COGNITIVE BEHAVIORAL THERAPY AND SLEEP QUALITY IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A REVIEW

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Abstract
Sleep disturbances are highly prevalent among individuals with type 2 diabetes mellitus (T2DM) and are associated with adverse effects on glycemic control and quality of life. Cognitive behavioral therapy (CBT) and cognitive behavioral therapy for insomnia (CBT-I) are established non-pharmacological interventions; however, their effectiveness across specific sleep quality domains in this population remains insufficiently clarified. This review aimed to evaluate the effectiveness of CBT-based interventions across distinct sleep quality domains in individuals with T2DM. This review employed a narrative synthesis without meta-analysis (SWiM) approach to synthesize evidence on the effects of CBT/CBT-I on sleep quality in individuals with T2DM. The literature search was conducted using the PubMed, Scopus, EBSCOhost, and ProQuest databases. Sleep outcomes were categorized into six domains: overall sleep quality, sleep efficiency, sleep disturbances, sleep latency, sleep duration, and wake after sleep onset (WASO). Most studies reported significant improvements in overall sleep quality and sleep duration following CBT or CBT-I, with sustained benefits observed for up to 12 months post-intervention. In contrast, effects on sleep efficiency, sleep latency, sleep disturbances, and WASO were inconsistent and varied across studies. The effectiveness of CBT-based interventions appeared to be influenced by factors including session frequency, intervention duration, delivery modality, and patient engagement. CBT and CBT-I are effective in improving core aspects of sleep quality in individuals with T2DM, particularly when interventions are structured, sustained, and tailored to individual needs. Further large-scale, methodologically rigorous studies using standardized outcome measures are required to strengthen the evidence base and inform clinical practice.
***Keywords**: Type 2 Diabetes Mellitus, Cognitive Behavioral Therapy; Sleep Quality; Review*

Abstrak
Gangguan tidur merupakan masalah yang sering dialami oleh individu dengan diabetes melitus tipe 2 (DMT2) dan dapat berdampak negatif terhadap kontrol glikemik serta kualitas hidup. Cognitive Behavioral Therapy (CBT) dan Cognitive Behavioral Therapy for Insomnia (CBT-I) merupakan intervensi nonfarmakologis yang telah banyak digunakan untuk mengatasi gangguan tidur, namun efektivitasnya pada berbagai domain kualitas tidur pada pasien DMT2 masih belum sepenuhnya dipahami. Tinjauan ini bertujuan untuk mengevaluasi efektivitas intervensi berbasis CBT terhadap berbagai domain kualitas tidur pada individu dengan DMT2. Sintesis bukti dilakukan menggunakan pendekatan Synthesis Without Meta-analysis (SWiM). Penelusuran literatur dilakukan pada basis data PubMed, Scopus, EBSCOhost, dan ProQuest. Luaran tidur dikategorikan ke dalam enam domain, yaitu kualitas tidur secara keseluruhan, efisiensi tidur, gangguan tidur, latensi tidur, durasi tidur, dan *wake after sleep onset* (WASO). Sebagian besar penelitian menunjukkan bahwa CBT dan CBT-I secara signifikan meningkatkan kualitas tidur secara keseluruhan dan durasi tidur pada individu dengan DMT2, dengan manfaat yang dapat bertahan hingga 12 bulan setelah intervensi. Sebaliknya, pengaruh terhadap efisiensi tidur, latensi tidur, gangguan tidur, dan WASO menunjukkan hasil yang bervariasi antarpenelitian. Efektivitas intervensi dipengaruhi oleh berbagai faktor, termasuk frekuensi sesi, durasi intervensi, metode penyampaian, dan tingkat keterlibatan peserta. Secara keseluruhan, CBT dan CBT-I efektif dalam meningkatkan beberapa aspek utama kualitas tidur pada individu dengan DMT2, terutama apabila intervensi diberikan secara terstruktur, berkelanjutan, dan disesuaikan dengan kebutuhan individu. Penelitian lebih lanjut dengan desain yang lebih kuat, ukuran sampel yang lebih besar, serta penggunaan instrumen pengukuran yang terstandar diperlukan untuk memperkuat bukti ilmiah dan mendukung penerapannya dalam praktik klinis.
Kata kunci: Diabetes Melitus Tipe 2, Cognitive Behavioral Therapy, Kualitas Tidur, Review

INTRODUCTION

Type 2 diabetes mellitus is one of the important health problems in the world, with a prevalence that continues to increase and has become a health burden for all countries worldwide (WHO, 2023). Diabetes can adversely affect a person, as they may experience complications that worsen their health condition. Common complications include blindness, kidney failure, heart attack, stroke, amputation, and even death (WHO, 2023). In addition, diabetes can also have a negative impact on psychological and mental health, and become a financial burden due to its expensive treatment, greatly affecting the well-being of sufferers (Robinson et al., 2023).

Many recent studies have linked diabetes with poor sleep quality (Alamer et al., 2022; Barakat et al., 2019; Darraj et al., 2018). Diabetes patients often experience nighttime sleep disturbances and excessive daytime sleepiness experienced by more than 50% of patients (Kuo et al., 2021). Sleep disorders among patients with diabetes can affect various medical conditions, worsening quality of life (Medic et al., 2017).

Many factors affect sleep quality, such as long diabetes duration, social and demographic factors, and economic status (Surani et al., 2015). Therefore, patients with diabetes need appropriate management of sleep quality (Grandner et al., 2016). Various interventions in addressing sleep quality of diabetes patients include administration of neuropathic pain medications (Choi et al., 2021), nutritional diet and physical activity (Delevatti et al., 2018; Sejbuk et al., 2022). However, these interventions cannot be fully implemented for every patient due to various barriers and differing patient conditions, resulting in additional costs and short-term effects (Koffel et al., 2015).

Currently, CBT is being developed, which is considered to have various benefits in addressing psychological problems such as anxiety, depression (Abbas et al., 2023; Ramsawh et al., 2016), pain (Jungquist et al., 2010), insomnia (Bai et al., 2024), to improve sleep quality (Octaviani et al., 2023), and has better long-term effects (Koffel et al., 2015). Recent meta-analyses have reported the benefits of CBT for improving sleep quality in the general population (Octaviani et al., 2023), and in patients with cardiometabolic syndrome (Xu et al., 2024).

We searched for previous review studies that did not focus on all attributes of sleep quality (Wang et al., 2024). To complement and expand upon their findings, we adopted the SWiM framework. This approach allowed us to structure and interpret the evidence based on five key attributes of sleep quality as proposed by Nelson et al. (2022). This attribute-based synthesis offers a more granular and clinically applicable interpretation of the evidence.

METHODS

Study design

The reporting of this study was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Haddaway et al., 2022). This review examined the effects of cognitive behavioral therapy (CBT) and cognitive behavioral therapy for insomnia (CBT-I) on key components of sleep, including overall sleep quality, sleep efficiency, sleep disturbances, sleep latency, sleep duration, and WASO. A narrative synthesis approach without meta-analysis was applied in accordance with the Synthesis Without Meta-analysis (SWiM) framework (Campbell et al., 2020).

Eligibility criteria

The inclusion criteria comprised experimental studies, including randomized controlled trials (RCTs) and quasi-experimental studies, published in English, that evaluated the effects of CBT or CBT-I on sleep quality in patients with T2DM. Exclusion criteria included review articles, study protocols, case reports, and studies involving individuals with type 1 diabetes mellitus.

Search strategy

A literature search was conducted in December 2024 using the following electronic databases: EBSCOhost, PubMed, Scopus, and ProQuest. The search strategy combined controlled vocabulary and free-text terms related to "cognitive behavioral therapy", "sleep quality", "type 2 diabetes mellitus". Boolean operators ("AND" and "OR") were applied to combine the concepts, and the search strategy was adapted to the specifications of each database (**Table 1**).

Table 1. Search Strategy

Database	Keywords	Filter	Results
PubMed	((((Cognitive behavioral therapy[Title/Abstract]) OR (cbt[Title/Abstract])) AND (insomnia[Title/Abstract])) OR (quality of sleep[Title/Abstract])) AND (diabet*[Title/Abstract])	English language	180
EBSCOhost	AB (cognitive behavioral therapy or cbt) AND AB (quality of sleep or sleep quality) AND AB (diabetes or diabetes mellitus or type 1 diabetes or type 2 diabetes or diabetic)	English language	16
Proquest	abstract(cognitive behavioural therapy) AND abstract(diabetes OR diabetic) AND abstract(quality of sleep OR sleep quality)	-	12
Scopus	cognitive behavioural therapy AND diabetes OR diabetic AND quality of sleep OR sleep quality	Article type, english language	68
Total			276

Study selection

Three independent reviewers initially screened the literature by eliminating duplicate records, followed by a detailed evaluation of article titles and abstracts to select studies that met the inclusion criteria. Subsequently, these reviewers conducted independent, in-depth assessments of the full-text articles, examining key elements including study aims, methodologies, outcomes, and conclusions to confirm eligibility. When disagreements arose, a collective discussion among all authors were held to achieve a unanimous consensus. The data extraction process was systematically guided by the PRISMA framework, as depicted in **Figure 1.**

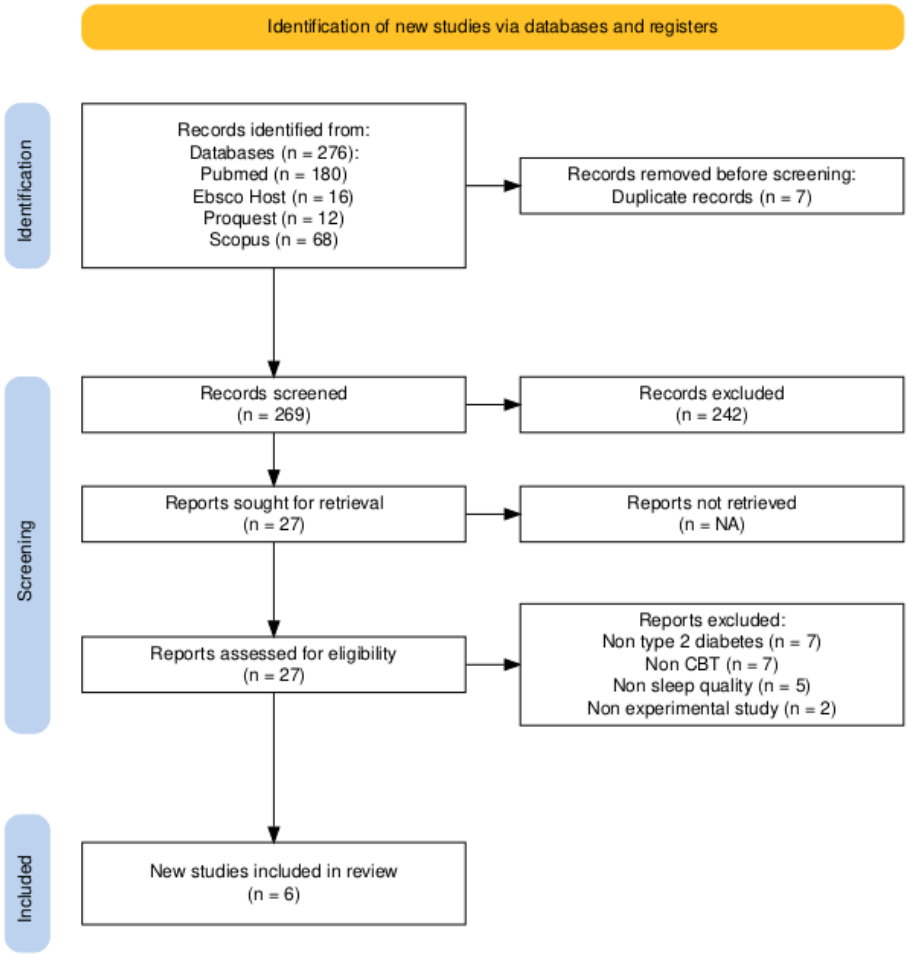

Figure 1. PRISMA Flowchart

Data extraction

Data extraction was conducted to identify studies relevant to the research topic. Data were systematically extracted using a standardized table to summarize key study characteristics, including author, publication year, country, study design, sample size, attrition rate, participant age, study setting, measurement instruments, intervention and control conditions, treatment duration and frequency, mode of delivery, intervention provider, follow-up period, and main outcomes, with outcomes categorized according to sleep quality domains (**Table 3**).

Quality appraisal

The included studies were critically appraised using the Joanna Briggs Institute (JBI) critical appraisal tools (Barker et al., 2023, 2024). Three reviewers independently assessed the studies according to their respective study designs, namely RCTs and quasi-experimental studies. Any discrepancies identified during the appraisal process were resolved through discussion among all authors until consensus was reached. Quality ratings were assigned using predefined thresholds: <65% (low quality), 65–80% (moderate quality), and >80% (high quality), in accordance with established criteria (Negash et al., 2023) (**Table 2**).

Table 2. Evaluation Quality of Studies by JBI

Author, year	JBI Form	Yes	No	Unclear	N/A
(Zuo et al., 2020)	RCT	77%	-	-	23%
(Alshehri et al., 2020)	RCT	92%	8%	-	-
(Irandoust et al., 2022)	Quasi-experimental	89%	-	11%	
(Li et al., 2023)	RCT	85%	15%	-	-
(Groeneveld et al., 2024)	RCT	77%	23%	-	-
(Zhang et al., 2021)	RCT	77%		15%	8%

Data synthesis and analysis

The data obtained were summarized and combined into a table for analysis. This study focuses on discussing the effects of CBT/CBT-I on sleep quality attributes in T2DM patients using the SWiM guideline (Campbell et al., 2020). The data were selected, reviewed, grouped, and discussed based on sleep quality attributes (**Table 4**).

RESULTS

The initial database search identified 276 records. After removing seven duplicate records, 269 articles were screened based on their titles and abstracts. Twenty-seven studies met the eligibility criteria and were assessed through full-text review. Of these, 22 articles were excluded for the following reasons: seven did not focus on patients with T2DM, seven were not related to CBT, five did not assess sleep quality outcomes, and two did not employ an experimental study design. This study selection process followed the PRISMA framework (**Figure 1**).

Study characteristics

Overall, studies were conducted in China (Li et al., 2023; Zhang et al., 2021; Zuo et al., 2020), United States (Alshehri et al., 2020), Iran (Irandoust et al., 2022), and Netherlands (Groeneveld et al., 2024) (Figure 2). Five studies used RCT designs (Alshehri et al., 2020; Groeneveld et al., 2024b; Li et al., 2023b; Zhang et al., 2021b; Zuo et al., 2020), and one quasi-experiment with a pre-post test with a control group (Irandoust et al., 2022). One study used a large sample size >500 per group (Zhang et al., 2021), five studies used samples of less than 100 per group (Alshehri et al., 2020; Groeneveld et al., 2024b; Irandoust et al., 2022b; Li et al., 2023b; Zuo et al., 2020) (**Figure 2**).

There were two studies with a mean age of <60 years (Irandoust et al., 2022; Li et al., 2023) and four studies with a sample age of ≥60 years (Alshehri et al., 2020; Groeneveld et al., 2024; Zhang et al., 2021; Zuo et al., 2020). Three studies were conducted in community health centres (Groeneveld et al., 2024; Zhang et al., 2021; Zuo et al., 2020), two in medical centres (Alshehri et al., 2020; Irandoust et al., 2022b), and one in a hospital (Li et al., 2023). Five studies measured sleep quality was using the PSQI instrument (Alshehri et al., 2020; Irandoust et al., 2022; Li et al., 2023; Zhang et al., 2021; Zuo et al., 2020), one used the PROMIS Short Forms (Groeneveld et al., 2024), one study used a combination of PSQI, SSES, ISI, and ESS (Alshehri et al., 2020), and two studies used a sleep diary and an accelerometer (Alshehri et al., 2020; Groeneveld et al., 2024) (**Table 3**).

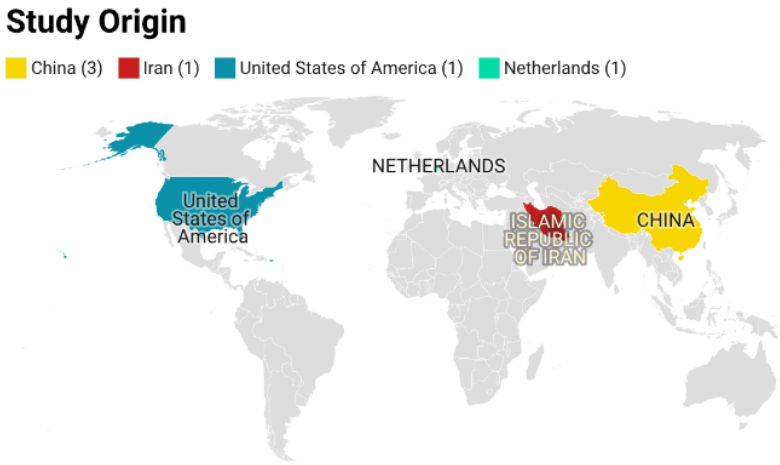

Figure 2. Study Origin

Characteristics of intervention

The intervention lasted 5 to 24 weeks, the frequency ranged from 5 to 14 sessions, and each session lasted 20 to 60 minutes. Of the six studies, only one included a control group that received additional aerobic interventions (Zuo et al., 2020). Four studies delivered the intervention in face to face (Alshehri et al., 2020; Irandoust et al., 2022; Zhang et al., 2021; Zuo et al., 2020), one study delivered the intervention in face to face combined online (Li et al., 2023), and one study delivered the intervention fully online (Groeneveld et al., 2024). Three studies reported the intervention implementers as general doctors (Zhang et al., 2021; Zuo et al., 2020) and doctoral students (Groeneveld et al., 2024). For the control group, four studies provided usual care only (Groeneveld et al., 2024; Irandoust et al., 2022; Li et al., 2023; Zhang et al., 2021), one provided health education (Alshehri et al., 2020), and one provided usual care combined with aerobic exercise (Zuo et al., 2020). Two studies reported a 6-month follow-up (Li et al., 2023; Zuo et al., 2020), one reported a 3-month follow-up (Irandoust et al., 2022), one reported a 12-month follow-up (Zhang et al., 2021), and two did not report the follow-up (Alshehri et al., 2020; Groeneveld et al., 2024) (**Table 3**).

Table 3. Summary of Included Studies

Author, year	Sample Size, age, drop out	Intervention setting, measurement, provider	Intervention, control	Time, frequency	Time per session, method, follow up
(Zuo et al., 2020)	• Total: 187 (IG: 94/ CG: 93) • Age: IG: 63.9 ± 10.2/ CG: 61.7 ± 10.4 • DO: 4 (IG: 2/ CG: 2)	• Community Health Center • PSQI • General doctor	• IG: CBT • CG: Aerobic and usual care	• 8 weeks • CBT 7 sessions, discussion 7 sessions	• 40 - 50 minutes • Face to face • 24 weeks
(Alshehri et al., 2020)	• Total: 28 (IG: 14/ CG: 14) • Age: IG: 61.86 ± 6.48/ CG: 59.43 ± 9.49 • DO: 2 (IG: 1/ CG: 1)	• University Medical Center • PSQI, ISI, ESS; SSES; sleep diary, and actigraph. • Not mention	• IG: CBT-I • CG: Health education	• 6 weeks • 6 sessions	• 60 menutes • Face to face • Not mention
(Irandoust et al., 2022)	• Total: 63 (IG: 32/ CG: 31) • Age: IG: 44.45 ± 6.91/ CG: 43.03 ± 6.31 • DO: 1 (IG: 1/ CG: 0)	• General Medical Center • PSQI • Not mention	• IG: CBT • CG: Usual care	• Not mention • 6 sessions	• Not mention • Face to face • 12 weeks
(Li et al., 2023)	• Total: 281 (IG: 148/ CG: 133) • Age: IG: 47.66 ± 12.31/ CG: 52.41 ± 10.80 • DO: 40 (IG: 21/ CG: 19)	• Central Hospital • PSQI • Not mention	• IG: CBT • CG: Usual care	• 24 weeks • Total 12 sessions: 1 sessions per week for 8 weeks and 1 sessions per month for 4 months)	• 20 – 30 minutes • Face to face combined online • 24 weeks
(Groeneveld et al., 2024)	• Total: 57 (IG: 29/ CG: 28) • Age: IG: 67.7 ± 8.4/ CG: 71.8 ± 7.3 • DO: 5 (IG: 4/ CG: 1)	• Community Health Center • PROMIS s*hort forms, s*leep diary, and actigraph.	• IG: CBT-I • CG: Usual care	• 5 weeks • 5 sessions	• 60 minutes • Fully online • Not mention

Author, year	Sample Size, age, drop out	Intervention setting, measurement, provider	Intervention, control	Time, frequency	Time per session, method, follow up
		• PhD student			
(Zhang et al., 2021)	• Total: 1.142 (IG: 574/ CG: 568) • Age: IG: 61.58 ± 9.17/ CG: 61.83 ± 8.64 • DO: 109 (IG: 47/ CG: 62)	• Community Health Center • PSQI • General doctor	• CBT • Usual care	• 24 weeks • 12 sessions lecture and discussion, CBT is given at the next when all lecture and discussion have been completed	• 50 – 65 minutes • Face to face • 12 months

Abbreviations: US: *United States*; RCT: *Randomize Control Trial*; PSQI: *Pittsburgh Sleep Quality Index*; ESS: *Epworth Daytime Sleepiness Scale*; ISI: *Insomnia Severity Index*; SSES: *Sleep Self-Efficacy Scale*; PROMIS: *Patient Reported Outcomes Measurement Information System*; CBT: *Cognitive Behavioral Therapy*; CBT-I: *Cognitive Behavioral Therapy for Insomnia*; IG: *Intervention Group*; CG: *Control Group;* DO: *Drop Out*

Table 4. Summary of the Studies Based on Sleep Quality Attributes

Authors	Attributes of sleep quality					
	Overall sleep quality	Sleep efficiency	Sleep disturbances	Sleep latency	Sleep duration	WASO
(Zuo et al., 2020)	The CBT group showed greater improvements in sleep quality than the usual care plus aerobics group at 2 and 6 months of follow-up.	Not reported	Not reported	Not reported	Not reported	Not reported
(Alshehri et al., 2020)	The CBT-I group showed significantly greater improvement in sleep outcomes than the	Sleep efficiency improved significantly in the CBT-I group	The CBT-I group experienced a greater reduction in nighttime awakenings than the	Sleep latency in the CBT-I group was significantly	No statistically significant effect was observed; however, the	WASO was significantly lower in the CBT-I group than in the health

Authors	Attributes of sleep quality					
	Overall sleep quality	**Sleep efficiency**	**Sleep disturbances**	**Sleep latency**	**Sleep duration**	**WASO**
	health education group, as measured by both sleep diaries and actigraphy.	compared with the health education group, as indicated by both sleep diaries and actigraphy.	health education group.	shorter than in the health education group, with a mean of 10.9 minutes.	CBT-I group reported an increase of approximately 30 minutes in sleep duration, as indicated by sleep diary results.	education group, as measured by both sleep diaries and actigraphy. The mean WASO was over 40 minutes, indicating improved sleep quality.
(Irandoust et al., 2022)	Sleep quality in the CBT group was significantly better than in the control group.	Not reported	Not reported	Not reported	Not reported	Not reported
(Li et al., 2023)	CBT-I had a significant effect on overall sleep quality, with the CBT-I group demonstrating better sleep quality than the health education group.	Sleep efficiency improved significantly in the CBT-I group. However, no significant between-group difference was observed.	CBT-I had a significant effect on sleep disorders, although no significant between-group differences were detected.	No significant difference in sleep latency was observed between the CBT and usual care groups; however, the CBT group showed a greater reduction in sleep latency than the usual care group.	No significant within-group effect on sleep duration was observed in either the CBT or the usual care group. However, a significant between-group difference was found, with the CBT-I group showing a greater improvement in sleep duration.	Non reported

Authors	Attributes of sleep quality					
	Overall sleep quality	**Sleep efficiency**	**Sleep disturbances**	**Sleep latency**	**Sleep duration**	**WASO**
(Groeneveld et al., 2024)	CBT-I had no significant effect on overall sleep quality, and there was no significant difference in overall sleep quality between the CBT-I and usual care groups.	No significant effect or difference in sleep disorders was observed in either the CBT-I or the usual care group; however, the CBT-I group experienced a greater reduction in sleep disturbances than the usual care group after 6 months.	No significant effect was observed; however, the CBT-I group showed a greater reduction in sleep disturbances than the usual care group.	A greater reduction in sleep difficulty symptoms over time was observed in the CBT-I group compared with the usual care group.	The CBT-I group showed a significant increase in sleep duration over time, as indicated by sleep diary data, compared to the control group. However, actigraphy results did not show a significant effect.	CBT-I did not have a significant effect on wake after sleep onset
(Zhang et al., 2021)	CBT is significantly more effective than usual care at improving sleep quality at 2, 6, and 12 months.	Not reported	Not reported	Not reported	Not reported	Not reported

DISCUSSION

This review suggests that CBT shows promising potential for improving multiple aspects of sleep quality in individuals with T2DM. However, its effects are not consistent across all analyzed sleep domains. Given the heterogeneity in study designs, intervention modalities, and measurement instruments, a narrative synthesis approach was employed to present the findings in a more contextualized and reflective manner. This framework allows for a more nuanced evaluation of CBT's impact across distinct sleep components and provides clinically relevant insights.

Overall sleep quality

Overall sleep quality is a crucial outcome measure for assessing sleep quality in T2DM patients (Zhang et al., 2021). In our narrative synthesis, most studies demonstrated that both CBT and CBT-I interventions significantly improved overall sleep quality, measured both subjectively and objectively. These positive effects were not only evident immediately after the intervention but also persisted for several months after therapy completion, indicating a stable medium-term effect. Our findings align with a recent meta-analysis reporting that RCT-based CBT significantly improved sleep quality, as measured by a reduction in PSQI scores in T2DM patients, both at the end of the intervention, 6 months, and 12 months post-intervention, although with a high degree of heterogeneity of >80% (Wang et al., 2024).

Our narrative approach adds value by identifying factors influencing intervention success, such as an intensive number of sessions (Alshehri et al., 2020; Zuo et al., 2020), an extended implementation period of up to 12 months (Zhang et al., 2021), and the presence of in-person sessions (Alshehri et al., 2020; Irandoust et al., 2022; Li et al., 2023; Zhang et al., 2021; Zuo et al., 2020),which are more likely to produce significant effects, compared to a shorter period of fully online delivery (Groeneveld et al., 2024). Previous studies have also reported that frequent in-person delivery is more effective than fewer sessions (Straten et al., 2018). Furthermore, the intensity, consistency (Trauer et al., 2015), and intensity of CBT-I interventions increase the effectiveness of therapy (Edinger et al., 2021) and can increase the risk of relapse if not implemented (Harvey et al., 2014). Furthermore, studies by (Zhang et al., 2021) and (Zuo et al., 2020) support the notion that sleep quality in patients with diabetes can be significantly improved with structured, sustained behavioural interventions.

Sleep efficiency

Sleep efficiency, the proportion of time spent asleep relative to the time spent in bed, is a key indicator of healthy sleep quality (Reed & Sacco, 2016). Of the three studies reporting sleep efficiency, all showed improvements after intervention, though effectiveness varied across studies. Two reported significant effects (Alshehri et al., 2020; Li et al., 2023), while one reported no significant effect (Groeneveld et al., 2024). A recent meta-analysis found that the effect of CBT on sleep efficiency was not statistically significant, despite a relatively large effect size; however, heterogeneity across studies was also high. Suggests that the effects of CBT on this domain may vary significantly across populations or settings (Wang et al., 2024). Furthermore, there are several striking differences between the two studies, including the use of a complete face-to-face method, the use of various measurement tools, more intensive sessions (Alshehri et al., 2020), and the use of actigraphy, which allows for more direct comparisons of results (Mitchell et al., 2019). It may have had an indirect impact on participants. In terms of implementation methods, face-to-face methods are indeed far superior to online ones (Lancee et al., 2016).

This increase in sleep efficiency is significant because low sleep efficiency in patients with diabetes is associated with metabolic disorders and poor glucose control (Mehrdad et al., 2022). CBT-I can increase sleep efficiency in patients with

sleep disorders from 86.0% to 89.2% (Eigl et al., 2023). Improved sleep efficiency through CBT-I contributes to reduced symptoms of depression and anxiety, which often worsen sleep quality in patients with diabetes (Pchelina et al., 2024). The effectiveness of CBT on sleep efficiency can be influenced by psychosocial factors and patient adherence to therapy (Hapsari & Kurniawan, 2019). The results of CBT in patients with chronic illnesses are more heterogeneous (Morin et al., 2009). It is thought to be related to physiological factors, such as neuropathy or chronic pain, that affect sleep quality independently of behavioural interventions (Karmilayanti et al., 2021). Therefore, modifications to both CBT and CBT-I protocols may be necessary in patients with chronic illnesses to optimize sleep efficiency (Morin et al., 2009).

Sleep disturbances

Sleep disorders include disorders that disrupt restful sleep, such as parasomnias, including spontaneous awakenings, sleepwalking, nightmares, and periodic limb movements (Krystal & Edinger, 2008). Three studies reported varying results regarding sleep disturbances. Two found significant effects (Alshehri et al., 2020; Li et al., 2023), while one found no significant effect (Groeneveld et al., 2024). The effects of CBT-I tend to be smaller in patients with comorbidities (Iwashita et al., 2022). Sleep disturbances after CBT intervention can vary in severity and may be influenced by pain levels, diet, medication, and stress (Iwashita et al., 2022; Pavan et al., 2023). Therefore, some researchers recommend combining CBT-I with specific medical interventions for diabetes (Straten et al., 2018). Although several studies have reported positive CBT-I effects on sleep disturbance in general patients (Espie et al., 2012) and comorbidities (Wu et al., 2015), those specifically addressing T2DM patients are very limited. This limitation also prevented the meta-analysis study by Wang et al. (2024) from testing the effectiveness of sleep disturbance. Therefore, future studies are highly recommended to report the full effects of CBT on sleep quality attributes.

Sleep latency

Sleep latency is the time it takes to fall asleep (Iskander et al., 2023). Changes in sleep latency after CBT/CBT-I in T2DM patients tend to vary. Some studies report a decrease in the time to fall asleep (Alshehri et al., 2020; Groeneveld et al., 2024; Li et al., 2023), with some even reducing sleep latency to less than 11 minutes (Alshehri et al., 2020). However, CBT-I is not always statistically significant in patients with diabetes (Groeneveld et al., 2024). This finding has also been reported in previous studies in older adults (Lovato et al., 2014) and in T2DM patients (Wang et al., 2024). Several studies have reported a significant effect on sleep latency in patients with chronic insomnia (Edinger et al., 2001) and in older adults with insomnia (Sivertsen et al., 2006). However, the results are more moderate in patients with chronic illnesses. Individual response is strongly influenced by psychological and medical factors (Espie et al., 2001). Furthermore, sleep latency is strongly influenced by anxiety and depression (Pavan et al., 2023), making CBT that targets cognitive aspects more effective (Harvey et al., 2014).

Reduced sleep latency contributes to increased sleep duration and quality (Castiglione-Fontanellaz et al., 2023), as well as reduced stress and improved emotional regulation, which are particularly important in diabetic patients who are vulnerable to chronic stress (Coccaro et al., 2022). Patients with long-term diabetes and neurological complications may limit the effects of CBT on sleep latency (Fu et al., 2024). Therefore, integrating relaxation techniques into CBT-I is highly recommended to optimise sleep latency outcomes (Edinger et al., 2021).

Sleep duration

Sleep duration is the total amount of sleep a person spends during 24 hours (Kline, 2013). Our results indicate that total sleep duration increased after CBT/CBT-I intervention; however, this effect varied

across studies. Groeneveld et al. (2024) reported a significant effect based on sleep diaries alone, but not on actigraphy results. Two studies reported no significant effect (Alshehri et al., 2020; Li et al., 2023), but the CBT-I group experienced a greater increase in sleep duration by up to 30 minutes based on sleep diaries (Alshehri et al., 2020), and significant differences were found between groups (Li et al., 2023). Previous studies in the general population also reported significant results (Trauer et al., 2015; Wang et al., 2024). Wu et al. (2015) reported no significant effect on total sleep time in patients with comorbidities. Scott et al. (2022) in their study of the general population with chronic insomnia showed that sleep duration can increase after CBT-I, particularly after 6–8 intervention sessions. However, only 17% achieved a 30-minute increase in sleep duration by the end of treatment.

Total sleep time varied widely, and although there were significant improvements in several other aspects, not all patients experienced a significant increase in sleep duration. Suggests that sleep duration may not always significantly increase in patients with severe sleep disorders after CBT-I, whether conducted face-to-face or online, depending on the patient's profile and prognostic factors (Furukawa, Sakata, Furukawa, et al., 2024; Furukawa, Sakata, Yamamoto, et al., 2024; Pchelina et al., 2024). Other factors, such as neuropathic pain in diabetes patients, can also affect sleep duration, so CBT therapy needs to be combined with pain management (Strambi, 2017).

WASO

WASO data describe wakefulness after sleep onset, excluding wakefulness before sleep onset, which reflects sleep fragmentation (Shrivastava et al., 2014). The effect of CBT-I/CBT on WASO in T2DM patients has been reported to be minimal, as was the case in this study. However, several studies have reported reductions in WASO after various interventions. Alshehri et al. (2020) study reported significant results based on sleep diaries and actigraphy, while Groeneveld et al. (2024) did not report a significant effect. Wu et al. (2015) meta-analysis also stated that CBT-I was effective in reducing WASO in insomnia patients with medical disorders, but the effect was small.

CBT-I reduces WASO in insomnia patients, but data on chronic comorbidities such as diabetes are still minimal (Espie et al., 2012). This finding was also reported in previous meta-analyses, such as Wang et al. (2024), which did not specifically report WASO as a primary outcome due to study limitations. Other studies have reported improvements in WASO, but they did not focus specifically on the diabetes population. Illustrates the importance of research that comprehensively measures sleep domains, including WASO, in T2DM patients. (Riemann et al., 2017)emphasized that reducing WASO is a key indicator of CBT-I success. However, people with diabetes may require additional therapy to address physical issues, such as neuropathy. Neuropathy in patients with diabetes negatively impacts sleep quality, including WASO (Schreiber, 2015; Zakin et al., 2019).

Limitation

Variations in intervention protocols across the analyzed studies, ranging from the number of sessions to the implementation format (online, offline, group, or individual) and the background and competency of the facilitators, may affect the consistency and generalizability of the findings. Most studies still rely on subjective assessment instruments, such as the PSQI and ISI, to measure sleep quality, which may introduce bias due to perceptions or reporting biases. Several studies had small sample sizes and relatively short follow-up durations, which prevented a comprehensive evaluation of long-term effectiveness and the risk of recurrence of sleep disturbance. Heterogeneity in patient characteristics, particularly regarding diabetes severity, and variations in glycemic control have not been extensively analyzed

as factors that may influence response to CBT/CBT-I therapy.

CONCLUSION

This study demonstrates that both CBT and CBT-I interventions improve overall sleep quality and total sleep time in patients with T2DM. Improvement is evident both subjectively, as reflected in PSQI scores, and quantitatively, as reflected in increased sleep duration, with benefits lasting up to 6–12 months post-intervention. However, the effects of CBT/CBT-I on specific domains, such as sleep latency and sleep efficiency, are not yet statistically significant, and WASO data remain limited. We recommend that future research on the effects of CBT and CBT-I on sleep quality in T2DM patients be conducted with larger sample sizes and adequate follow-up to evaluate long-term effectiveness and relapse risk. Intervention protocols need to be standardized, including the number and duration of sessions, the delivery method (online, offline, group, or individual), and therapist competency requirements, to ensure greater comparability and broader implementation in clinical practice. Furthermore, the use of objective measures, such as actigraphy, is highly recommended to strengthen the validity of results on changes in sleep quality, particularly in domains with currently limited data, such as sleep efficiency, sleep latency, and WASO. Future research is also expected to conduct subgroup analyses based on clinical characteristics, such as glycemic control, diabetes duration, presence of neurological complications, and other psychiatric comorbidities, to identify populations that may benefit most from this intervention.

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INTEREST CONFLICT

The authors declare no conflict of interest.

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