% of the interviews conducted by the student were cross-checked on-site by the guide for completeness and adherence to the study protocol, and supportive supervision was ensured. For quality control during data collection, double data entry and cross-checking were conducted.

Data were compiled and analyzed using the International Business Machine (IBM) Statistical Package for Social Sciences (SPSS) Statistics for Windows, version 23 (IBM Corp., Armonk, New York, USA). Continuous variables were expressed in terms of means and standard deviation. Frequencies and proportions were used to express categorical variables. The Chi-square test was applied to find out the association between the study variables and the presence of OSA. A P value of < 0.05 was considered as the criterion for statistical significance.

The approval from the Institutional Ethics Committee was obtained before conducting the study. Detailed information pertaining to the nature, objectives of the study, and test procedures was provided to the study participants, and written informed consent was obtained. The anonymity of the study participants was ensured. Strict confidentiality of the information collected was maintained. The study participants found to have high risk of OSA on screening were referred to the medical college hospital for further management.

Results

A total of 180 adults with T2DM participated in the study. The mean age of the study participants was 58.12 ± 11.60 years, and more than half (58.30%) were men. Most of the study participants, 170 (94.40%), were on medications for T2DM. The socio-demographic and morbidity profiles of the study participants are depicted in Table 1.

On analysis of the various components of the STOP-BANG questionnaire, 108 (60%) revealed that they snore loudly while asleep, which they considered louder than talking loud enough to be heard through closed doors. A high percentage (82.80%) felt tired or fatigued or sleepy during daytime. Nearly 29.0% revealed that someone had observed that their breathing had stopped during sleep. More than half (52.80%) were either diagnosed or treated for hypertension. The mean BMI of the study participants was 24.64 ± 4.9 kg/m^2, while the mean neck circumference was 37.71 ± 3.22 cms. A total of 52 (28.90%) had neck circumference of >40 cms [Table 2].

Table 1: Socio-demographic and morbidity profile of the study participants (n=180)

Socio-demographic factors	Numbers (n=180)	Percentage
Age in years		
<60 years	91	50.60
≥60 years	89	49.40
Gender		
Men	105	58.30
Women	75	41.70
Education		
Up to primary school	99	55.0
Beyond primary school	81	45.0
Occupation		
Currently employed	87	45.79
Not employed at present	93	54.21
Marital status		
Married	150	83.30
Widowed/separated/unmarried	30	16.70
Socio-economic status[†]		
Class I	60	33.30
Class II	21	11.70
Class III	31	17.20
Class IV	42	23.30
Class V	26	14.40
Duration of diabetes		
<7 years	101	56.10
≥7 years	79	43.90
Medication status for diabetes		
On medication	170	94.40
Not on medication	10	5.60
Family history of diabetes	‘	
Present	81	45.0
Absent	99	55.0

[†]Modified BG Prasad Classification, August 2017

Further, the mean STOP-BANG score was 3.87 ± 1.65. A total of 69 (38.30%) had high risk of OSA and had an STOP-BANG score ranging from 5 to 8 [Figure 1].

A total of 45 (50.60%) study participants aged ≥60 years had a high risk of OSA, while 24 (26.40%) study participants aged <60 years had high risk of OSA. A statistically significant association was found ($P < 0.001$). Further, a significant association was found between high risk of OSA among those who had T2DM <7 years and among those study participants who had T2DM for a duration of ≥7 years ($P < 0.001$). The factors associated with high risk of OSA are presented in Table 3.

Discussion

We undertook this study to find out the prevalence and factors

associated with OSA among adults with T2DM residing in an urban area. We used the STOP-BANG questionnaire to screen the study participants for OSA and quantify the risk as high, intermediate, and low. The STOP-BANG questionnaire is well-recognized as a reliable OSA screening tool that is both simple and self-reported. The validity of this method is evidenced in several systemic reviews. Timofticiuc *et al.*[21] have reported in their study that the STOP-BANG score can be used in patients with diabetes to detect severe OSA, with the test having a sensitivity of 88.2% and a specificity of 62.9%. We found a high proportion, (38.30%) to be at high risk for OSA. Studies conducted elsewhere reported the prevalence of OSA among persons with T2DM to be ranging from 30 to 68.4%.[22-25] In Canada, Chung *et al.*[22] subjected 746 persons with T2DM to STOP-BANG questionnaire assessment and PSG. OSA was present in 68.4% with 29.9% mild, 20.5% moderate, and 18.0% severe OSA. The prevalence of OSA in persons with T2DM was 58% in the Sleep Heart Study that included older individuals, used self-reported diabetes, and an oxygen desaturation threshold of at least 4% for defining hypopneas.[23] In the multi-centric Sleep Action for Health in Diabetes (Sleep AHEAD) study,

Table 2: Responses to the various components of the STOP-BANG questionnaire (*n*=180)

STOP-BANG	Numbers (*n*=180)	Percentage
Loud snoring		
Yes	108	60.0
No	72	40.0
Tiredness during daytime		
Yes	149	82.80
No	31	17.20
Stoppage of breathing while asleep		
Yes	52	28.90
No	128	71.10
Diagnosed/treated for hypertension		
Yes	95	52.80
No	85	47.20
Body mass index >35 kg/m^2		
Yes	7	3.90
No	173	96.10
Neck circumference >40 cms		
Yes	52	28.90
No	128	71.10
Male gender		
Yes	105	58.30
No	75	41.70

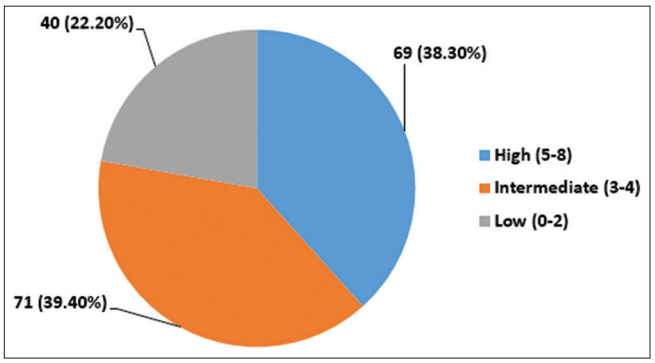

Figure 1: Risk of obstructive sleep apnea among the study participants (n = 180)

Table 3: Factors associated with obstructive sleep apnea risk among the study participants (*n*=180)

Study variables	High risk of OSA (*n*=69) (%)	Intermediate + low OSA risk (*n*=111) (%)	Total	$\chi^{2\dagger}$	df	*P*
Age in years						
≤50	60 (47.60%)	66 (52.30%)	126	15.32	1	<0.001††
50	09 (16.70%)	45 (83.30%)	54			
Gender						
Women	17 (22.70%)	58 (77.30%)	75	13.35	1	<0.001††
Men	52 (49.50%)	53 (50.50%)	105			
Education						
Up to primary school	42 (42.40%)	57 (57.60%)	99	1.56	1	0.212
Beyond primary school	27 (33.30%)	54 (66.70%)	81			
Occupation						
Employed at present	28 (32.18%)	59 (67.82%)	87	2.21	1	0.137
Not employed at present	41 (44.08%)	52 (55.92%)	93			
Socio-economic status†††						
Class I	26 (43.33%)	34 (56.70%)	60	3.69	2	0.158
Class II + Class III	23 (44.20%)	29 (55.80%)	52			
Class IV + Class V	20 (29.40%)	48 (70.60%)	68			
Duration of T2DM						
<7 years	28 (22.70%)	73 (72.30%)	101	10.96	1	<0.001††
≥7 years	41 (51.90%)	38 (48.10%)	79			
Family history of T2DM						
Present	27 (33.30%)	54 (66.70%)	81	1.56	1	0.212
Absent	42 (42.40%)	57 (57.60%)	99			
Hypertension						
Present	58 (61.10%)	37 (38.90%)	88	43.93	1	<0.001††
Absent	11 (12.90%)	74 (87.10%)				

†Chi-square test, ††Statistically significant (*P*<0.05), †††Modified BG Prasad Classification, August 2017

the prevalence of OSA among obese persons with T2DM was reported to be 86%.[26] In another study, the prevalence of OSA in persons with T2DM was found to be 77% using a cut-off of 3% for oxygen desaturations, and when the dataset was reanalyzed using a stricter 4% criteria, this figure decreased to 58%. Similarly, a high prevalence of OSA was observed in adults with T2DM, ranging from 48% (Apnea-hypopnea Index: AHI ≥10) to 29% (AHI ≥20) in another study.[24] In another recent study, at least one-third of people with T2DM referred to a diabetes clinic in Denmark were found to have symptomatic OSA.[25]

There appears to be a paucity of Indian studies on OSA among adults, particularly using the STOP-BANG questionnaire as a screening tool. Agrawal *et al.*[26] in Dehradun, India, used the STOP-BANG questionnaire to screen patients scheduled for elective surgical procedures for OSA and found that 24.50% had a high risk for OSA. A study conducted in Delhi, India, used the Berlin questionnaire to find out the prevalence of OSA in T2DM. Among the 325 persons with T2DM, the prevalence of OSA in T2DM was found to be 24.3% (males 28% and females 19.9%).[10] Another study conducted in Bengaluru, India, attempts to describe the occurrence of OSA among patients with myocardial infarction (MI). Sleep studies were conducted on the patients using PSG to quantify SDB. OSA was diagnosed in 28.60% of the patients.[27]

Age >50 years, male gender, T2DM duration of ≥7 years, and presence of hypertension were the factors significantly associated with OSA. One of the studies undertaken stated a significant association between age and risk of OSA with the risk being higher in age-group >50 years similar to the findings of this study.[28] A study conducted in China showed that OSA was not significantly associated with gender, which was in contrast to the findings of the study.[29] The findings from an Indian study conducted in Delhi reported OSA to be not just restricted to obese individuals but to non-obese individuals as well. However, the severity was found to be less in non-obese individuals and the prevalence of diabetes was higher in the obese group.[30] The association between hypertension and high risk of OSA was significant in a study from Korea. This study also reported that when hypertension, DM, and obesity were combined, the risk increased synergistically (OR = 3.88).[31] Some studies have also found that the association of OSA with DM is bidirectional.[10,11] The mechanism stated was that sleep disorders lead to insulin resistance and beta-cell dysfunction that play a significant role in the development of T2DM in those with sleep disorders.[32] Aurora *et al.*[33] reported the bidirectional link between OSA and T2DM and concluded that early identification of OSA in patients with metabolic dysfunction—including T2DM—and assessment for metabolic abnormalities in those with OSA could reduce cardiovascular disease risk and improve the quality of life of patients.

Our study is not devoid of limitations. Firstly, as this study was conducted in a resource-constrained primary care setting, we could not conduct PSG among the study participants and accurately determine the prevalence of OSA. Secondly, there may be an element of bias, owing to poor recall of a few symptoms among the study participants, while answering the STOP-BANG questionnaire. Third, confounder-adjusted estimates could not be calculated, considering the low sample size.

However, despite these drawbacks, the study provides valuable insights into the issue of OSA among individuals with T2DM. The strength of this study lies in its novelty. This study highlights an underdiagnosed issue with serious implications, particularly in the vulnerable population, such as individuals with T2DM. As mentioned previously, there have been very few studies on OSA conducted in an Indian population. Moreover, STOP-BANG approach which has been used in this study could be used as an easy-to-administer and brief screening tool to determine risk of OSA in primary care settings, which could be further diagnosed by the confirmatory PSG in advanced settings. Further, the participants who were found to have a high risk of OSA were referred to the medical college hospital for further evaluation and management. Thus, this study is a good attempt to screen diabetics for OSA in a resource-constrained setting and could pave the way for the development of a stepped-care model for OSA care.

This study could lay the foundations for further large-scale community-based studies to assess the prevalence of OSA among T2DM and the general population. The development of community-based strategies to intervene and manage OSA among vulnerable population, such as individuals with diabetes, should be encouraged. Implementation research to evaluate the feasibility and effectiveness of such interventions needs to be conducted.

Conclusion

The study highlights the risk of OSA among the 180 participants screened using the STOP-BANG questionnaire. Nearly 38.30% were found to have high risk of OSA, with 39.20% and 22.20% having intermediate and high risk of OSA, respectively. This study concludes that age >50 years, male gender, presence of hypertension, and duration of diabetes ≥7 years were significantly associated with a high risk of OSA. We recommend mandatory screening for sleep disorders, such as OSA, among persons with diabetes. Further, large-scale studies on this topic are needed.

Acknowledgements

We would like to acknowledge the Department of Community Medicine, Yenepoya Medical College, for encouraging student research. We also extend our gratitude to Dr. Meenakshi Jayabalan, MPH Scholar, Department of Epidemiology, NIMHANS, Bengaluru, for her assistance.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Karna B, Sankari A, Tatikonda G. Sleep disorder. [Updated 2023 Jun 11]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2024. Available from: https://www.ncbi.nlm.nih.gov/books/NBK560720/. [Last accessed on 2024 Jan 02].
2. Abbasi A, Gupta SS, Sabharwal N, Meghrajani V, Sharma S, Kamholz S, *et al.* A comprehensive review of obstructive sleep apnea. Sleep Sci 2021;14:142-54.
3. Stamatakis KA, Punjabi NM. Effects of sleep fragmentation on glucose metabolism in normal subjects. Chest 2010;137:95-101.
4. Benjafield AV, Ayas NT, Eastwood PR, Heinzer R, Ip MSM, Morrell MJ, *et al.* Estimation of the global prevalence and burden of obstructive sleep apnoea: A literature-based analysis. Lancet Respir Med 2019;7:687–98.
5. Rana D, Torrilus C, Ahmad W, Okam NA, Fatima T, Jahan N. Obstructive sleep apnea and cardiovascular morbidities: A review article. Cureus 2020;12:e10424.
6. Heilbrunn ES, Ssentongo P, Chinchilli VM, Oh J, Ssentongo AE. Sudden death in individuals with obstructive sleep apnoea: A systematic review and meta-analysis. BMJ Open Respir Res 2021;8:e000656.
7. Magliano DJ, Boyko EJ; IDF Diabetes Atlas 10th edition scientific committee. IDF DIABETES ATLAS. 10th edition. Brussels: International Diabetes Federation; 2021. Chapter 3, Global picture. Available from: https://www.ncbi.nlm.nih.gov/books/NBK581940/. [Last accessed on 2024 Jan 02].
8. Pradeepa R, Mohan V. Epidemiology of type 2 diabetes in India. Indian J Ophthalmol 2021;69:2932-8.
9. Jehan S, Zizi F, Pandi-Perumal SR, Wall S, Auguste E, Myers AK, *et al.* Obstructive sleep apnea and obesity: Implications for public health. Sleep Med Disord 2017;1:00019.
10. Rajan P, Greenberg H. Obstructive sleep apnea as a risk factor for type 2 diabetes mellitus. Nat Sci Sleep 2015;7:113-25.
11. Muraki I, Wada H, Tanigawa T. Sleep apnea and type 2 diabetes. J Diabetes Investig 2018;9:991-7.
12. Malik JA, Masoodi SR, Shoib S. Obstructive sleep apnea in Type 2 diabetes and impact of continuous positive airway pressure therapy on glycemic control. Indian J Endocrinol Metab 2017;21:106-12.
13. Laursen DH, Rom G, Banghøj AM, Tarnow L, Schou L. improving diabetes self-management by providing continuous positive airway pressure treatment to patients with obstructive sleep apnea and type 2 diabetes: Qualitative exploratory interview study. JMIR Form Res 2021;5:e27062.
14. Nannapaneni S, Ramar K, Surani S. Effect of obstructive sleep apnea on type 2 diabetes mellitus: A comprehensive literature review. World J Diabetes 2013;4:238.
15. Mahajan BK. Sampling. In: Mahajan BK, editor. Methods in Biostatistics. 7th ed. New Delhi: M/S Jaypee Brothers; 2010. p. 80-93.
16. Robert E, Suri JC, Singh C, Sen MK, Gupta A. Prevalence of obstructive sleep apnea in Type 2 diabetes mellitus. Indian J Sleep Med 2010;5:18-26.
17. Chung F, Abdullah HR, Liao P. STOP-Bang Questionnaire: A practical approach to screen for obstructive sleep apnea. Chest 2016;149:631-8.
18. Chung F, Yegneswaran B, Liao P, Chung SA, Vairavanathan S, Islam S, *et al.* STOP questionnaire: A tool to screen patients for obstructive sleep apnea. Anesthesiology 2008;108:812-21.
19. Rehman S, Hashmi MF, Nelson VL. Blood pressure measurement. [Updated 2022 Dec 28]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2024. Available from: https://www.ncbi.nlm.nih.gov/books/NBK482189/. [Last accessed on 2024 Jan 01].
20. Raju A, Santhanakrishnan N, Sathiyaseelan M. Neck circumference is associated with general and central obesity in young Indian adults. Indian J Community Med 2023;48:264-8.
21. Timofticiuc DCP, Vladu IM, Stefan AG, Forțofoiu MC, Mitrea A, Fortofoiu M, *et al.* Stop-Bang Questionnaire – An Easy Tool for Identifying Obstructive Sleep Apnea Syndrome in Patients with Type 2 Diabetes Mellitus. Acta Endocrinologica (Bucharest) 2022;18:49–57.
22. Chung F, Subramanyam R, Liao P, Sasaki E, Shapiro C, Sun Y. High STOP-bang score indicates a high probability of obstructive sleep apnea. Survey Anesthesiol 2012;56:312.
23. Gottlieb D, Yenokyan G, Newman A, O'Connor G, Punjabi N, Quan S, *et al.* prospective study of obstructive sleep apnea and incident coronary heart disease and heart failure: The sleep heart health study. Circulation 2010;122:352-60.
24. Aronsohn RS, Whitmore H, Van Cauter E, Tasali E. Impact of untreated obstructive sleep apnea on glucose control in type 2 diabetes. Am J Respir Crit Care Med 2010;181:507–13.
25. Jacobsen AR, Eriksen F, Thorup L, Skødeberg LB, Holm JPY, Hansen KW. Newly diagnosed obstructive sleep apnoea and type 2 diabetes mellitus. Dan Med J 2017;64:A5390.
26. Agrawal S, Gupta R, Lahan V, Mustafa G, Kaur U. Prevalence of obstructive sleep apnea in surgical patients presenting to a tertiary care teaching hospital in India: A preliminary study. Saudi J Anaesth 2013;7:155.
27. Devaraj U, Ramachandran P, D'souza G. Obstructive sleep apnea in patients with myocardial infarction: Experience from a tertiary care hospital in South India. Heart India 2013;1:12.
28. Shnaimer JA, Dahlan HM, Hanbashi FM, Bahammam AS, Gosadi IM. Assessment of the risk of obstructive sleep apnoea among patients with type 2 diabetes and its associated factors using the STOP-BANG questionnaire: A cross-sectional study. J Taibah Univ Med Sci 2022;17:606–13.
29. Wang C, Tan J, Miao Y, Zhang Q. Obstructive sleep apnea, prediabetes and progression of type 2 diabetes: A systematic review and meta-analysis. J Diabetes Investig 2022;13:1396-411.
30. Kumar P, Rai DK, Kanwar MS. Comparison of clinical and polysomnographic parameters between obese and nonobese obstructive sleep apnea. J Family Med Prim Care 2020;9:4170.
31. Huh G, Do Han K, Park YM, Park CS, Lee KN, Lee EY, *et al.* Comorbidities associated with high-risk obstructive sleep apnea based on the STOP-BANG questionnaire: A nationwide population-based study. Korean J Int Med 2023;38:80.
32. Paschou SA, Bletsa E, Saltiki K, Kazakou P, Kantreva K, Katsaounou P, *et al.* Sleep apnea and cardiovascular risk in patients with prediabetes and type 2 diabetes. Nutrients 2022;14:4989.
33. Aurora RN, Punjabi NM. Obstructive sleep apnoea and type 2 diabetes mellitus: A bidirectional association. Lancet Respir Med 2013;1:329-38.