Risk of Obstructive Sleep Apnea and Sleep Quality Among Persons with Type 2 Diabetes Mellitus*

ความเสี่ยงของภาวะหยุดหายใจขณะนอนหลับจากการอุดกั้นและคุณภาพการนอนหลับของผู้ที่เป็นโรคเบาหวานชนิดที่ 2*

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Abstract

Type 2 diabetes mellitus (T2DM) is a chronic condition which is prevalent worldwide. Sleep quality and the risk of obstructive sleep apnea (OSA) can impact the health outcomes and quality of life of individuals with T2DM. This descriptive study aimed to explore the risk of OSA and sleep quality, and to investigate the differences in sleep quality among T2DM individuals with different OSA risks. The participants consisted of 384 individuals with T2DM from two tertiary hospitals in Jinghong City, Yunnan Province, China. The Chinese Pittsburgh Sleep Quality Index (CPSQI) and the Chinese STOP-BANG questionnaire (CSBQ) were used to measure the sleep quality and risk of OSA, respectively. The reliability of CPSQI and CSBQ were 0.88 and 0.95, respectively. Descriptive statistics and chi-square analysis were used for data analysis.

The results indicated that among the participants with T2DM, 33.85% were at low risk, 34.64% were at intermediate risk, and 31.51% were at high risk for OSA. The mean global score for PSQI was 7.71 (SD 4.40). About 50.78% of the participants had poor sleep quality. Furthermore, sleep quality significantly differed at each risk level of OSA among individuals with T2DM ($p < .001$).

Healthcare professionals should consider assessing and managing sleep-related issues as an integral part of T2DM care. Future research should focus on developing effective interventions to improve sleep quality and reduce the risk of OSA in this population.

Keywords: Type 2 diabetes mellitus; Obstructive sleep apnea; Sleep quality

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บทคัดย่อ

โรคเบาหวานชนิดที่ 2 เป็นภาวะเรื้อรังที่พบได้บ่อยทั่วโลก คุณภาพการนอนหลับและความเสี่ยงของภาวะหยุดหายใจขณะนอนหลับจากการอุดกั้น เป็นปัจจัยที่มีผลกระทบต่อผลลัพธ์ด้านสุขภาพและคุณภาพชีวิตของผู้ที่เป็นโรคเบาหวานชนิดที่ 2 การศึกษาเชิงพรรณนาครั้งนี้ มีวัตถุประสงค์เพื่อศึกษาความเสี่ยงของภาวะหยุดหายใจขณะนอนหลับจากการอุดกั้น คุณภาพการนอนหลับ และความแตกต่างของคุณภาพการนอนหลับของผู้ที่เป็นโรคเบาหวานชนิดที่ 2 ในแต่ละระดับความความเสี่ยงของภาวะหยุดหายใจขณะนอนหลับจากการอุดกั้น กลุ่มตัวอย่าง คือ ผู้ที่เป็นโรคเบาหวานชนิดที่ 2 จำนวน 384 คน จากโรงพยาบาลตติยภูมิจำนวน 2 โรงพยาบาลในเมืองจิงฮอง จังหวัดยูนาน สาธารณรัฐประชาชนจีน เครื่องมือในการวิจัย ได้แก่ แบบสอบถามคุณภาพการนอนหลับของพิสเบอร์ก ฉบับภาษาจีน และแบบสอบถามความเสี่ยงของภาวะหยุดหายใจขณะนอนหลับจากการอุดกั้น ฉบับภาษาจีน เครื่องมือมีค่าความเชื่อมั่นเท่ากับ 0.88 และ 0.95 ตามลำดับ วิเคราะห์ข้อมูลโดยใช้สถิติเชิงพรรณนา และสถิติ chi-square

ผลการศึกษาพบว่า ผู้ที่เป็นโรคเบาหวานชนิดที่ 2 ร้อยละ 33.85 มีความเสี่ยงของภาวะหยุดหายใจขณะนอนหลับจากการอุดกั้นระดับต่ำ ร้อยละ 34.64 มีความเสี่ยงในระดับปานกลาง และร้อยละ 31.51 มีความเสี่ยงในระดับสูง คะแนนเฉลี่ยของคุณภาพการนอนหลับเท่ากับ 7.71 (SD 4.40) ร้อยละ 50.78 ของกลุ่มตัวอย่างเป็นผู้ที่มีคุณภาพการนอนหลับที่ไม่ดี นอกจากนี้ คุณภาพการนอนหลับมีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติกับความเสี่ยงของภาวะหยุดหายใจขณะนอนหลับจากการอุดกั้นแต่ละระดับ ($p < .001$)

บุคลากรทางสุขภาพ ควรให้ความสำคัญต่อการประเมินและจัดการปัญหาที่เกี่ยวข้องกับการนอนหลับในการดูแลจัดการโรคเบาหวานชนิดที่ 2 และการศึกษาวิจัยต่อไปควรมุ่งประเด็นไปที่การพัฒนาวิธีการส่งเสริมคุณภาพการนอนหลับ และลดความเสี่ยงของการเกิดภาวะหยุดหายใจขณะนอนหลับจากการอุดกั้นในผู้ป่วยกลุ่มนี้

คำสำคัญ: โรคเบาหวานชนิดที่ 2 ภาวะหยุดหายใจขณะนอนหลับจากการอุดกั้น คุณภาพการนอนหลับ

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Background and significance

The prevalence of type 2 diabetes mellitus (T2DM) has rapidly increased over recent decades and has become a leading public health challenge in China (Maimaitituerxun et al., 2024). The classic symptoms of T2DM include polyuria, polydipsia, polyphagia, and unexplained weight loss. Polyuria, especially nocturia, can cause sleep disruption and affect sleep quality (Razaq et al., 2020).

Sleep quality (SQ) is the perception of both objective and subjective aspects of sleep (Buysse et al., 1989). The impacts of T2DM on sleep quality are related to physiological imbalance and co-morbid sleep pathologies. For instance, nocturia can affect sleep onset and maintenance, leading to sleep disturbance (Nasir et al., 2022). Obstructive sleep apnea (OSA) is a common sleep disorder in persons with type 2 diabetes, especially in obese individuals (Nasir et al., 2022).

OSA risk refers to an individual having complete or partial airway obstruction during sleep despite efforts to breathe. In patients with T2DM, OSA risk varies across different regions and populations, ranging from 31.97% to 47.30% (Bamanikar et al., 2019; Worku et al., 2023). Diabetic neuropathy (DN) and hyperglycemia impair respiratory control and carotid body parenchymal degeneration during sleep, which may increase OSA risk. Several pathological changes related to OSA, such as sleep fragmentation, can affect sleep quality (Song et al., 2019).

However, several studies have presented a contrasting perspective (Frangopoulos et al., 2021; Kania et al., 2022). In 2021, Frangopoulos and colleagues indicated that the severity of OSA was not closely correlated with sleepiness, a major phenotype of decreased sleep quality. Moreover, Kania et al. (2022) found that increased slow-wave sleep (N3) percentages of total sleep time were linked to higher risks of poor sleep quality in patients with OSA. They further pointed out that this was contrary to the general opinion that N3 is significantly impaired among patients with OSA due to certain symptoms such as excessive fatigue or sleepiness, and falling asleep during the day. The investigation of the precise relationship between sleep quality and OSA in T2DM patients, as well as the identification of research disparities in this domain, is therefore imperative.

In addition, due to the cost and limited availability of polysomnography (PSG) as a reference standard for diagnosing OSA, a significant proportion of individuals at high risk for OSA remain undetected. The presence of "hidden" OSA poses additional health concerns for individuals with diabetes, such as insulin resistance/tolerance and other severe complications (Natsky et al., 2021). A series of screening questionnaires were developed as a feasible method for assessing the risk of OSA. For example, the STOP-BANG questionnaire developed by Chung and colleagues (2008) is an effective screening tool for OSA risk. Practitioners, including clinic nurses, can provide patients with more professional assistance based on screening results.

In summary, the relationship between sleep quality and OSA risk has been elusive in previous studies among this population (Frangopoulos et al., 2021; Kania et al., 2022). Therefore, it is necessary to establish research to explore OSA risk and sleep quality and investigate whether

sleep quality is different at each OSA risk level among T2DM persons in China.

Research objectives

1. To explore the risk of OSA in persons with T2DM.
2. To explore sleep quality in persons with T2DM.
3. To investigate the difference in sleep quality among persons with T2DM with different OSA risks.

Conceptual framework

The conceptual framework of this study is based on the pathogenesis of OSA risk in T2DM patients and a literature review on the relationship between OSA risk and SQ, which is significantly impaired in T2DM persons due to physiological imbalance and co-morbid sleep pathologies (Nasir et al., 2022). SQ is defined as the perception of both objective and subjective aspects of sleep, consisting of subjective sleep perception, sleep onset latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep medication use, and daytime dysfunction (Buysse et al., 1989). OSA poses a risk for diabetic patients of having periodic narrowing and obstruction of the pharyngeal airway during sleep. The relationship between the risk of OSA and sleep quality can be elucidated by the fact that recurrent episodes of upper airway obstruction during sleep in individuals at high risk for OSA are frequently accompanied by a decrease in intrathoracic pressure, resulting in intermittent hypoxia, sleep restriction, and fragmented sleep (Chattu et al., 2019). T2DM persons are usually at high risk of OSA due to several mechanisms that impact central control of respiration, upper airway neural reflexes, and carotid body parenchymal degeneration, further suppressing the hypoxia response (Song et al., 2019). Thus, T2DM persons with a high risk of OSA may have poorer sleep quality than those with a lower OSA risk.

Methodology

Population and sample

The prevalence of the risk for OSA among T2DM persons has been reported in a previous study (Bamanikar et al., 2019). Therefore, the following formula was used to calculate the sample size:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Notably, P = expected prevalence (a previous study used SBQ to investigate the risk of OSA in T2DM persons; the result was 47.3% (Bamanikar et al., 2019). Z = the statistic corresponding to the level of confidence, defined as 1.96 (for a level of confidence of 95%) while d = precision (corresponding to effect size), defined as 5%. According to the formula, the sample size required for this study was 384.

The participants who met the inclusion criteria were selected from the Outpatient Department (OPD) of two tertiary hospitals in Jinghong City, Yunnan Province, China. The inclusion criteria were: (1) has been diagnosed with T2DM more than one year; (2) aged ≥ 18 years; and (3) able to read and write Mandarin. Those who had already been diagnosed with OSA or other sleep-related breathing disorders or were being treated with continuous positive airway pressure (CPAP) were excluded.

Research instruments

1. Demographic Data Record Form

The Demographic Data Record Form, which was developed by the researcher, collected participants' general information including age, marital status, occupation, and education level information.

2. Clinical Data Record Form

The Clinical Data Record Form, developed by the researcher, collected health-related history including family history of OSA, diabetes symptoms during nighttime, other symptoms or diseases, alcohol and caffeine consumption, and smoking.

3. The Chinese Pittsburgh Sleep Quality Index (CPSQI)

Sleep quality was evaluated using the CPSQI. The original PSQI was designed by Buysse et al. (1989), and the translated version (the CPQSI) was validated by Liu et al. (1996). The CPSQI contains seven components: subjective sleep perception, sleep onset latency (the length of time that it takes to accomplish the transition from full wakefulness to sleep), sleep duration, habitual sleep efficiency (refers to the percentage of time spent sleeping in bed = total sleep time (TST)/time in bed (TIB) x 100%), sleep disturbances, sleep medication use, and daytime dysfunction. Each component is scored from 0 to 3. The scores for the seven components are then added together to obtain a global CPSQI score ranging from 0 to 21 points. A CPSQI score greater than 7 indicates poor sleep quality. A score exceeding 7 yielded a diagnostic sensitivity of 98.3% and a specificity of 90.2% in discriminating between individuals with normal sleep quality and those experiencing sleep disturbances (Liu et al., 1996). In our study, the internal consistency of the CPSQI was 0.88.

4. The Chinese STOP-BANG questionnaire (CSBQ)

The risk of OSA was evaluated using the CSBQ. The original SBQ was designed by Chung et al. (2008), and it was translated into Chinese by Yu et al. (2012). The CSBQ contains eight items, divided into four STOP questions (snoring, tiredness, observed apnea, blood pressure) and four BANG questions (BMI, age, neck circumference, and gender). With a score of 1 for "yes" and 0 for "no," the total score ranges from 0 to 8. The scoring criteria are as follows: (1) low risk of OSA: 0-2; (2) intermediate risk of OSA: 3-4; (3) high risk of OSA: 5-8 or ≥2 STOP scores plus male/BMI > 35 kg/m2/or neck circumference >40 cm (Chung et al., 2014). The sensitivities of CSBQ for mild, moderate, and severe OSA were 85.7%, 92.5%, and 100%, respectively. The coincidence rate of CSBQ with the golden standard to diagnose OSA was 78.9% (Yu et al., 2012). In our study, we

tested the test-retest reliability of CSBQ, and the result was 0.95.

Ethical considerations

The research proposal was approved by the Research Ethical Committee of the Faculty of Nursing, Chiang Mai University (No.101/2021, Approval date: September 29, 2021). Permission for data collection was obtained from the hospital. Participants were informed about the purpose and methods of this research and then signed the informed consent form. Information provided by the participants was only to be used for research and was kept confidential.

Data collection

After obtaining permission from the Research Ethics Committee of the Faculty of Nursing, Chiang Mai University, and the two tertiary hospitals, the researcher identified persons who met the eligibility criteria, and if they agreed to participate in this study, they were invited. First, the researcher explained the study's purpose, benefits, human rights protection, and data collection procedure for participants. Second, the researchers delivered the written informed consent form to participants and obtained their consent. Third, participants completed the questionnaires independently in a separate room. For the CSBQ, the first four items were completed by the participants themselves. Thereafter, the researcher measured a participant's height and weight to calculate the BMI and neck circumference, completing all the items.

Data analysis

The data utilized was analyzed using a statistical package, and the significance level was set at α = .05. The demographic and clinical data were analyzed using descriptive statistics which were also used to analyze the global and subgroup scores of CPQSI. Frequency and percentage were used to analyze the risk levels of OSA while chi-square was used to analyze the difference in sleep quality between persons with T2DM and with different OSA risk levels.

Results

About 56.25% of the participants were males. The average age was 57.06 (SD 11.69), and most participants were married or living together (80.21%). Most participants had no family history of OSA (92.19%). More than half of the participants had nocturnal symptoms (59.11%), including nocturia (46.09%), nocturia and nocturnal hypoglycemia (8.59%), and nocturnal hypoglycemia (4.43%). Nearly two-thirds (61.20%) of participants had only one comorbidity: hypertension (35.16%), restless leg syndrome (12.24%), and anxiety (13.80%). Moreover, most participants did not drink coffee (96.09%), smoke (79.17%), or drink alcohol (75.52%).

Regarding OSA risk, participants' risks were low, intermediate, and high (33.85%, 34.64%, and 31.51%, respectively). Notably, about 43.49% of participants felt tired, fatigued, or sleepy during the daytime. Only 2.08% of participants had a BMI greater than 35, and 19.79% had a neck circumference more than 40 cm (Table 1).

Table 1 The Risk of OSA and its Component Scores Among Study Participants (n = 384)

The CSBQ score	Frequency (n)	Percentage (%)
Risk of OSA		
Low risk of OSA	130	33.85
Intermediate risk of OSA	133	34.64
High risk of OSA	121	31.51
Component of OSA risk		
Snoring		
Yes	180	46.88
No	204	53.13
Tiredness		
Yes	167	43.49
No	217	56.51
Observed apnea		
Yes	37	9.64
No	347	90.36
Hypertension		
Yes	173	45.05
No	211	54.95
BMI		
> 35	8	2.08
≤ 35	376	97.92
Age		
> 50 years	286	74.48
≤ 50 years	98	25.52
Neck Circumference		
> 40 cm	76	19.79
≤ 40 cm	309	80.21
Gender		
Male	216	56.25
Female	168	43.75

The total mean score of the CPSQI was 7.71 (SD 4.40). Using a cutoff point to define good or poor sleepers, almost half (50.78%) had poor sleep quality. The average sleep duration was 6.34 (SD 1.34) hours. Notably, nearly half of the participants had poor sleep quality; however, most of them did not use sleep medications (Table 2).

Table 2 Sleep Quality and its Component Scores Among Study Participants (n = 384)

Components of CPSQI	Frequency	%	Mean (SD)
Subjective sleep quality			
Very good	100	26.04	
Good	136	35.42	
Bad	117	30.47	
Very bad	35	8.07	
Mean sleep duration (h) (SD)			6.34 (1.34)
≥ 7	164	42.71	
< 7 and ≥ 6	108	28.12	
< 6 and ≥ 5	70	18.23	
< 5	42	10.94	
Sleep onset latency (min)			
≤ 15	76	19.79	
16-30	124	32.29	
31-60	52	13.54	
> 60	132	34.38	
Habitual sleep efficiency (%)			
≥ 85	214	55.47	
75-84	89	23.18	
65-74	43	11.20	
< 65	39	10.15	
Use of sleeping medication			
Never	367	92.97	
Use less than once a week	19	4.95	
Use once or twice a week	4	1.04	
Use three or more times a week	4	1.04	
Daytime dysfunction			
0	97	25.26	
1-2	125	32.55	
3-4	103	26.82	
5-6	59	15.37	
Sleep disturbance			
0	13	3.39	
1-9	276	71.87	
10-18	90	23.44	
19-27	5	1.30	

Table 2 Sleep Quality and its Component Scores Among Study Participants (n = 384) (continue)

Components of CPSQI	Frequency	%	Mean (SD)
Mean global PSQI score (SD)			7.71 (4.40)
Poor sleep quality	195	50.78	
Good sleep quality	189	49.22	

There was a significant difference in SQ among individuals with T2DM at different OSA risk levels ($p < .001$). In the high-risk OSA group, 71.07% of T2DM patients had poor SQ, whereas only 29.93% had good SQ. In the intermediate-risk group, 57.14% of T2DM patients had poor SQ, whereas 42.86% had good SQ. In the low-risk group, only 25.38% had poor SQ, but about 74.62% had good SQ (Table 3).

Table 3 The Difference of Sleep Quality Between Persons with T2DM with Different Risk Levels of OSA (n = 384)

Risk of OSA	Poor sleep quality (PSQI > 7)	Good sleep quality (PSQI ≤ 7)	χ^2	P
Low	33 (25.38%)	97 (74.62%)	55.639	< .001
Intermediate	76 (57.14%)	57 (42.86%)		
High	86 (71.07%)	35 (29.93%)		

Discussion

The results of this study indicated that the risk of OSA is prevalent in patients with T2DM, and that sleep quality is significantly impaired. The sleep quality of patients with low, intermediate, and high-risk T2DM was significantly different.

Among participants diagnosed with T2DM, a third of the participants (31.51%) exhibited a high risk for OSA, which is consistent with previous studies (31.97%) (Worku et al., 2023). Diabetic Neuropathy (DN) can involve the entire autonomic nervous system (ANS), which partially controls respiratory function during sleep. This respiratory control may be impaired by the effect of DN on central or peripheral chemoreceptors; and glossopharyngeal, vagal, or proprioceptive nerves. These effects may lead to reduced airway function and more breathing control variables, resulting in OSA (Song et al., 2019). Additionally, hyperglycemia can lead to carotid body parenchymal degeneration. Since the carotid bodies regulate respiration through peripheral chemoreceptors, this parenchymal degeneration may inhibit hypoxic reactivity (Song et al., 2019).

The findings of the study confirm that a significant proportion of individuals with diabetes experience snoring (46.88%) and tiredness (43.49%). These symptoms are associated with recurrent upper airway obstruction during sleep, as well as fragmented and non-restorative sleep, leading to sleep insufficiency (Song et al., 2019). Clinic nurses should systematically ask about these symptoms when admitting patients with T2DM to identify OSA risk as early as possible.

Using CPSQI scores with a cutoff point of global PSQI > 7 for sleep evaluation in the present study revealed that 50.78% of diabetic patients had poor sleep quality. This finding agrees with previous studies conducted in Northwest Ethiopia (47.2%) (Birhanu et al., 2020). The impact of T2DM on sleep quality is associated with physiological imbalances and comorbidities in sleep pathology. Disturbances such as nocturia can significantly disrupt sleep maintenance (Razaq et al., 2020). In another Chinese study, the prevalence of poor sleep quality was 40.50% (Maimaiti-tuerxun et al., 2024). This can be explained by the fact that participants in our study had significantly lower rates of alcohol consumption, and there were fewer females that study than in ours. Males generally sleep better than females because of differences in circadian clock genes, respiratory control, the action of sex hormones, and stress responses to sleep mechanisms (Lee, 2024). Moreover, alcohol intake has been closely linked with decreased sleep quality (Zheng et al., 2021).

It is noteworthy that the present study has confirmed that many diabetic patients have poor sleep quality, but only a minority (7.03%) of them receive hypnotic medication for promoting sleep. The reason for this discrepancy may be that many patients tend to believe that improper use of these medications leads to adverse consequences such as abuse, dependence, drug tolerance, or memory impairment. However, the positive effect of appropriate medication on sleep quality has been confirmed by many studies (Lou et al., 2022). For diabetic patients with poor sleep quality, attention should be paid to rational medication to reduce the side effects of insufficient sleep on individual health, including those with a risk of OSA.

We also demonstrate that the sleep quality of persons with diabetes was different at each risk level for OSA. Patients with a high risk of OSA had poorer sleep quality (PSQI > 7) compared to those with low or intermediate risk. Diabetes affects central respiration control, upper airway neural reflexes, and carotid body parenchymal degeneration, ultimately impairing the hypoxia response. These pathological changes increase the risk of OSA. Heightened susceptibility to OSA is associated with intermittent hypoxia, sleep fragmentation, and non-restorative sleep, further exacerbating sleep quality (Song et al., 2019).

On the other hand, we observed that persons with T2DM had a higher incidence of specific factors that may contribute to poor sleep quality and an increased risk for OSA. These factors included nocturia, restless leg syndrome (RLS), and nocturnal hypoglycemia. Nocturia can affect sleep onset and maintenance, and RLS can delay sleep onset and interrupt sleep because of the discomfort experienced in the lower limbs (Nasir et al., 2022). Moreover, hyperglycemia can inhibit hypoxic reactivity by causing carotid body parenchymal degeneration (Song et al., 2019). Nurses should pay more attention to sleep issues and OSA risk in diabetic patients with these symptoms or comorbidities.

Regarding the prevalence of OSA risk in T2DM patients, a significant proportion of persons at high risk of OSA go undetected due to multiple factors (cost, availability limitations of polysomnography, etc.) (Natsky et al., 2021). Therefore, routine screening for OSA risk is necessary

for T2DM patients with poor sleep quality. Otherwise, it is reasonable to surmise that persons with diabetes are often at high risk for, or even already have, OSA which can lead to decreased sleep quality. Moreover, the adverse effects of OSA (or risk of OSA) combined with insufficient sleep may unknowingly lead to more severe comorbidities and complications in diabetic patients.

Overall, it can be concluded that the current findings are consistent with most previous studies on sleep quality and the risk of OSA in diabetic patients. Studies have shown that poor sleep quality and OSA risk are prevalent in diabetic patients. Sleep quality among persons with T2DM with different OSA risk levels is significantly different. Patients with a high risk for OSA had poor sleep quality.

Application of research findings

This study highlights that the risk of OSA is prevalent in persons with T2DM. Clinic nurses must pay more attention to screening OSA risk in this group to assist patients in seeking the correct diagnosis and treatment, especially for those with increased risk. Systematically asking persons with diabetes if they have snoring and daytime fatigue can help identify OSA risk, and this can be done using validated questionnaires, such as the CSBQ. Additionally, clinic nurses need to emphasize sleep problems among patients with T2DM and develop practical solutions, such as rational use of medications, to reduce the side effects of poor sleep quality.

Suggestions for further research

It is suggested for further study that longitudinal study designs and regression analysis can be employed to establish a causal relationship between sleep quality and OSA risk among persons with T2DM.

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