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ORIGINAL ARTICLE

A comparison of diabetes self-care behavior in people with type 2 diabetes with and without insomnia symptoms

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Abstract

Aims Individuals with type 2 diabetes (T2DM) are advised to undertake diabetes self-care behavior (DSCB) in order to avoid complications of T2DM. However, comorbidities, such as insomnia symptoms which are commonly reported in people with T2DM, may limit the ability to engage in DSCB. Insomnia and the common sequelae accompanying insomnia such as pain, depression, and anxiety may negatively influence the performance of DSCB. Therefore, this study aimed to compare the DSCB of people with T2DM with and without insomnia symptoms.

Methods Sixty participants with T2DM were divided into two groups based on the presence of insomnia symptoms: T2DM-only group and T2DM+ insomnia group. Insomnia symptoms were identified using the Insomnia Severity Index (ISI). DSCB was assessed using the Diabetic Care Profile (DCP). A standardized composite score was established to account for all of the DCP domains. Chi-square and independent sample *t* tests were used to assess between-group differences in categorical and continuous variables, respectively. Stepwise linear regression analysis used the ISI score to predict standardized DCP composite score, while controlling for covariates.

Results Significant between-group differences were found in age, symptoms of pain, depression, and anxiety. The total DCP composite score was significantly lower in the T2DM+ insomnia group compared to the T2DM-only group (-0.30 ± 0.46 vs. 0.36 ± 0.48, respectively, $p < 0.001$) with large effect size ($g = 1.40$). Stepwise linear regression results showed that a 1-point increase in ISI score significantly predicted a .03-point decrease in standardized DCP composite score, after controlling for age, symptoms of pain, depression, and anxiety ($\beta = -0.03$, $p = 0.04$).

Conclusions The data suggest that people with T2DM and insomnia symptoms had worse scores on the majority of the DSCB domains and a worse DCP composite score compared to people with T2DM only. The data suggest a negative association between insomnia severity and DSCB among people with T2DM. Further research using a larger sample size and more rigorous research design is required to examine the causal relationship between insomnia symptoms and DSCB.

Keywords Type 2 diabetes · Insomnia · Self-care · Diabetes self-care behavior · Composite score · Diabetic Care Profile

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Introduction

The current American Diabetes Association Standards of Medical Care recommends people with type 2 diabetes (T2DM) to perform lifestyle management to optimize glycemic control and prevent complications [1]. Lifestyle management is a fundamental aspect of diabetes self-care behavior (DSCB) activities [1], which include: understanding the disease better, receiving support from friends and family, controlling glucose level, self-addressing social and personal barriers, improving attitudes toward diabetes, adhering to healthy diet and exercise routines, considering long-term care, and addressing barriers to monitoring glucose [2, 3]. Improved DSCB has been associated with optimal glycemic control [4] and has predicted glycemic control due to its relationship with daytime activities that are essential for successful management of T2DM [5]. Thus, understanding factors, such as sleep disturbances, that may influence DSCB might help people with T2DM by aiding in improving diabetes outcomes and in preventing long-term complications.

Sleep disturbances have been shown to prevent people with T2DM from engaging in optimal DSCB. Several barriers related to psychological or physiological factors, such as sleep disturbances, might prevent people with T2DM from engaging in optimal DSCB [6–8]. Common daily symptoms, such as depression, anxiety, and pain, that are associated with both T2DM and poor sleep quality may exacerbate the difficulties to adhere with optimal DSCB [9, 10]. Taken together, poor sleep quality and these common daily symptoms can yield a vicious cycle that decreases the daytime functioning of people with T2DM [11, 12]. Previous research has shown the relationship of domains in DSCB with sleep disturbances [8, 13, 14]. These studies suggested the associated risk factors with sleep disturbances including low physical activity, fatigue, depression may result in low adherence to optimal DSCB and poor glycemic control. Since the majority of these studies agreed that DSCB and sleep quality predict glycemic control, understanding the effect of a specific sleep disturbance on the DSCB domains is warranted.

Insomnia symptoms are commonly reported in people with T2DM [15], and insomnia symptoms are characterized as one or more of the following symptoms: difficulty in falling asleep, maintaining sleep, and/or waking up too early at least 3 nights/week for the past 3 months, which impacts daytime functioning [16]. Despite the advancing research on T2DM pathophysiology, the current research often focuses on barriers that might affect good DSCB [6–8, 13, 14, 17]. However, previous studies relied on global sleep quality measurements to define sleep disturbances. There is a lack of information on the effect of insomnia symptoms on adherence with activities required for optimal DSCB in people with T2DM. It remains uncertain whether insomnia symptoms act as barriers to engage in better DSCB. In our preliminary findings, it has been shown that improving insomnia symptoms using non-pharmacological intervention showed positive effect of glycemic control [18]. Therefore, understanding the effect of insomnia symptoms on the DSCB domains is warranted.

Since DSCB is an important aspect of T2DM care, understanding negative factors related to DSCB may increase our understanding of T2DM care in future research, clinical evaluation, and health management. Therefore, in this study, the primary aim was to examine the DSCB domains among people with T2DM with insomnia symptoms compared to those without insomnia symptoms. We hypothesized that people with T2DM and insomnia symptoms will have worse DSCB domains of understanding of their disorder, friends and family support, controlling problems, social and personal barriers, attitudes toward diabetes, diet and exercise adherence, long-term care, and monitoring barriers compared with people with T2DM only. Our secondary aim was to examine the association of insomnia symptoms with the DSCB composite scores among people with T2DM. The results of this paper may help in determining the impact of insomnia symptoms on people with T2DM to help effective clinical assessment and treatment development in T2DM population.

Methods

Research design

The design of this study was cross-sectional on people with T2DM with and without insomnia symptoms. Participants with T2DM were stratified to two groups, with insomnia symptoms (T2DM+ insomnia) and without insomnia symptoms (T2DM only). A cutoff score of > 10 on Insomnia Severity Index (ISI) was used to stratify participants, and this cutoff score provided optimal sensitivity (97.2%) and specificity (100%) for the detection of insomnia in a clinical sample [19].

Participants

A total of 60 participants with self-reported T2DM were recruited at the University of Kansas Medical Center (KUMC) as well as through flyers in the community around KUMC. The Frontiers registry at KUMC was used to communicate with the potential participants during the daytime via phone calls and emails [20]. The recruitment period was between November 2018 and April 2019. The study was approved by the institutional review board at KUMC.

Written informed consent was obtained for each participant prior to their inclusion in the study.

Procedures

All participants were enrolled in this study after being screened for meeting the inclusion criteria during a phone and in-person screening session. Individuals were included if they: (1) self-reported T2DM, which was confirmed by reviewing participants' medication list during the in-person screening session; (2) were 40–75 years old; (3) were able to understand and follow verbal commands in English; and (4) were able to attend and finish the testing procedure. Individuals were excluded if they: (1) reported untreated sleep apnea or scored > 4 on STOP-Bang questionnaire; (2) were at risk of the restless leg syndrome (RLS) according to the RLS Diagnostic Index [21]; (3) reported being pregnant; (4) reported consuming ≥ 15 alcoholic drinks/week for men and ≥ 8 alcoholic drinks/week for women; (5) self-reported neurological diseases (e.g., multiple sclerosis, Alzheimer's disease, Parkinson's disease, traumatic brain injury, and stroke), bipolar disorder, seizure disorder, chronic fatigue syndrome, rheumatic diseases, being on dialysis, blindness, or transfemoral amputation; (6) reported working at night; (7) scored ≥ 7 out of 10 on the Brief Pain Inventory (BPI); (8) scored ≥ 21 on the Beck Depression Inventory (BDI); or (9) scored ≥ 15 on the Generalized Anxiety Disorder 7-item (GAD-7) scale. A description of the clinical features for the excluded participants is provided in Fig. 1.

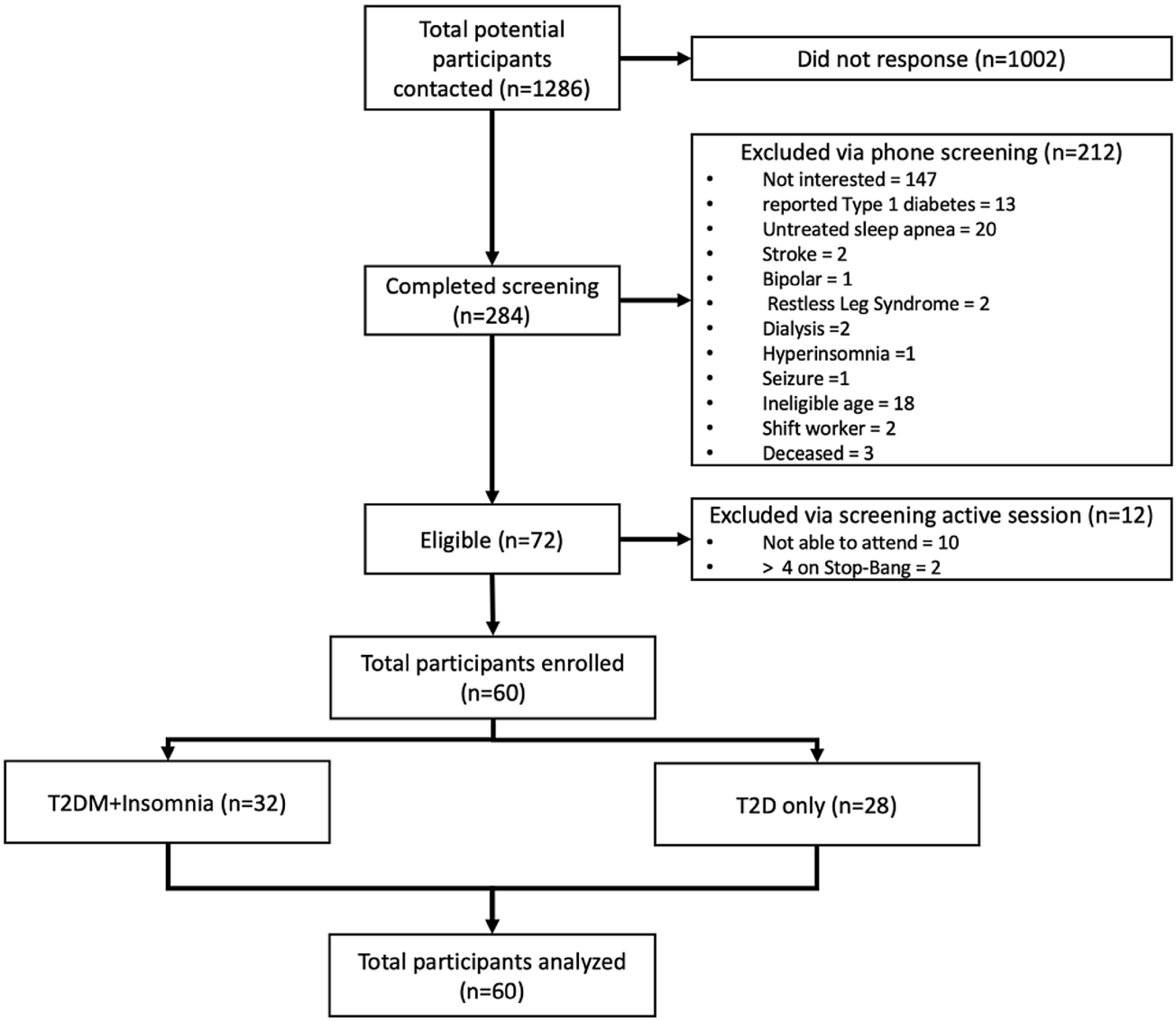

Fig. 1 Participant recruitment process

Participants were divided into either the T2DM+ insomnia group or the T2DM-only group, based on their ISI score. Participants in the T2DM+ insomnia group scored > 10 on ISI, with self-reported symptoms of difficulty in falling asleep, maintaining sleep, or waking up too early at least 3 nights/week for the past 3 months. Participants who scored ≤ 10 on ISI were assigned to the T2DM-only group. The ISI is a self-report measure designed to evaluate the nature, severity, and impact of insomnia [19].

Measures

Demographic variables Age, sex, ethnicity, and education were gathered at the first assessment session.

Clinical variables: Body mass index (BMI) was calculated using the NIH National Heart, Lung, and Blood Institute Web site (https://www.nhlbi.nih.gov/health/educational/lose_wt/BMI/bmicalc.htm). *Random blood glucose level:* Glucose level was measured by a glucose meter (FreeStyle Flash, Contour® (Bayer Healthcare, Diagnostic Division, Tarrytown, NY)). *Glycemic control (HbA1c)* was tested using A1CNow + testing kit (TMS Company) which provides percent of glycated hemoglobin A1c levels in the capillaries (fingerstick). *Passive airway pressure (PAP) utilization:* Determining whether participants were using a PAP machine was obtained by asking a yes/no question (e.g., "Do you use a PAP machine?").

Pain severity symptoms Daily pain symptoms were measured using the four-item BPI, which has demonstrated strong evidence of reliability and validity in assessing painful diabetic peripheral neuropathy [22]. We averaged the four items to represent the daily severity scale of the BPI.

Depression severity symptoms Depression symptoms were measured using the 21-item BDI, with scores ≥ 21, indicating severe depression symptoms. The BDI has demonstrated strong evidence of reliability and validity [23, 24].

Anxiety severity symptoms The GAD-7 contains 7 items where the total score ranged from 0 to 21, with higher scores indicating severe anxiety symptoms. The GAD-7 has been shown to be highly sensitive and specific for the detection of anxiety symptoms, and it is correlated with other anxiety scales [25].

Diabetes self-care behavior (DSCB) The diabetic care profile (DCP) was used to assess DSCB. The DCP is a validated instrument that measures psychosocial and educational factors associated with the management of diabetes [26, 27]. It has been shown that the DCP has demonstrated evidence of validity based on internal structure and relations to other variables in diverse samples of people with diabetes [26]. In addition, poor diabetes outcomes, such as poor glycemic control, were associated with poor scores in DCP domains [26, 28, 29]. The DCP consists of 13 domains, including understanding management of practice, support, control problems, social and personal factor, positive attitude, negative attitude, care ability, importance of care, self-care adherence, diet adherence, long-term care benefits, exercise barriers, and glucose monitoring barriers [27]. Detailed description of questions and number of items of each domain on DCP are provided in Table 1. To create the standardized DCP composite score, each domain of the DCP was scored according to the scoring rules provided by Fitzgerald et al. [27]. Next, each participant's domain score was standardized using *z*-scores. Support needs, support received, and support attitudes were averaged together for the subscale titled support. We then averaged the 13 standardized domain scores to create a standardized DCP composite score.

Statistical analysis

All data analyses were performed using SPSS 23.0 for Mac (Chicago, IL) and R (https://www.R-project.org/) [30]. Descriptive statistics included means and standard deviations for continuous variables and frequencies for categorical variables. Chi-square and independent sample *t* test analyses were used to assess for between-group differences in categorical and continuous variables, respectively. The Mann–Whitney *U* test was utilized for between-group differences in non-normally distributed data. A stepwise linear regression analysis with two models was utilized with the ISI score as the independent variable and total DCP composite score as the dependent variable. Covariates were determined based on the demographics, and clinical variables that were statistically significant differ between groups. Hedges' g (g) was used to calculate the effect size between groups, in which small effect equals 0.2, medium effect equals 0.5, and large effect equals 0.8. All tests were conducted at an alpha level of 0.05.

Results

Sixty participants were recruited and included in the final analysis. The flowchart is shown in Fig. 1. DCP data from one participant in T2DM+ insomnia group were excluded because more than 50% of the items were not completed. Participants' demographics and clinical variables of both groups are summarized in Table 2. Participants in both groups were similar in all demographics except age ($p = 0.02$), where the T2DM+ insomnia group was approximately 65 years old and the T2DM-only group was approximately 60 years old. The mean score of the ISI was 16.00 ± 3.08 in the T2DM+ insomnia group and 4.64 ± 3.15 in the T2DM-only group ($p < 0.001$). Participants in the T2DM+ insomnia group reported higher symptoms of depression (11.00 ± 5.91) and anxiety (7.41 ± 4.71) compared to participants in the T2DM only (4.79 ± 4.77 and 2.93 ± 4.00, respectively).

Table 1 Description of DCP domain questions and number of items

Domain	Number of items	Questions about the…
Understanding management of practice	13	…understanding of role factors related to diabetes such as, stress, diet, exercise, medication, foot-care, and blood sugar
Support (needs, received, and attitudes)	18	…need and help from family and friends such as, planning meal, taking medication, getting enough exercise, caring of feet, and handling feeling about diabetes
Control problems	19	…number of symptoms of hyper and hypoglycemia (during past month), and frequency of causes that blood sugar become too high or too low (during past year) such as infection, upset or angry, wrong medication or food
Social and personal factor	13	…feelings that diabetes keeps from performing daily activities (during past year) and avoids from social and personal aspects such as having enough money, meeting family responsibilities, having good relationship, being active, and eating as much food as wanted
Positive attitude	5	…satisfaction with life such as ability and willingness to do anything
Negative attitude	6	…feeling about diabetes such as being afraid, unhappy, and depressed, or dissatisfied with life because of diabetes
Care ability	4	…ability to control common aspects for diabetes care such as blood sugar, weight, diet, medicine, exercise and stress
Importance of care	4	…knowing the importance of common aspects for diabetes care such as blood sugar, weight, diet, medicine, exercise and stress
Self-care adherence	4	…blood sugar and weight were in good control, duties (diet, medicine, exercise) done for diabetes control, and feelings (fear, worry, anger) handled well
Diet adherence	4	…meal plan, food quantity, and food exchange lists
Long-term care benefits	5	…best possible care of eye, kidney, foot, hardening of the arteries, and heart
Exercise barriers	5	…trouble getting enough exercise because of effort, useless, hatred, and health
Glucose monitoring barriers	11	…don't testing sugar as often as have been told because of keeping forget, not right place or time, costing a lot, running out of materials, and hurting fingers

Severity of pain was significantly higher in people with T2DM+ insomnia group (3.27 ± 2.10) compared to participants in T2DM-only group (1.55 ± 1.67). There were no significant between-group differences in random glucose level and glycemic control ($p = 0.08$ and $p = 0.58$, respectively). The mean duration of self-reported T2DM diagnosis was 16.50 ± 10.35 years in the T2DM+ insomnia group versus 14.23 ± 12.00 years in the T2DM-only group ($p = 0.44$).

The total standardized DCP composite score was significantly lower in the T2DM+ insomnia group compared to the T2DM-only group (-0.30 ± 0.46 vs 0.36 ± 0.48, respectively, $p < 0.001$; $g = 1.40$; Table 3). In addition, participants in the T2DM+ insomnia group scored significantly lower on 10 out of 13 domains of the DCP, including understanding management of practice, support, control problems, social and personal factor, positive and negative attitudes, care ability, self-care adherence, diet adherence, log-term care benefits, and exercise barriers compared to participants in T2DM-only group, which all indicate poor outcomes (Table 3). The effect sizes of all the significantly differed DSCB domains ranged from 0.51 to 1.40, which indicate moderate to large effect sizes. The stepwise linear regression analysis of potential predictors of ISI for all participants is presented in Table 4. The final model of the stepwise linear regression results showed that a 1-point increase in ISI significantly predicted a .03-point decrease in standardized DCP composite score in people with T2DM, even after controlling for age, pain, depression, and anxiety ($\beta = -0.03$, $p = 0.04$).

Discussion

This is the first study comparing domains of DSCB in people with T2DM with and without insomnia symptoms. Despite the small sample size, our findings showed that participants with T2DM and insomnia symptoms had a lower total DCP composite score and worse scores on 10 out of 13 DSCB domains, compared to participants with T2DM only. These findings suggested a negative relationship between insomnia symptoms and DSCB in people with T2DM. People with T2DM and insomnia symptoms showed more severe symptoms of pain, depression, and anxiety compared to participants with T2DM without insomnia symptoms. After controlling for age and psychological symptoms, decreased ISI scores significantly predicted greater DCP composite scores for the sample. These results may indicate the importance of screening insomnia symptoms in people with T2DM for better DSCB outcomes.

Table 2 Comparison of demographics and clinical variables between T2DM with and without insomnia symptoms

	T2DM only (mean ± SD) ($n = 59$)	T2DM+ insomnia (mean ± SD) ($n = 59$)	p value	Effect size
Age	64.79 ± 6.50	60.28 ± 7.83	0.02	$g = 0.62$
Gender, female, n (%)	13 (46.42)	19 (59.37)	0.44	OR = 1.68
BMI	35.57 ± 7.90	32.54 ± 5.26	0.08	$g = 0.46$
Education, n (%)			0.42	OR = 1.11
8 grades or less	0 (0)	1 (3.12)		
High school	5 (17.85)	6 (18.75)		
Some college	11 (39.28)	6 (18.75)		
College graduate	7 (25)	11 (34.37)		
Graduate degree	5 (17.85)	8 (25)		
Ethnicity, n (%)			0.28	OR = 1.08
White	21 (75)	23 (71.87)		
Black	5 (17.85)	3 (9.37)		
Other	2 (7.14)	6 (18.74)		
ISI total	4.64 ± 3.15	16.00 ± 3.08	< 0.001	$g = 3.65$
BPI	1.55 ± 1.67	3.27 ± 2.10	0.001	$g = 0.90$
BDI	4.79 ± 4.77	11.00 ± 5.91	< 0.001	$g = 1.15$
GAD-7	2.93 ± 4.00	7.41 ± 4.71	< 0.001	$g = 1.02$
Using PAP, n (%)			0.74	OR = 1.2
Never	18 (64.28)	20 (62.5)		
Current	9 (32.14)	12 (37.5)		
Random glucose level	134.96 ± 26.67	162.09 ± 78.88	0.08	$g = 0.45$
HbA1c, %	6.77 ± 1.03	6.92 ± 0.96	0.58	$g = 0.15$
Diabetes duration	14.23 ± 12.00	16.50 ± 10.35	0.44	$g = 0.20$

G Hedges' g; OR = odds ratio

Table 3 Comparison of DCP 15 domains and composite score between T2DM with and without insomnia symptoms

	T2DM only (mean ± SD) ($n = 59$)	T2DM+ insomnia (mean ± SD) ($n = 59$)	p value	Effect size	95% confidence interval
Control problems	.37 ± 1.01	− .26 ± .95	0.02[a]	0.64	(0.08 to 1.16)
Social and personal factors	.61 ± .86	− .34 ± .89	< 0.001[a]	1.08	(0.49 to 1.4)
Exercise barriers	.39 ± .1.00	− .37 ± .86	0.003[a]	0.81	(0.27 to 1.25)
Monitoring barriers	.08 ± .82	− .13 ± 1.21	0.87[b]	0.21	(− 0.36 to 0.79)
Negative attitude	.38 ± 1.11	− .2 ± .81	0.02[b]	0.59	(0.07 to 1.08)
Understanding management of practice	.55 ± .97	− .47 ± .81	< 0.001[a]	1.13	(0.56 to 1.48)
Support	.22 ± .81	− .15 ± .61	0.04[a]	0.51	(0.01 to 0.75)
Positive attitude	.26 ± 1.33	− .17 ± .74	0.02[b]	0.39	(− 0.12 to 1.00)
Care ability	.42 ± 1.07	− .35 ± .82	0.002[a]	0.80	(0.31 to 1.27)
Importance of care	.07 ± 1.28	− .21 ± .88	0.08[b]	0.26	(− 0.28 to 0.85)
Self-care adherence	.63 ± 1.02	− .43 ± .78	< 0.001[a]	1.16	(0.60 to 1.54)
Diet adherence	.44 ± .89	− .32 ± 1.00	0.005[a]	0.80	(0.24 to 1.28)
Log-term care benefits	.27 ± .76	− .33 ± 1.20	0.02[b]	0.60	(0.06 to 1.12)
DCP total composite score	.36 ± .48	− .30 ± .46	< 0.001[a]	1.40	(0.42 to 0.92)

[a]Independent sample t test

[b]Mann–Whitney U test

Table 4 Stepwise linear regression results of the potential predictors of ISI

Model	Predictors	β	t	p	
First model ($n=59$)	ISI	−0.05	−5.26	<0.001	$R=0.57$
					R^2 change = 0.33
					$p<0.001$
Final model ($n=59$)	ISI	−0.03	−2.11	0.04	$R=0.72$
					R^2 change = 0.20
	Age	0.006	0.77	0.44	$p=0.001$
	BPI	0.001	0.03	0.98	
	BDI	−0.04	−2.84	0.006	
	GAD-7	−0.01	−0.56	0.58	

Dependent variable: DCP composite score

First model: ISI

Final model: ISI, age, BPI, BDI, and GAD-7 that remained in the final model

Several potential explanations may illustrate the association between insomnia symptoms and DSCB. The 10 DSCB domains that were worse in people with T2DM and insomnia symptoms compared to people with T2DM only were understanding management of practice, support, control problems, social and personal factors, positive attitude, negative attitude, care ability, diet adherence, self-care adherence, log-term care benefits, and exercise barriers. These domains required complex actions related to psychosocial, judgmental, educational, and emotional distress aspects [31]. Generally, people with T2DM required more effort for diabetes education in order to be able to perform optimal self-care, diet adherence, and long-term benefits, in which extra effort may eventually increase diabetes distress [31]. Our findings indicated that the effects of insomnia symptoms may contribute in diabetes-related distress and may eventually affect domains that are important in DSCB for people with T2DM. In addition, insomnia symptoms are associated with declining initial learning and consolidation of treatment plans [32], which could be a factor in suboptimal DSCB. Also, another study has shown the effect of sleep disturbances on mood and cognition function [33] and cognitive declines on self-care [34]. However, it was difficult to determine whether low scores of domains on DSCB related to educational aspects were due to learning issues or cognitive difficulties related to sleep disturbances [35]. This is consistent with a previous study which found that people with insomnia have impaired psychological well-being outcomes, which may further complicate T2DM management [31]. In addition, our data suggested that people with T2DM and insomnia symptoms tended to receive less support from family and friends, which is consistent with an 8-year longitudinal study which found that a lack of friend and family support was predictors of sleep disturbances in middle-aged adults [36]. Our findings were consistent with previous studies that suggested an association between poor sleep quality and positive attitude, control problems [8], and high burdens of self-care in people with T2DM [14]. In a longitudinal study, sleep quality was a strong prediction of poor self-care for 64 older adult patients with T2DM [6]. Also, recent study suggested improving sleep quality may help to increase diabetes self-care management among people with T2DM [37]. Overall, future research needs to investigate the underlying mechanisms that cause suboptimal DSCB in people with T2DM and insomnia.

Psychological factors such as depression and anxiety have been associated with DSCB in people with T2DM [38, 39]. We found that people with T2DM and insomnia symptoms had worse symptoms of depression and anxiety than those with T2DM only. It might be that the combination of psychological issues along with insomnia symptoms explains relationship between insomnia symptoms and suboptimal DSCB. Although we excluded people with severe symptoms of depression and anxiety, we did observe changes in the magnitude of the regression coefficient for insomnia symptoms when covariates were added, but ISI still significantly predicted the total DCP composite score. Our findings supported the association between negative psychological well-being and social outcomes with insomnia that has been found in previous studies [40, 41], and this association may exacerbate poor adherence to DSCB. Future studies are needed to evaluate the complex relationship between DSCB and insomnia symptoms in T2DM with and without severe symptoms of psychological health.

Contrary to the domains of DSCB previously mentioned, we found no between-group differences in the glucose monitoring barriers and importance of care domains. People with T2DM and insomnia symptoms had lower scores in these domains but did not reach the significant level. Glucose monitoring is important diabetes daily routines to control hyperglycemia or hypoglycemia for optimal glycemic control [42]. However, a systematic surveillance of 247 studies showed that routine home glucose monitoring is not needed in patients with T2DM [43]. In addition, our study suggested

that insomnia symptoms might not have an additional effect on barriers related to glucose monitoring such as financial, environmental, or psychological barriers. Additionally, our work suggested no effects of insomnia symptoms on participants' knowledge of the importance of diabetes care, which includes managing blood sugar, weight, diet, medicine, exercise, and stress in people with T2DM. Although both groups had enough knowledge of diabetes care, insomnia symptoms showed evidence of deteriorating other domains related to DSCB. To our knowledge, there is limited research investigating the glucose monitoring barriers importance of care domains in people with T2DM and sleep disturbances, which made difficulties in comparing our findings with previous studies.

Insomnia symptoms and DSCB may be associated due to different potential mechanisms. A meta-analysis regarding glycemic control in people with T2DM and sleep disturbances showed between-study heterogeneity [44]. They concluded that the presence of comorbidities, diabetes medications, untreated other sleep disorders, unreported depression, and sample size may have contributed to the between-study heterogeneity. With the reported information, it is possible that we did not find between-group differences in glycemic control or glucose level due to the low sample size and less sensitive blood measures. However, we did find severe insomnia symptoms predicted low adherence to DSCB in people with T2DM after controlling for covariates. It has been suggested that the association between insomnia symptoms and glycemic control may have resulted from changes in physiological pathways which led to metabolic changes. These changes may eventually deteriorate DSCB and increase the risk of poor glycemic control [45]. In addition, exploring the efficacy of a sleep behavioral intervention combined with diabetes education to address the insomnia symptoms and improve DSCB in people with T2DM is needed.

Although this is the first study to compare multiple domains of DSCB in T2DM with and without insomnia symptoms, some limitations of this study should be mentioned. Although we used a sensitive and valid screening instrument to screen for clinical insomnia in community sittings, conducting clinical interviews to ascertain the diagnosis and duration of symptoms is a gold standard criterion to diagnose people with insomnia. Measuring glycemic control using HbA1c kits is less sensitive than laboratory blood tests. We recommend future studies use more sensitive measures of glycemic control and include other common diabetes laboratory outcomes to identify any between-group differences. We measured DSCB subjectively, since there are no standardized objective measures that could be used to assess self-care in this population. It could be beneficial to develop an objective measure to capture activities related to DSCB such as physical activity, diet, sleep quality, medication adherence, and glucose monitoring. Finally, future studies with larger sample sizes and more rigorous designs are needed to overcome the limitations associated with low sample sizes and to minimize the impact of extraneous variables.

In conclusion, this study found that individuals with T2DM and insomnia symptoms showed lower total DCP composite scores and worse scores on the majority of DSCB domains when compared to those with T2DM only. These findings suggested a negative relationship between insomnia symptoms and DSCB in people with T2DM. After controlling for age and psychological symptoms, decreased ISI scores were associated with positive DCP composite scores in this population. Thus, the data suggested that T2DM and insomnia symptoms were associated with worse DSCB compared to the DSCB of those with T2DM only. Further research is required using a longitudinal design to examine the causality relationship between insomnia symptoms and DSCB on a larger sample size. In addition, we recommend future work explore the association between DSCB and insomnia symptoms in people with T2DM with and without psychological symptoms to help in establishing interdisciplinary interventions for this population.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights All procedures were approved by the University of Kansas Medical Center Institutional Review Board.

Informed consent All participants provided informed consent prior to their participation.

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