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Original Article

Discrepancy between desired time in bed and desired total sleep time in patients with cancer: the DBST index and the relationship with insomnia severity or sleep onset latency

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Simple Summary: Insomnia is an important psychiatric issue for patients with cancer, which does not seem to be managed easily. Discrepancy between a patient's desired time in bed and total sleep time (DBST) index could be a measurement tool for insomnia severity in cancer patients. The DBST index was significantly correlated with long sleep onset latency[SOL] and long SOL is predicted by high DBST index. The DBST index could give additional information about insomnia severity and clinicians could use this index for evaluating treatment effect.

Abstract: Patients with cancer experience insomnia or sleep disturbances. This study aimed to explore whether the discrepancy between a patient's desired time in bed and total sleep time (DBST) index is a measurement tool for insomnia severity or sleep onset latency [SOL] in patients with cancer. This retrospective medical records review study gathered clinical information and rating scale scores including Insomnia Severity Scale (ISI), Cancer-related Dysfunctional Beliefs about Sleep scale (C-DBS), Patient Health Questionnaire-9 items (PHQ-9), State subcategory of State and Trait Anxiety Inventory, and Short form of Fear of Progression Questionnaire. Sleep indices of time variables (bedtime, sleep onset time, and wake-up time), duration variables [SOL, time in bed (TIB), time in bed for 24 hours (TIB/d), and duration from wake-up time to bedtime (WTB)], and the DBST index were calculated. The ISI score was predicted by PHQ-9 (β=0.34, P<0.001), C-DBS (β=0.17, P=0.034), and DBST index (β=0.22, P=0.004) with a significant correlation with the DBST index (r=0.19, p=0.020). The DBST index was significantly correlated with long SOL (r=0.23, P=0.005). Long SOL was predicted by early bedtime (β=0.18, P=0.045), short WTB (β=-0.26, P=0.004), and high DBST index (β=0.19, P=0.013). The DBST index was significantly correlated with a predicting variable each for insomnia severity and SOL in patients with cancer.

Keywords: cancer; insomnia; sleep; circadian; the DBST index

1. Introduction

Insomnia could be defined using different perspectives; however, in the context of symptoms, almost one-third of individuals experience insomnia [1]. Many studies have shown that the causes underlying insomnia are not only biological factors, but also behavioral and cognitive factors [2]. Some individuals could be treated for insomnia within a few days to weeks, while in other patients' symptoms improved to chronic insomnia, which last for several years. If the majority of insomnia causes are based on biochemical factors, most pharmacological treatments should have been successful in all the patients. However, even the British Association for Psychopharmacology consensus statement advises cognitive behavior therapy (CBT) as the first choice for the short-term treatment of chronic insomnia [3]. Moreover, according to the guideline of the USA based on a systematic review, CBT is supported by moderate evidence in differently aged groups [4].

Several studies, including a case-control and meta-analysis recently have shown that cognitive behavioral therapy for insomnia (CBT-I) is significantly effective in reducing

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sleep disturbance [4,5]. The CBT-I is based on the management of illogical cognitive thoughts to insomnia; therefore, dysfunctional beliefs regarding sleep could be improved by cognitive reconstructing and changing. A systematic literature review and meta-analysis showed that CBT-I significantly reduced the dysfunctional beliefs regarding sleep with moderate to large effect [6]. Dysfunctional beliefs about sleep contribute to sleep disturbances and aggravate sleep problems. These include beliefs about the immediate consequences, long-term consequences, and control [7]. To measure this concept, the Dysfunctional Beliefs and Attitudes about Sleep Scale (DBAS) is commonly used in clinical fields with different numbers of questionnaire versions.

Insomnia is an important psychiatric issue for patients with cancer, which does not seem to be managed easily. A longitudinal study showed that 74% of patients' experience insomnia for a period of at least 1 year and 46% report insomnia over a period of 3 years [8]. A cross-sectional study found that approximately 43% of patients with cancer complained of insomnia and 32% of patients with insomnia reported severe insomnia [9]. Its risk factors and correlation with cancer-related symptoms have not yet been elucidated. However, cancer itself, the process of treatment, and psychological status could affect each other, and this relationship could be the cause of distorted cognition adding to the fear of death. Notably, patients with cancer respond in a more sensitive manner with dysfunctional beliefs for insomnia, such as "If I don't get enough sleep, my immune system will be broken down and then I will get sick," even though those thoughts usually do not have medical evidence. In a medical records review study in Korea, dysfunctional beliefs about sleep in patients with cancer correlates with the severity of insomnia regardless of depression [10].

Up to 50% of patients with cancer complain of insomnia; however, physicians pay limited attention to it compared to that for other accompanied symptoms, such as pain [11]. Untreated insomnia affects the caregivers and family of patients as well as patients with cancer and it could be another burden in the process of treatment. Several studies suggest that insomnia can have a deleterious impact on the physical symptoms, social well-being, survival rates, and relapse in patients with cancer [12]. Therefore, managing insomnia and improving sleep is essential for patients with cancer, as well as other major treatments like chemotherapy or radiotherapy [13].

Discrepancy between the desired time in bed and desired total sleep time: the DBST index

The DBST index refers to the discrepancy between one's desired total hours in bed and one's desired hours of total sleep [14,15]. One of the most popular misbeliefs of patients with insomnia is that the longer the sleeping time, the better it is for health. People need only a certain amount of sleep every 24 h and the average amount of sleep needed gradually decreases during the course of the life span [16]. For example, during adulthood, the average individual needs 7 to 8 hours of sleep in a day. If people go to bed and sleep during any period of daytime, their "real" sleep time, the duration that people report they would sleep, would be deducted from the amount of sleep needed. This could be explained by the sleep regulation model of two factors: process S, homeostasis and process C, circadian control. Process S refers to the longer the period of one's arousal, the more they need to sleep.Moreover this can be referred to as the pressure to sleep. This is significantly associated with the circadian rhythm controlled by suprachiasmatic nuclei (SCN). This model supported non-pharmacological treatment paradigms in psychiatry, based on manipulating the circadian phase, sleep, and light exposure [17].

Discrepancies between the actual time and reporting/desired time has been an issue for studying insomnia. Several studies previously have been interested in the concept of "paradoxical insomnia." [18,19]. The polysomnographic (PSG) findings of paradoxical insomnia patients show a significantly longer total sleep time than the patients' report of

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sleep time [20]. As an extension of this concept, a higher DBST index reflects that one wants to sleep more than the actual duration that he/she needs to sleep. We hypothesized that the more severely the individuals experience sleep disturbances, the larger this discrepancy would be.

We previously reported that the DBST index may be an index for insomnia severity [14,15]. Among the general population [14], the DBST index was significantly correlated with insomnia severity or preoccupation with sleep. In addition, a persistent preoccupation with sleep partially mediated the influence of the DBST index on their insomnia severity. In another study conducted among the general population [21], the DBST index was significantly correlated with insomnia severity, depression, preoccupation with sleep, and dysfunctional beliefs about sleep. Additionally, a mediation analysis showed that the DBST index directly influenced the severity of insomnia, and depression, dysfunctional beliefs about sleep, and preoccupation with sleep mediated the association between the DBST index and severity of insomnia.

However, there is no study on DBST among patients with cancer to date. Patients with cancer experience insomnia or sleep disturbance due to the disease itself, symptoms of cancer, side effects of treatment modalities, or fear of progression; assessing the severity of the insomnia is important when we psychologically support the patients. In this study, we aimed to explore whether the DBST index can be a measurement tool for the severity of insomnia in patients with cancer. The hypotheses of this study are that 1) the DBST index may be associated with insomnia severity among patients with cancer, and 2) the DBST index may be associated with sleep onset latency.

2. Methods

2.1. Participants and procedure

This study was a retrospective medical records review study among patients with cancer who visited the sleep clinic specialized for patients with cancer for the first time, which was running in ASAN Medical Center. We reviewed the medical records of patients with cancer who visited between May 1, 2021 and March 15, 2022. We collected a total of 146 patients, excluding those who met the following exclusion criteria: 1) patients who are immobile, 2) patients who have severe medical problems or metastasis to their brain which influence their cognitive function, 3) patients having severe psychotic symptoms or delirium, 4) patients who cannot respond to the questionnaires, and 5) patients who have difficulty in communication. At the first visit, a psychiatrist (a sleep specialist, S.C.), who was trained to manage cancer patients' psychological problems, routinely evaluated the patient's psychiatric diagnosis using clinical interviews. We gathered the patients' information on age, sex, types of cancer, staging, current treatment modalities, their responses to questions on sleep pattern, and rating scales scores. The protocol of this study was approved by the Asan Medical Center Institutional Review Board (2022-0353), and the requirement for informed consent was waived.

2.2. Measures

2.2.1. Sleep indices and the DBST index

We measured the sleep indices of time variables (bedtime, sleep onset time, and wake-up time), duration variables [sleep onset latency (SOL), time in bed (TIB), time in bed during 24 hours (TIB/d), and duration from wake-up time to bedtime (WTB)[22]], and the DBST index based on the patients' responses to questions on sleep patterns. The sleep indices were calculated from responses to the questions: "What is your usual bedtime?", "What is your usual time to fall asleep?", and "What is your usual time to finally get out of bed in the morning?" [14,15].

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2.2.2. Calculating the time variables

The time variables were obtained by averaging the usual times responded. If a patient answered that they usually went to bed between 22:00 and 23:00, we estimated that the usual bedtime as 22:30 by averaging those times. For the statistical analysis, we transformed the usual times as numeric variables. A period of 15 min (one quarter of 1 h) was transformed into 0.25 (one quarter) and 30 min (half of 1 h) was 0.50. Therefore, 22:15 was transformed into 10.25.

2.2.3. Calculating duration variables

The duration variables were estimated using the time variables. The SOL was estimated on the difference from sleep onset time to bedtime, and TIB was estimated on the difference from the wake-up time to bedtime (TIB = wake-up time + 12 - bedtime). We also estimated the patients' WTB, since it was reported that the WTB was significantly different between insomnia patients whose sleep latency $\leq$ 30 and > 30 minutes [22]. The WTB was estimated on the duration from wake-up time to bedtime (i.e., WTB = 24 - TIB [22]). The TIB/d was also estimated, since the TIB/d was a sleep index, which can reflect a patient's physical activity during 24 h a day [23]. Patients with cancer easily get fatigue symptoms while being treated, and the TIB/d can be helpful to evaluate their physical activity in a day. It was estimated based on the responses to questions of "How long do you stay lying down on your bed during a day?"

2.2.4 Calculating the DBST index

The DBST index was estimated as a difference in the patient's desired total sleep time estimated on the response to the question of "For how many hours do you want to sleep in a day?" and the desired time in bed estimated by the response to the question of "From what time to what time do you want to sleep?" Finally, the DBST index was calculated as [desired hours of time in bed] - [desired hours of total sleep time][14].

2.3. Insomnia Severity Scale

The ISI is a self-rating scale developed to measure the severity of insomnia of an individual [24]. A higher total score reflects a severe level of insomnia. We applied the Korean version of the ISI scale [25].

2.4. Cancer-related Dysfunctional Beliefs about Sleep scale (C-DBS)

The C-DBS is a self-reported rating scale, which can measure the cancer-related dysfunctional beliefs about sleep in patients with cancer [26]. It consists of two items which can be rated on a 0–10 scale. A higher total score reflects a higher level of dysfunctional beliefs about sleep in cancer patients. The C-DBS was originally developed in the Korean language, and we applied the original version in this study.

2.5. Patient Health Questionnaire-9 items (PHQ-9)

The PHQ-9 is a self-rating scale, which can measure the severity of depression in an individual [27]. It consists of 9 items, which can be rated on a 4 point Likert scale, ranging from 0 (not at all) to 3 (nearly every day). A total score of PHQ-9 scale reflects higher levels of depression. In this study, we applied the Korean version of PHQ-9 [28].

2.6. State subcategory of State and Trait Anxiety Inventory (STAI-S)

The STAI is a self-rating scale, which was developed for assessing one's trait and state of anxiety. It consists of 40 items, and these were categorized into two parts: 20 items for

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the state and 20 items for trait [29]. The items can be rated on a 4 point Likert scale ranging from 1 (not at all) to 4 (very much so). In this study, we applied 20 items of state of anxiety from the Korean version of the scale [30].

2.7. Short form of Fear of Progression Questionnaire (FoP-Q-SF)

The FoP-Q-SF was a shortened version of the original FoP-Q scale [31], which can measure the fear of disease progression of an individual. It was reported to be applied among cancer patients [32]. The FoP-Q-SF consists of 12 items, which can be rated on a XX point Likert scale, and a higher total score reflects a higher level of fear of progression. We applied the Korean version in this study [33].

Statistical analysis

The data on the demographic characteristics and scores of rating scales are summarized as mean ± standard deviation. The level of significance for the analyses was defined as two-tailed at values of $P<0.05$. In this study, we aimed to explore the usefulness of the DBST index in predicting the insomnia severity or sleep onset latency. We divided the clinical variables into two parts: 1) rating scales scores and the DBST index and 2) sleep indices and the DBST index. In the first part, Pearson's correlation coefficients were examined to explore the association of insomnia severity with other rating scales and the DBST index. A linear regression analysis with stepwise methods was performed to explore whether the DBST index can predict the insomnia severity. In the second part, Pearson's correlation analysis was performed to explore the association of sleep onset latency with other sleep indices and the DBST index. A stepwise linear regression analysis was performed to explore whether the DBST index can predict the sleep onset latency. The statistical analysis was performed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA) and Jamovi version 1.6.18.0.

3. Results

A total of 146 patients were included in the analysis. The mean age of the patients was 56.7 (SD = 11.6) years, of whom 74.0% (N = 108) were women. Most patients (N = 109, 74.7%) were diagnosed with sleep-wake disorders. The others were diagnosed with depressive disorder (11.6%), anxiety disorder (5.5%), adjustment disorder (2.1%) and others as presented in Table 1. As for the cancer-related variables, 137 patients (93.8%) had solid tumors and 17.2% were at stage IV disease among TNM classification available patients. 28.8% of patients had undergone surgery within 3 months. The mean scores of the self-report questionnaires were as follows: the ISI (17.6 ± 5.9), PHQ-9 (11.1 ± 6.3), STAI (41.8 ± 8.9), FoP-Q-SF (35.3 ± 12.3), and the C-DBS (13.6 ± 4.9) (**Table 1**). For the sleep indices, the mean of time variables and duration variables are shown in **Table 2**. DBST index was calculated and the mean was 0.8 ± 1.0 (-1.0 ~ 4.5).

3.1 Part 1 - The DBST index and psychological factors among patients with cancer

The patients' age was correlated with ISI (r=0.26, $P<0.001$) and FoP-Q-SF (r=-0.16, $P<0.001$) (**Table 3**). The ISI score was significantly correlated with PHQ-9 (r=0.37, $P<0.001$), C-DBS (r=0.24, $P=0.002$), and the DBST index (r=0.19, $P=0.020$). The DBST index was significantly correlated with only the ISI score (r=0.19, $P=0.020$, **Figure 1-A**).

Table 1. Demographic and clinical characteristics of the study subjects (n=146)

Variable	N (%), Mean ± SD

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Gender, female	108 (74.0%)
Age (years)	56.7 ± 11.6
Marital status	
Unmarried	11 (7.5%)
Married	132 (90.4%)
Divorced	3 (2.1%)
Psychiatric illness, presence	144 (98.6%)
Sleep-wake disorders	109 (74.7%)
Depressive disorders	17 (11.6%)
Anxiety disorders	8 (5.5%)
Adjustment disorder	3 (2.1%)
Somatic symptom and related disorders	2 (1.4%)
Specific phobia	1 (0.7%)
Others	4 (2.7%)
Cancer types	
Solid tumor	137 (93.8%)
Breast cancer	65 (44.5%)
Gastrointestinal, hepatobiliary, and pancreatic cancer	37 (25.3%)
Other malignancy	35 (24.0%)
Hematologic malignancy	9 (6.2%)
Cancer stages (among TNM classification available patients, N = 128)	
Stage I, II, III	106 (82.8%)
Stage IV	22 (17.2%)
Surgery within 3 months	42 (28.8%)
Current cancer treatment, presence	
Chemotherapy	46 (31.5%)
Radiation therapy	18 (12.3%)
Hormone therapy	41 (28.1%)
Immune/target therapy	7 (4.8%)

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Questionnaires, score	
Insomnia Severity Index (ISI)	17.6 ± 5.9
Patients Health Questionnaire-9 (PHQ-9)	11.1 ± 6.3
State subcategory of the State and Trait Anxiety Inventory (STAI-S)	41.8 ± 8.9
Fear of Progression questionnaire-short form (FoP-Q-SF)	35.3 ± 12.3
Cancer-related Dysfunctional Beliefs about Sleep (C-DBS)	13.6 ± 4.9

Table 2. Sleep indices of the study subjects (n=146)

Variable	Mean ± SD
Time variables	
Bedtime	10:42 ± 1:12 PM
Sleep onset time	11:59 ± 1:18 PM
Wake-up time	6:36 ± 1:24 AM
Duration variables	
Sleep onset latency (min)	90.0 ± 60.0
Time in bed (h)	7.9 ± 1.5
Duration from wake-up time to bedtime (h)	16.1 ± 1.5
Time in bed during 24 hours (h)	10.2 ± 3.6
DBST	
Desired hours of time in bed	7.4 ± 1.0
Desired hours of total sleep time	6.6 ± 1.2
DBST index	0.8 ± 1.0 (-1.0 ~ 4.5)

DBST, Discrepancy between desired time in bed and desired total sleep time

Table 3. Correlation coefficients of rating scale scored and the DBST index among patients with cancer (n=146)

Variables	Age	ISI	PHQ-9	STAI-S	FoP	C-DBS2
ISI	0.26**					

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PHQ-9	0.13	0.37**				
STAI-S	-0.03	0.12	0.45**			
FoP	-0.16**	0.10	0.64**	0.45**		
C-DBS	-0.03	0.24**	0.28**	0.16	0.41**	
DBST index	0.14	0.19*	-0.04	-0.03	-0.14	-0.08

ISI, Insomnia Severity Index; PHQ-9, Patient Health Questionnaire-9 items; STAI-S, State category of State and Trait Anxiety Inventory; FoP, Fear of Progression; C-DBS, Cancer-related Dysfunctional Beliefs about Sleep; DBST, Discrepancy between desired time in Bed and desired total Sleep Time
* $P < 0.05$, ** $P < 0.01$

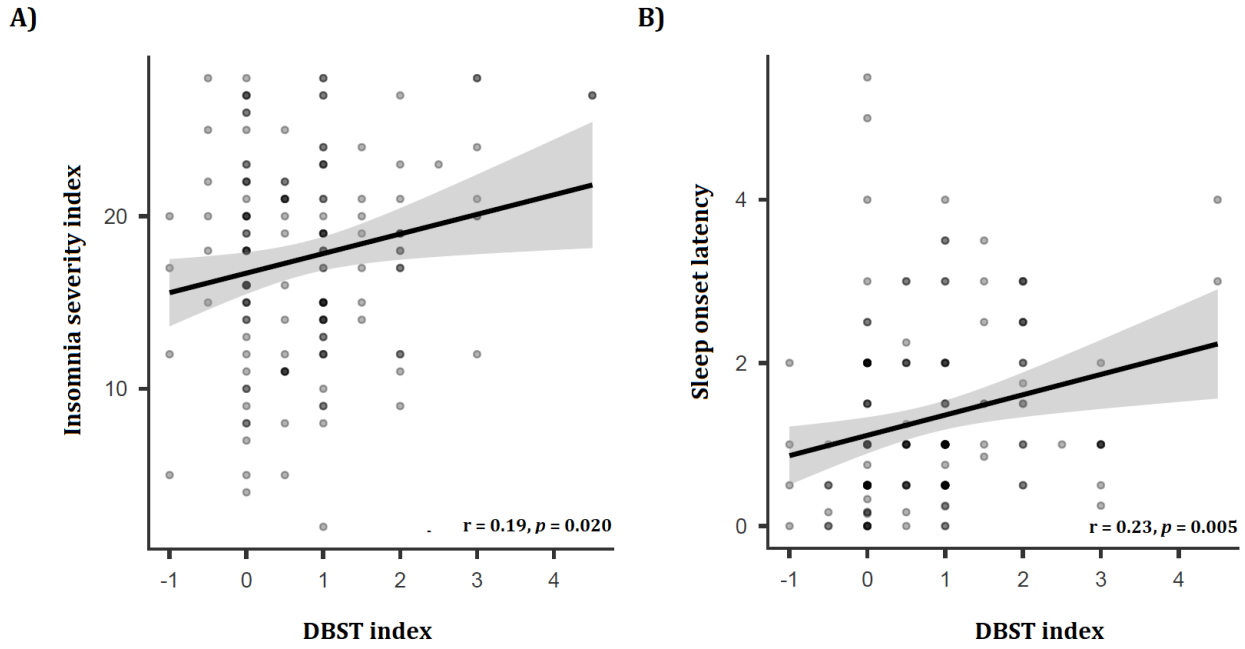

Figure 1. (A) Correlation between insomnia severity index and DBST index (B) Correlation between sleep onset latency and DBST index

A stepwise linear regression analysis was conducted to explore which variables predict the ISI score among age, PHQ-9, STAI-S, FoP-Q-SF, C-DBS, and the DBST (**Table 4**). It revealed that PHQ-9 (β=0.34, *P*<0.001), C-DBS (β=0.17, *P*=0.034), and the DBST index (β=0.22, *P*=0.004) predicted insomnia severity (adjusted R^2=0.19, F=12.5, *P*<0.001).

Table 4. Stepwise linear regression analysis to explore the predicting variables for insomnia severity of patients with cancer (n=146)

Dependent Variables	Included parameters	Beta	*P*-value	Adjusted R^2	F, *P*-value

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Insomnia Severity Index	PHQ-9	0.34	< 0.001	0.19	F=12.5 p<0.001
	C-DBS	0.17	0.034		
	DBST index	0.22	0.004		

*adjusted with age and scores of state category of the State and Trait Anxiety Inventory and Fear of Progression scale
PHQ-9, Patient Health Questionnaire-9 items; C-DBS, Cancer-related Dysfunctional Beliefs about Sleep-2 items; DBST, discrepancy between desired time in bed and desired total sleep time

3.2 Part 2 - The DBST index and sleep indices among patients with cancer

A correlation analysis showed that a long SOL was significantly associated with long TIB (r=0.35, *P*<0.001), long TIB/d (r=0.23, *P*=0.007), short WTB (r=-0.35, *P*<0.001), early bedtime (r=-0.32, *P*<0.001), late sleep onset time (r=0.54, *P*<0.001), high DBST index (r=0.23, *P*=0.005, **Figure 1-B**), and short desired TST (r=-0.17, *P*=0.039) (**Table 5**). We conducted a stepwise linear regression analysis to explore variables, which can predict the long sleep onset latency. We included the variables of age, bedtime, TIB/d, WTB, and the DBST index in the final model, since the wake-up time, TIB, desired TST, and desired TIB influenced the multicollinearity. The stepwise regression model revealed that long SOL was predicted by early bedtime (β=0.18, *P*=0.045), short WTB (β=-0.26, *P*=0.004), and high DBST index (β=0.19, *P*=0.013) (adjusted R^2=0.17, F=10.5, *P*<0.001, **Table 6**).

Table 5. Correlation coefficients of the DBST index, time, and duration variables among patients with cancer (n=146)

Variables	Age	SOL	TIB	TIB/d	WTB	Bedtime	Sleep onset time	Wake-up time	the DBST index	Desired TIB
SOL	-0.06									
TIB	-0.16	0.35**								
TIB/d	0.09	0.23**	0.43**							
WTB	0.16	-0.35**	-1.00**	-0.43**						
Bedtime	-0.18*	-0.32**	-0.48**	-0.25**	0.48**					
Sleep onset time	-0.20*	0.54**	-0.14	-0.04	0.14	0.63**				
Wake-up time	-0.32**	0.10	0.66**	0.24**	-0.66**	0.34**	0.38**			
DBST index	0.14	0.23**	0.06	-0.08	-0.06	-0.13	0.07	-0.05		
Desired TIB	-0.03	0.24	0.28**	0.14	-0.28**	-0.15	-0.11	0.17*	0.29**	
Desired TST	-0.14	-0.17*	0.19*	0.18*	-0.19*	-0.16	-0.16	0.19*	-0.59**	0.60**

SOL, Sleep Onset Latency; TIB, Time In Bed; TIB/d, Time In Bed during 24 hours; WTB, duration from Wake-up time

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To Bedtime; DBST, Discrepancy between desired time in Bed and desired total Sleep Time; TST, Total Sleep Time
* $P < 0.05$, ** $P < 0.01$

Table 6. Stepwise linear regression analysis to explore the predicting variables for sleep onset latency of patients with cancer (n=146)

Dependent Variables	Included parameters	Beta	*P*-value	Adjusted R^2	F, *P*-value
Sleep Onset Latency	Bedtime	-0.18	0.045	0.17	F=10.5 *P*<0.001
	WTB	-0.26	0.004		
	DBST index	0.19	0.013		

* adjusted with age and time in bed during 24 hours
WTB, duration from Wake-up time To Bedtime; DBST, Discrepancy between desired time in Bed and desired total Sleep Time

4. Discussion

In this study, we attempted to explore whether the DBST index can be used as a measurement tool for insomnia severity in patients with cancer, and we hypothesized that the DBST index may be associated with 1) the severity of insomnia among patients with cancer, and 2) the SOL. We observed that the DBST index was significantly correlated with one of the predicting variables each for insomnia severity and SOL of patients with cancer.

4.1 Insomnia severity and the DBST index among patients with cancer

We observed that the DBST index can predict the insomnia severity of patients with cancer in this study as hypothesized. Furthermore, the severity of insomnia in patients with cancer was predicted by the DBST index with PHQ-9 and C-DBS scales scores. Patients with cancer are observed to worry that their sleep disturbance might influence the cancer recurrence and impair their immune function, [26] and they desperately want to sleep for at least 6.6 hours (6.6 ± 1.2 hours, **Table 2**). This hope was influenced by their cancer-related dysfunctional beliefs about sleep. The C-DBS scale was developed to assess these dysfunctional beliefs about sleep among patients with cancer with the question "My immune system will have serious problems if I don't go to sleep at a certain time" (Q1-immune) and "If I don't sleep well at night, my cancer may recur or metastasize" (Q2-recurrence [26]). Patients with cancer may experience cancer-related fatigue symptoms due to chemotherapy and their physical or psychological states [34], and they unconsciously try to sleep for more time laying on their bed or sofa. This might increase their desired TIB, and the discrepancy might increase the DBST index. Paradoxically, this discrepancy reflects the severity of their insomnia and spending a long time in bed during daytime and early bedtime might aggravate the severity of their insomnia. Therefore, we should develop the CBT-I approach adapted for patients with cancer [35]. Further study is needed to examine whether decreasing this discrepancy may reduce their insomnia severity.

Parallel to the previous study, we observed that the C-DBS was one of the predicting factors for insomnia severity in this study. Additionally, we considered that the DBST index of patients with cancer may be influenced by their dysfunctional beliefs about sleep. However, we could not observe the association between the DBST index and C-DBS score. In our previous study [14], the DBST index was significantly correlated with insomnia severity, preoccupation with sleep (measured with the Glasgow Sleep Effort Scale), but not with dysfunctional beliefs about sleep (measured with the Dysfunctional Beliefs about Sleep-2 items scale) among the general population. The lack of correlation between the DBST index with dysfunctional beliefs about sleep in these studies can be explained. First, the DBST index might not reflect the dysfunctional beliefs about sleep. One of the core dysfunctional beliefs about sleep is that the patients think that they should sleep more (e.g., "I must get 8 hours of sleep to feel refreshed and function well the next day" [36]). However, the DBST index resulted from the discrepancy of patients' desperate and "consciously reduced" desired sleep duration from "unconsciously" long time in bed. They do not calculate their desired time in bed based on their desired total sleep time. Therefore, they decide their time in bed in accordance with their total sleep time; i.e. there should be no discrepancy. Therefore, this discrepancy might not reflect the classical dysfunctional beliefs about sleep. Second, the C-DBS scale, applied to measure cancer-related dysfunctional beliefs in this study, might not reflect well the dysfunctional beliefs of patients with cancer in a certain component linked with the DBST index. In another previous study [21], the DBST index was significantly correlated with the Dysfunctional Beliefs and Attitudes about Sleep-16 items scale scores, one of the most popularly applied rating scales [36].

The association between the DBST index and depression needs to be explored further, since we could not identify the correlation in the current study parallel to that in a previous study [14] despite the significant findings in one study [15]. It might depend on the participant's characteristics, and it must be elucidated in a further study investigating the DBST index among the clinical samples of patients with insomnia.

4.2 Sleep onset latency and the DBST index among patients with cancer

In this study, we also explored the relationship between the DBST index and SOL. We hypothesized that the DBST index of patients with cancer may be associated with their long SOL. We observed that a long SOL was predicted by a high DBST index, late sleep onset time, and short WTB. It reflects that the DBST index can be a tool for assessing cancer patients' initiation of insomnia, parallel to the association between the DBST index and insomnia severity.

The concept of the DBST index was based on the idea that insomnia patients often go to bed early in the evening. They dysfunctionally believe that an early bedtime can induce early sleep onset [37,38]. Patients with cancer also sometimes want to go to bed early in the evening, since they feel cancer-related fatigue symptoms due to the cancer itself or treatment modalities. However, based on the two process model [39], an early bedtime does not guarantee early sleep onset time. Sleep can be regulated by the interaction of a homeostatic drive and circadian rhythm, and it means that sleep can be forced by prolonged wakefulness (process S) and circadian timing to fall asleep (process C). The WTB index can be useful to explore the sleep-wake pattern of the patients. In our previous study [22], a short sleep latency was correlated with long WTB (16.5 h in SOL ≤ 30 min group and 15.8 h in SOL > 30 min group). In the current study, a long SOL was significantly correlated with a short WTB, early bedtime, or long TIB/d. It reflects that, based on the two process model of sleep regulation, a low homeostatic drive (presented as long TIB/d and short WTB) and early circadian timing (presented as early bedtime) cannot shorten the patients' sleep latency. The SOL can be considered a relatively objective index, which can be influenced by circadian timing and homeostatic drive, compared to that of

the ISI score. It shows that the DBST index can be a useful index that can predict the objective measure of insomnia and not subjective. Notably, we did not conduct nocturnal polysomnography in this study, and we could not determine the relationship between the DBST index and objective sleep data. Further study is needed to explore this relationship.

There are several limitations in this study. First, data were collected from the medical records of patients with cancer who visited the sleep clinic specialized for patients with cancer at a tertiary hospital. Therefore, most of the participants had psychiatric disorders or sleep disorders. It might lead to a selection bias, which could limit the generalizability. Second, the concept of DBST is not well known, and it might be biased since the responses were from the participants' subjective answers to the physician's questions. Third, the participants' sleep-wake cycles were assessed only by clinical interviews based on their responses, not with objective measurement tools such as polysomnography or actigraphy. Furthermore, other sleep disorders, such as obstructive sleep apnea or restless legs syndrome were not perfectly excluded, since we did not perform nocturnal polysomnography. Further study is needed to explore the DBST index and parameters of polysomnography.

5. Conclusion

We observed that the DBST index can predict the severity of insomnia in patients with cancer. In addition, their long SOL also can be predicted by the DBST index. Notably, DBST index can be a possible new sleep index, which can predict sleep problems experienced by patients with cancer. In a clinical setting, it will be useful to apply the DBST index while assessing the sleep problems experienced by patients with cancer.

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