Title

Change in Dysfunctional Sleep-Related Beliefs is Associated with Changes in Sleep and Other Health Outcomes Among Older Veterans With Insomnia: Findings From a Randomized Controlled Trial

Journal

Annals of Behavioral Medicine, 56(1)

ISSN

0883-6612

Authors

Song, Yeonsu
Kelly, Monica R
Fung, Constance H
et al.

Publication Date

2022

DOI

10.1093/abm/kaab030

Peer reviewed

ann. behav. med. (2022) 56:35–49
DOI: 10.1093/abm/kaab030

REGULAR ARTICLE

Change in Dysfunctional Sleep-Related Beliefs is Associated with Changes in Sleep and Other Health Outcomes Among Older Veterans With Insomnia: Findings From a Randomized Controlled Trial

Yeonsu Song, PhD, RN[1,2,3] · Monica R. Kelly, PhD[2] · Constance H. Fung, MD, MSHS[2,3] · Joseph M. Dzierzewski, PhD[4] · Austin M. Grinberg, PhD[2] · Michael N. Mitchell, PhD[2] · Karen Josephson, MPH[2] · Jennifer L. Martin, PhD[2,3] · Cathy A. Alessi, MD[2,3]

Published online: 4 May 2021

Abstract

Background Cognitive behavioral therapy for insomnia (CBTI) targets changing dysfunctional sleep-related beliefs. The impact of these changes on daytime functioning in older adults is unknown.

Purpose We examined whether changes in sleep-related beliefs from pre- to post-CBTI predicted changes in sleep and other outcomes in older adults.

Method Data included 144 older veterans with insomnia from a randomized controlled trial testing CBTI. Sleep-related beliefs were assessed with the Dysfunctional Beliefs and Attitudes about Sleep-16 (DBAS-16, subscales: Consequences, Worry/Helplessness, Sleep Expectations, Medication). Outcomes included sleep diary variables, actigraphy-measured sleep efficiency, Pittsburgh Sleep Quality Index (PSQI), Insomnia Severity Index (ISI), Epworth Sleepiness Scale (ESS), Flinders Fatigue Scale (FFS), Patient Health Questionnaire-9, and health-related quality of life. Analyses compared slope of change in DBAS subscales from baseline to posttreatment between CBTI and control, and assessed the relationship between DBAS change and the slope of change in outcomes from baseline to 6 months.

Results Compared to controls, the CBTI group demonstrated stronger associations between improvement in DBAS-Consequences and subsequent improvement in PSQI, ISI, ESS, and FFS. The CBTI group also demonstrated stronger associations between improvement in DBAS-Worry/Helplessness and subsequent improvements in PSQI, ISI, and FFS; improvements in DBAS-Medication and PSQI; and improvements in DBAS-Sleep Expectations and wake after sleep onset (sleep diary) and FFS (all $p < .05$).

Conclusions Significant reduction in dysfunctional sleep-related beliefs following CBTI in older adults predicted improvement in several outcomes of sleep and daytime functioning. This suggests the importance of addressing sleep-related beliefs for sustained improvement with CBTI in older veterans.

Trial Registration ClinicalTrials.gov Identifier: NCT00781963.

Keywords: Sleep-related beliefs · Cognitive behavioral therapy · Insomnia · Older adults · Veterans

✉ Yeonsu Song
ysong@sonnet.ucla.edu

1 School of Nursing, University of California, Los Angeles, CA, USA

2 Geriatric Research, Education, and Clinical Center, VA Greater Los Angeles Healthcare System, CA, USA

3 David Geffen School of Medicine, University of California, Los Angeles, CA, USA

4 Department of Psychology, Virginia Commonwealth University, Richmond, VA, USA

Introduction

More than half of older adults experience insomnia symptoms, including difficulty initiating or maintaining sleep, and/or early morning awakening [1, 2]. Sleep problems among older adults are associated with negative health outcomes such as impaired daytime [3] and cognitive function [4], increased risk of falls [5], poor quality of life [6], and higher rates of mortality [7].

Based on Spielman's model for the development of chronic insomnia [8] (also known as the "3-P" model), three key factors contribute to chronic insomnia: predisposing factors, precipitating factors, and perpetuating factors. Predisposing factors are individual background risk factors such as increasing age [9], female gender [2], or a prior history of insomnia [10]. According to this model, predisposing conditions do not cause chronic insomnia per se, but precede its onset and increase the likelihood for its occurrence [11]. Precipitating factors include physiological, environmental, and psychological stressors or major life events (e.g., death of a family member, acute medical illness, retirement, winning the lottery, hospitalization, separation) [12], which may produce acute insomnia. Perpetuating factors include behavioral, psychological, environmental, and physiological factors that prevent individuals from re-establishing normal sleep patterns after the acute stressor resolves. These factors include sleep-wake schedule irregularities, disrupted daytime activities, poor sleep hygiene (e.g., over-use of caffeine), and misconceptions and unrealistic expectations about normal sleep patterns [13]. People with insomnia tend to develop more extreme dysfunctional beliefs about sleep than those without insomnia [14–16]; thus, understanding the cognitive aspects of sleep disruption is typically a target of psychoeducational and cognitive therapy components of effective insomnia interventions.

Cognitive behavioral therapy for insomnia (CBTI) is recommended as the first-line treatment for insomnia disorder [17–19]. This approach combines behavioral strategies with components of cognitive therapy focused on identifying the patient's automatic, maladaptive thoughts and underlying beliefs affecting sleep, and then introducing strategies for changing these maladaptive beliefs about sleep. CBTI has shown significant effects on improving sleep among older adults [20–24] using its key behavioral and cognitive components (i.e., sleep restriction, stimulus control, cognitive therapy, sleep hygiene, and counter-arousal techniques). Patients who undergo this multicomponent therapy not only learn cognitive techniques to challenge and change their maladaptive beliefs about sleep, but also simultaneously make behavioral changes such as limiting time in bed thereby increasing sleep drive at night, which may facilitate reductions in maladaptive beliefs. For example, following sleep restriction, a patient may have increased homeostatic sleep drive that enables the patient to fall asleep quickly without using sleep medication. When presented with thoughts regarding the need to take medications to fall asleep, the patient may be more likely to change the belief, having recently experienced firsthand the ability to fall asleep quickly without medications following a change in behavior. Similarly, behavioral relaxation therapy has been shown to reduce cognitive arousal and maladaptive beliefs [25].

Although both behavioral and cognitive therapies are beneficial for insomnia patients, greater improvement of sleep and daytime functioning was shown in CBTI group [26]. Long-term sustainability in sleep-related beliefs was also shown in cognitive therapy or CBTI compared to behavioral therapy [27]. This may suggest a critical role of CBTI in enhancing sleep and other outcomes including belief change.

Some clinical trials of CBTI have measured sleep-related beliefs using validated instruments [28, 29] to identify which dysfunctional beliefs may be contributing to the perpetuation of insomnia. In addition, a few studies have investigated the effect of CBTI on quantitative measures of sleep-related beliefs in relation to treatment outcomes (e.g., severity of insomnia symptoms) [30], yet results are inconsistent. Some studies showed that improved sleep-related beliefs upon CBTI completion were significantly associated with improved sleep [31–34]. However, the main outcomes of these studies either included only sleep outcomes or included only subjective measures of both sleep and other outcomes (e.g., depression). Also, existing studies have not focused on older adults, who may have different beliefs and attitudes about sleep than younger individuals. Moreover, the specific types of sleep-related beliefs that are associated with CBTI response are not specifically focused on how age-related cognitions may play a role in insomnia.

Older adults may believe that having a sleep problem is a part of the natural aging process. They may also downplay difficulties with their sleep because of change in lifestyle accompanying retirement (e.g., not having to wake up for work, being able to nap throughout the day) [35]. Evidence shows that compared to older adults without insomnia, those with insomnia endorse greater concerns that disturbed sleep might be harmful to physical and mental health, expressed more hopelessness and felt helpless about their lost sleep, and endorsed more frequently that they needed less sleep with aging [29]. Older adults with insomnia also endorsed the need to use a sleeping pill to ensure next day alertness more strongly than those without insomnia. Such beliefs about sleep may be more dysfunctional among older veterans, given the high prevalence of insomnia [36] and multiple comorbidities (e.g., posttraumatic stress disorder, traumatic brain injury, pain, depression, anxiety, chronic pain) [37–39]. Veterans may perceive insomnia as a function of their medical conditions and perceive their insomnia as hopeless and uncontrollable due to the complex nature of their insomnia given comorbid conditions [40]. Therefore, it is important to understand how changes in these dysfunctional beliefs about sleep in the context of insomnia treatment impact sleep outcomes among the older veteran population.

For the current analysis, we used data from a randomized controlled trial that compared CBTI to a sleep education control program among older veterans, delivered by trained "sleep coaches" under the supervision of a behavioral sleep medicine specialist [20]. The trial demonstrated statistically significant and clinically meaningful improvements in insomnia symptoms that persisted for 1-year posttreatment. We examined whether changes in dysfunctional beliefs about sleep that occurred with CBTI treatment (baseline to posttreatment) were associated with changes in sleep and other health outcomes from baseline to 6-month follow-up. We hypothesized that improvement in specific types of sleep-related beliefs (i.e., misattribution of consequences of insomnia; issues of worry and helplessness about insomnia; unrealistic sleep expectations; and belief that sleep can only improve with the use of sleep medication) would be associated with greater improvements in subjective and objective sleep quality, daytime sleepiness, fatigue, depression, and health-related quality of life 6 months after CBTI treatment among older veterans with insomnia.

Methods

Study Design and Participants

The current study involved secondary analyses of data from a randomized controlled trial of older veterans with chronic insomnia that tested a 5-session CBTI program (ClinicalTrials.gov Identifier: NCT00781963), compared to a 5-session sleep education/attention control condition. The study period was from June 2010 to March 2013. Detailed information about this clinical trial is addressed in a previous publication [20]. Participants were eligible if they were community-dwelling veterans, aged 60 and older, and met diagnostic criteria for chronic insomnia disorder based on the International Classification of Sleep Disorders, Second Edition (ICSD-2) [41]. The study was approved by the Institutional Review Board at our institution.

Data Collection

A postal screening survey [42] was mailed to 9,080 veterans who had at least one outpatient clinic visit (from any type of the clinic) at a local VA healthcare system in the prior 18 months and lived within 30 miles of the facility. Of the 4,717 (52%) individuals who returned a completed survey, 1,947 veterans provided responses endorsing symptoms of insomnia. Of these, 1,663 veterans were assessed for study eligibility by telephone, and 519 completed an in-person baseline assessment (T1) to determine study eligibility. Of these, 159 veterans met eligibility criteria (including meeting diagnostic criteria for insomnia disorder [41]) and were assigned to receive either CBTI (individual CBTI or group CBTI) or the control condition. Of the randomized participants, nine participants were lost to follow-up at posttreatment assessments due to refusal to continue, death, being ill, or loss of contact, thus yielding 150 (94%) veterans who completed posttreatment assessments (T2) and 144 (91%) completed 6-month follow-up assessments (T3). Our analytic sample size included the 144 veterans (n = 92 in the combined CBTI group vs. n = 52 in the control group) who provided data at all three time points. The structure of our trial followed the Consolidated Standards of Reporting Trials (CONSORT) statement [43] as shown in Fig. 1 [20].

Randomization

Randomization occurred after baseline assessments were completed. We used the random allocation concealment to assign participants to one of three treatment groups (1:1:1 allocation to individual CBTI, group CBTI, or control). A senior statistician generated the randomization sequence. A separate senior research staff who was not involved in the enrollment, assessment, or intervention prepared and stored a set of sealed opaque envelopes containing group assignment (numbered) and implemented the random allocation sequence. Study participants and assessment research staff were blinded to group assignment.

CBTI Versus Control Conditions

The CBTI intervention consisted of 5 weekly, manual-based sessions, delivered individually or in a small group (3–5 participants per group). The content of the individual and small group CBTI programs were identical including the session-by-session components and numbers of sessions delivered. Our study was not designed to compare individual with group CBTI and we did not find significant differences in our primary sleep outcomes between these two groups [20]; thus, the intervention group consisted of both participants who received individual and group CBTI. Sleep coaches with master's level training (one in communication and the other in public health) delivered the CBTI intervention in both formats. Prior to delivering the treatment, sleep coaches attended a 2-day educational workshop on CBTI and completed a six-session webinar published

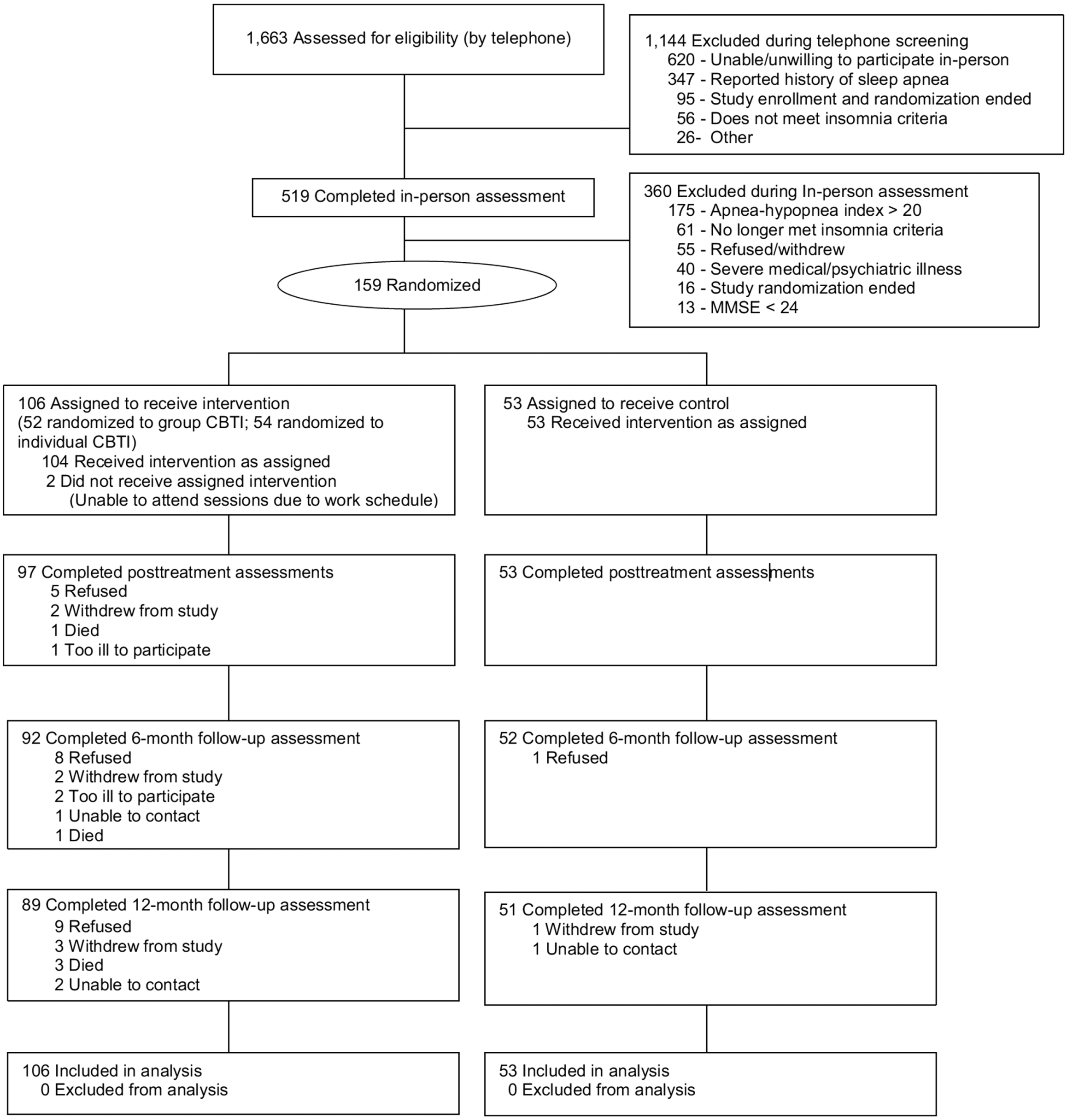

Fig. 1. Study flow chart (permission to reuse the figure was obtained from the publisher of the original article) [20].

by the American Academy of Sleep Medicine. The coach then received additional training on the intervention materials and feedback/supervision on delivering the intervention to a small number of pilot subjects from a licensed clinical psychologist certified in behavioral sleep medicine by the American Board of Sleep Medicine (JM). During the intervention period, the intervention sleep coach reviewed the intervention session progress for all currently active intervention participants, discussed any issues that may have arisen during the session, and received feedback/supervision from a licensed clinical psychologist with expertise in behavioral sleep medicine in a weekly telephone consultation. The same coach met each participant across all sessions in each condition.

Key components of the intervention included sleep restriction, stimulus control, cognitive therapy, sleep hygiene, relaxation, and relapse prevention. Study participants in CBTI (individual and group) received individualized sleep recommendations including bedtime and rise time and the sleep coach adjusted their sleep schedule based on the results of participants' daily sleep diary from the previous week. The sleep coach also identified maladaptive cognitions during the sessions and used them for the cognitive therapy component of the intervention. The control condition included manual-based, general sleep information only without directed guidance. The contents included stages of sleep, age-related sleep changes, sleep across the lifespan, mind and sleep, consequences of poor sleep, and sleep environment.

The control condition followed the same frequency and intervals used in the CBTI condition. A separate sleep coach with a master's degree in public health delivered the sessions for participants assigned to the control condition. Percentages of completing all five sessions for CBTI (individual and group) and control (individual) were 100%, 85%, and 100%, respectively.

Measures

Demographic characteristics collected via structured interview included age, race/ethnicity, education level, marital status, and employment status.

Sleep-related Beliefs

Dysfunctional Beliefs and Attitudes about Sleep, 16-item version (DBAS-16) [28] was used to assess sleep-related beliefs. The scale asks participants to rate their levels of agreement/disagreement on 16 statements about sleep between 0 (strongly disagree) and 10 (strongly agree). Higher scores represent a stronger endorsement of the beliefs. The 16-item DBAS measures four domains: perceived consequences of insomnia (five items: e.g., "After a poor night's sleep, I know that it will interfere with my daily activities on the next day"); worry/helplessness about insomnia (six items: e.g., "I am concerned that chronic insomnia may have serious consequences on my physical health"); sleep expectations (two items: e.g., "If I don't get the proper amount of sleep on a given night, I need to catch up on it the next day by napping or on the next night by sleeping longer"); and medication use (three items: e.g., "In order to be alert and function well during the day, I believe I would be better off taking a sleeping pill rather than having a poor night's sleep"). Items representing each domain are summed to determine the subscale scores, and all 16 items are averaged to determine the DBAS total score, which has shown good reliability (Cronbach alpha = 0.77–0.79) [28] in previous studies. The DBAS has differentiated people with insomnia from good sleepers where those with insomnia presented more endorsement on the DBAS items than good sleepers [14, 29, 44]. It has also been shown to be sensitive to changes with insomnia treatment where the DBAS total score decreased after completion of CBTI [31, 33, 44]. A DBAS overall score of >3.8 is considered the level of unhelpful beliefs associated with clinically significant insomnia [16]. DBAS total score and four subscale scores (collected at T1 and T2) were used in the current study.

Sleep Outcomes

Objective sleep was measured with a wrist actigraph (Actiwatch Spectrum, Phillips Respironics, Bend, OR) worn on the dominant wrist for seven consecutive days and nights at each time point. The actigraph is a small, unobtrusive, watch-sized device useful in longitudinal, naturalistic (i.e., not in an overnight sleep laboratory) assessment of sleep–wake patterns. In general, wrist activity below an established threshold is interpreted as sleep; high wrist activity is interpreted as wakefulness. Wrist actigraphy is useful for the assessment of sleep over several days and has been widely used in older adults [45]. Sleep efficiency (i.e., the percentage of total time spent asleep while in bed) was calculated from actigraphy data, using simultaneously collected sleep diary reported daily bedtime and rise time to determine the time in bed window. The automated sleep-scoring algorithm within the device-specific software was used to determine sleep versus wake (Actiware software version 5.0, Philips, Respironics, medium threshold setting).

Subjective sleep was measured using a daily sleep diary. Each morning for the seven days they wore a wrist actigraph, participants completed sleep diaries that were based on the American Academy of Sleep Medicine Consensus Sleep Diary [46]. Sleep efficiency and wake after sleep onset (i.e., total time spent awake after sleep onset and before rise time) were calculated from information provided on the diary (bedtime, rise time, sleep onset latency, and time awake after sleep onset).

Additional sleep-related questionnaires assessed global sleep quality, insomnia, and daytime symptoms. The Pittsburgh Sleep Quality Index (PSQI) [47] is an 18-item questionnaire that assesses sleep quality and sleep disturbances, where a total score >5 indicates poor sleep quality [47]. The 7-item Insomnia Severity Index (ISI) [48] was also administered to assess the symptoms and severity of insomnia. ISI total score ranges from 0 to 28 with higher scores indicating worse insomnia severity. The Epworth Sleepiness Scale (ESS) [49] is an 8-item questionnaire that asks participants their usual chances of dozing off or falling asleep while engaged in eight different activities on a 4-point scale (0–3). A total score ranges from 0 to 24 with higher scores indicating more daytime sleepiness.

Other Health Outcomes

The 7-item Flinders Fatigue Scale (FFS) [50] was used to measure characteristics (e.g., frequency, severity) of fatigue experienced over the past two weeks. Total scores range from 0 to 31, with higher scores indicating greater fatigue. The Patient Health Questionnaire (PHQ)-9 [51] was used to measure the severity of depression. It asks frequency (0 "not at all" to 3 "nearly every day") of experiencing nine depressive symptoms over the past 2 weeks. The PHQ-9 score ranges from 0 to 27 with a higher score indicating having more severe depressive symptoms. Medical Outcomes Study 12-item Short-Form Survey v2 (SF-12v2) [52] was used to assess participants' health-related quality of life. It produces two norm-based summary component scores (physical and mental health components), in which scores can range from 0 to 100 with a higher score indicating better health.

Changes in total scores on sleep outcomes (i.e., actigraphy-measured sleep efficiency, sleep diary-measured sleep efficiency and wake after sleep onset, PSQI, ISI, ESS), and other daytime outcomes (i.e., FFS, PHQ-9, and SF-12v2) between baseline and 6-month follow-up assessments were used in analyses.

Data Analyses

Descriptive statistics were used to summarize participants' characteristics, including demographics, sleep, other health-related information, and sleep-related beliefs. ANCOVA was used to test the study hypotheses described above. Since the study was not designed to test for differences between individual versus group delivery of CBTI, we combined data for the group and individual CBTI. There were no significant differences between individual and group CBTI in demographics and outcome variables [20]. We included change in DBAS-16 total score (from baseline to posttreatment; T1–T2) and group (CBTI versus. control) as covariates with an interaction term between DBAS change and treatment (CBTI versus control). We also examined changes in DBAS subscale scores (summarized in four subscale scores) using the same analytic approach. Analyses compared the degree of association between change in DBAS (baseline to posttreatment) and change in sleep and other health outcomes (baseline to 6-months; T1–T3) between the CBTI versus the control groups. For these statistical tests, $p < .05$ was considered statistically significant. Analyses were conducted using Stata statistical software (version 15, Stata Corporation, College Station, TX).

RESULTS

Participant Characteristics

Participants included 96.86% men, and 78.62% identified as white. The mean age was 72.18 ± 7.68 years. Nearly half (41.51%) of participants were married, and 23.90% were employed. Baseline DBAS total score was 3.84 ± 2.06. DBAS subscale scores were 3.69 ± 2.69 for perceived consequences of insomnia (DBAS-Consequence); 4.00 ± 2.31 for worry/helplessness about insomnia (DBAS-Worry/Helplessness); 4.73 ± 2.80 for sleep expectations (DBAS-Sleep Expectations); and 3.17 ±2.48 for medication (DBAS-Medication). Raw values showed that DBAS total score and subscale scores were lower at posttreatment and 6-month follow-up for both the CBTI and control groups, but only the difference in DBAS-Sleep Expectations at posttreatment was statistically significant (3.19 ± 2.62 in CBTI vs. 4.58 ± 3.02 in control, $p < .01$, see Table 1). Sleep and other health information at all three-time points (baseline, posttreatment, 6-month follow-up) are summarized in Table 2.

Table 1. Sleep-related beliefs among older veterans with insomnia

	Baseline (n = 159)	Posttreatment (n = 150)	6-month follow-up (n = 144)
DBAS-16 overall score			
Intervention	3.93 ± 2.07	2.90 ± 1.79	2.77 ± 1.91
Control	3.54 ± 2.01	3.14 ± 1.78	3.03 ± 1.92
Subscale 1: consequences			
Intervention	3.86 ± 2.74	2.83 ± 2.36	2.48 ± 2.28
Control	3.36 ± 2.58	2.67 ± 2.24	2.64 ± 2.30
Subscale 2: worry/helplessness			
Intervention	4.11 ± 2.29	3.05 ± 2.15	2.87 ± 2.25
Control	3.77 ± 2.36	3.38 ± 2.19	3.15 ± 2.30
Subscale 3: expectation			
Intervention	4.75 ± 2.79	3.19 ± 2.62**	3.43 ± 2.48
Control	4.69 ± 2.85	4.58 ± 3.02	4.26 ± 2.94
Subscale 4: medication			
Intervention	3.42 ± 2.52	2.56 ± 2.20	2.63 ± 2.43
Control	2.66 ± 2.31	2.50 ± 2.34	2.62 ± 2.24

Comparisons of intervention and control: *$p < .05$, **$p < .01$.

Baseline n = 106 CBTI, n = 53 control; posttreatment n = 97 CBTI, n = 53 control; 6-month follow-up n = 92 CBTI, n = 52 control.

DBAS, Dysfunctional Beliefs and Attitudes about Sleep.

Table 2. Sleep and other health information among older veterans with insomnia

	Baseline (n = 159)	Posttreatment (n = 150)	6-month follow-up (n = 144)
PSQI score			
Intervention	9.44 ± 3.48	5.51 ± 3.60	5.97 ± 3.80
Control	8.26 ± 3.22	7.60 ± 3.31	7.21 ± 3.49
ISI score			
Intervention	11.66 ± 5.26	6.13 ± 4.48	5.47 ± 4.80
Control	10.08 ± 5.26	8.94 ± 5.75	7.81 ± 5.62
Sleep efficiency-D			
Intervention	71.98 ± 14.80	85.74 ± 10.18	84.74 ± 9.72
Control	72.80 ± 16.78	76.17 ± 11.46	78.87 ± 12.85
WASO-D			
Intervention	55.84 ± 40.27	24.96 ± 23.76	30.53 ± 33.86
Control	58.14 ± 63.28	44.63 ± 36.35	42.97 ± 40.63
Sleep efficiency-A			
Intervention	83.73 ± 6.05	84.79 ± 6.03	82.72 ± 7.38
Control	82.80 ± 6.91	82.42 ± 6.82	83.01 ± 6.51
ESS			
Intervention	5.36 ± 4.05	4.48 ± 3.94	4.02 ± 3.78
Control	4.64 ± 2.79	4.72 ± 3.60	3.65 ± 2.89
FFS			
Intervention	9.82 ± 7.60	5.01 ± 6.43	5.83 ± 6.73
Control	9.11 ± 6.69	6.06 ± 5.91	7.33 ± 6.90
PHQ-9			
Intervention	5.06 ± 4.34	3.04 ± 4.04	2.97 ± 4.30
Control	4.35 ± 4.26	2.94 ± 2.70	3.31 ± 3.64
SF-12vs physical health			
Intervention	44.16 ± 10.86	45.88 ± 10.26	44.69 ± 10.50
Control	47.58 ± 10.25	49.82 ± 9.18	46.62 ± 10.92
SF-12vs mental health			
Intervention	52.88 ± 10.00	52.56 ± 10.29	53.43 ± 10.07
Control	52.57 ± 8.33	54.73 ± 6.91	54.30 ± 8.47

Baseline n = 106 CBTI, n = 53 control; posttreatment n = 97 CBTI, n = 53 control; 6-month follow-up n = 92 CBTI, n = 52 control.

PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; sleep efficiency-D, sleep diary measured sleep efficiency; WASO-D, sleep diary measured wake after sleep onset; sleep efficiency-A, actigraphy measured sleep efficiency; ESS, Epworth Sleepiness Scale; FFS, Flinders Fatigue Scale; PHQ-9, Patient Health Questionnaire-9 items; SF-12, Medical Outcomes Study 12-item Short-Form health-related quality of life.

Bivariate Associations Between DBAS Score Changes and Changes in Sleep and Other Health Outcomes

There were significant associations between DBAS score changes and changes in sleep and other health outcomes. DBAS total score change was significantly associated with PSQI change (r = .280), ISI change (r = .356), ESS (r = .176), FSS (r = .355), PHQ-9 (r = .423), and SF-12v2 physical health (r = −.183, all p < .05). Associations between DBAS subscale score changes and change in sleep and other health outcomes also showed similar patterns. Bivariate associations were summarized in Table 3.

Association Between DBAS Total Score Change and Changes in Sleep and Other Health Outcomes

Compared to controls, the CBTI group had stronger associations between reduced DBAS total score (T1−T2) and subsequent PSQI improvement (T1–T3) (difference in slopes [DIS] = 1.31, 95% CI = [0.53, 2.09], p = .001, Table 4). This pattern of significant results was also found for ISI (DIS = 1.80, 95% CI = [0.58, 3.02], p = .004), ESS (DIS = 1.00, 95% CI = [0.25, 1.75], p = .009), and FSS (DIS = 3.32, 95% CI = [1.78, 4.87], p < .001). Slopes were not statistically different for sleep diary measures, actigraphy sleep efficiency, PHQ-9, or SF-12v2.

Table 3. Pearson correlations between change of DBAS scores and change of sleep and other health outcomes

Variable	DBAS-16				
	Overall score	Subscale 1: consequences	Subscale 2: worry/helplessness	Subscale 3: expectation	Subscale 4: medication
PSQI score	0.280**	0.190*	0.193*	0.218**	0.258**
ISI score	0.356**	0.244**	0.270**	0.287**	0.272**
Sleep efficiency-D	−0.138	−0.094	−0.065	−0.094	−0.207*
WASO-D	0.104	0.116	0.046	0.076	0.067
Sleep efficiency-A	0.148	0.131	0.177*	0.076	-0.024
ESS	0.176*	0.190*	0.110	0.180*	0.007
FFS	0.355**	0.265**	0.301**	0.285**	0.170
PHQ-9	0.423**	0.327**	0.404**	0.180*	0.248**
SF-12vs physical health	−0.183*	−0.142	−0.250**	0.022	−0.045
SF-12vs mental health	−0.119	−0.093	−0.069	−0.047	−0.176*

*p < .05, **p < .01.

DBAS, Dysfunctional Beliefs and Attitudes about Sleep; PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; sleep efficiency-D, sleep diary measured sleep efficiency; WASO-D, sleep diary measured wake after sleep onset; sleep efficiency-A, actigraphy measured sleep efficiency; ESS, Epworth Sleepiness Scale; FFS, Flinders Fatigue Scale; PHQ-9, Patient Health Questionnaire-9 items; SF-12, Medical Outcomes Study 12-item Short-Form health-related quality of life.

Association Between DBAS Subscale Score Changes and Changes in Sleep and Other Health Outcomes

Compared to controls, the CBTI group had significantly stronger associations between reduction in DBAS-Consequence and subsequent improvements in PSQI (DIS = 0.86, 95% CI = [0.29, 1.43], p = .004), ISI (DIS = 1.09, 95% CI = [0.18, 1.99], p = .019) and ESS (DIS = 0.64, 95% CI = [0.10, 1.18], p = .020). The CBTI group also had significantly stronger associations between reduction in DBAS-Worry/Helplessness and subsequent improvements in PSQI (DIS = 0.87, 95% CI = [0.25, 1.48], p = .006) and ISI (DIS = 1.10, 95% CI = [0.13, 2.06], p = .027), as well as reduction in DBAS-Medication and PSQI (DIS = 0.67, 95% CI = [0.02, 1.32], p = .044). Similar stronger associations were also found between reduced DBAS-Consequence (DIS =1.93, 95% CI = [0.76, 3.09], p = .001), DBAS-Worry/Helplessness (DIS = 2.27, 95% CI = [1.05, 3.50], p < .001), and DBAS-Sleep Expectations (DIS = 1.31, 95% CI = [0.28, 2.34], p = .013) and subsequent improvement in FFS. Additionally, there was a significant relationship between reduced DBAS-Expectations subscale score and reduced wake after sleep onset (measured with sleep diary; DIS 8.03, 95% CI= [0.36, 15.71], p = .040), but not between wake after sleep onset and other DBAS subscales. Slopes between groups on DBAS subscale scores were not statistically significant for actigraphy sleep efficiency, PHQ-9, or SF-12v2. Tables 5–8 summarize the detailed results regarding select DBAS subscale analyses.

Discussion

Our findings partially support our a priori hypothesis that changes in beliefs and attitudes about sleep with CBTI would be associated with subsequent improvements in sleep and other outcomes at 6-month follow-up in older adults. Compared to control, we found that reducing maladaptive sleep-related beliefs were more strongly associated with improved insomnia symptoms, daytime sleepiness, and fatigue in the CBTI group, but not with change in objective sleep measures, depressive symptoms, or quality of life. Analyses also suggested that these relationships remained significant when assessing the more specific domains of dysfunctional beliefs. Reduced dysfunctional beliefs about the consequences of insomnia, worry/helplessness about insomnia, and medications following CBTI were significantly associated with improved insomnia symptoms and/or global sleep quality. Additionally, reduced maladaptive beliefs about the consequences of insomnia, worry/helplessness about insomnia, and sleep expectations were significantly associated with improved fatigue; reduced maladaptive beliefs about the consequences of insomnia following CBTI also improved daytime sleepiness.

In our study, reducing dysfunctional beliefs in the domain of sleep expectation (i.e., "I need 8 hours to function," "Need to catch up on lost sleep") was significantly associated with a reduction in sleep diary-measured wake after sleep onset only, but not with insomnia symptoms, perceived sleep quality, or sleep efficiency. This subscale had the highest baseline score, suggesting that it may be

Table 4. Association between change of DBAS total score and change of sleep and other outcomes

DBAS total score change by treatment interaction on outcome change		DBAS total score (baseline to posttreatment)	Treatment (CBTI)	DBAS total score change (baseline to posttreatment) × treatment
PSQI change	Coefficient [95% CI]	−0.39 [−1.05, 0.26]	−1.25 [−2.48, −0.03]	1.31 [0.53, 2.09]
	p-value	.239	.045	.001
ISI change	Coefficient [95% CI]	−0.15 [−1.18, 0.88]	−2.28 [−4.19, −0.37]	1.80 [0.58, 3.02]
	p-value	.778	.020	.004
Sleep efficiency-D change	Coefficient [95% CI]	1.21 [−1.73, 4.16]	4.81 [−0.73, 10.34]	−2.97 [−6.45, 0.51]
	p-value	.415	.088	.093
WASO-D change	Coefficient [95% CI]	−4.61 [−14.86, 5.63]	−3.22 [−22.49, 16.06]	10.25 [−1.85, 22.36]
	p-value	.375	.742	.096
Sleep efficiency-A change	Coefficient [95% CI]	0.27 [−0.80, 1.33]	−0.91 [−2.89, 1.07]	0.24 [−1.03, 1.51]
	p-value	.622	.363	.705
ESS change	Coefficient [95% CI]	−0.36 [−0.99, 0.27]	0.43 [−0.75, 1.60]	1.00 [0.25, 1.75]
	p-value	.266	.473	.009
FFS change	Coefficient [95% CI]	−0.81 [−2.11, 0.50]	0.34 [−2.08, 2.77]	3.32 [1.78, 4.87]
	p-value	.223	.781	<.001
PHQ-9 change	Coefficient [95% CI]	0.58 [−0.21, 1.38]	0.31 [−1.17, 1.79]	0.81 [−0.14, 1.75]
	p-value	.149	.683	.093
SF-12vs physical health change	Coefficient [95% CI]	−0.87 [−2.68, 0.95]	0.77 [−2.60, 4.13]	−0.20 [−2.35, 1.95]
	p-value	.347	.652	.857
SF-12vs mental health change	Coefficient [95% CI]	−0.87 [−2.66, 0.92]	−2.04 [−5.35, 1.28]	0.11 [−2.01, 2.23]
	p-value	.337	.227	.921

DBAS, Dysfunctional Beliefs and Attitudes about Sleep; PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; sleep efficiency-D, sleep diary measured sleep efficiency; WASO-D, sleep diary measured wake after sleep onset; sleep efficiency-A, actigraphy measured sleep efficiency; ESS, Epworth Sleepiness Scale; FFS, Flinders Fatigue Scale; PHQ-9, Patient Health Questionnaire-9 items; SF-12, Medical Outcomes Study 12-item Short-Form health-related quality of life.

hardest to change with CBTI as delivered in our study. It is possible that a skilled cognitive therapist may achieve different results. In addition, prior studies which found higher dysfunctional beliefs about sleep targeted young and/or middle-aged adults [27, 33, 34] whereas our study participants' mean age was 72 years. It is possible that sleep expectations among older adults may be less dysfunctional as most participants in our study were retired and likely had a more flexible sleep schedule, thus they may not have felt pressure about their total sleep time. Other factors may also play a role in beliefs about sleep expectation. For example, medical comorbidities causing fatigue or pain may affect older adults' belief that they need to sleep more the next day or night to make up for lost sleep, particularly in the veteran population that is at increased risk for factors associated with insomnia (e.g., posttraumatic stress disorder, depression, chronic pain).

Changes in sleep-related beliefs were not significantly associated with sleep parameters or other health outcomes including depression or quality of life. This finding is consistent with prior studies [27, 32, 53] that failed to identify relationships between changes in DBAS and sleep parameters (e.g., sleep efficiency, wake after sleep onset) measured with sleep diary or in-laboratory polysomnography [54]. Previous studies addressed one possible reason, that is, change in sleep-related beliefs may be more strongly related to general perceptions of one's sleep quality, distress, and daytime functioning rather than to nightly sleep experiences [27]. We previously published findings that the discrepancy

Table 5. Association between change of DBAS consequences subscale score and change of sleep and other outcomes

DBAS-Consequences subscale score change by treatment interaction on outcome change		DBAS consequences subscale score (baseline to posttreatment)	Treatment (CBTI)	DBAS consequences subscale score change (baseline to posttreatment) × treatment
PSQI change	Coefficient [95% CI]	−0.34 [−0.83, 0.15]	−1.61 [−2.83, −0.40]	0.86, [0.29, 1.43]
	p-value	.169	.010	.004
ISI change	Coefficient [95% CI]	−0.20 [−0.98, 0.58]	−3.04 [−4.97, −1.11]	1.09 [0.18, 1.99]
	p-value	.611	.002	.019
Sleep efficiency-D change	Coefficient [95% CI]	0.42 [−1.83, 2.67]	5.98 [0.47, 11.50]	−1.28 [−3.87, 1.31]
	p-value	.715	.034	.329
WASO-D change	Coefficient [95% CI]	1.19 [−6.63, 9.02]	−9.25 [−28.45, 9.95]	1.71 [−7.30, 10.73]
	p-value	.763	.342	.707
Sleep efficiency-A change	Coefficient [95% CI]	0.45 [−0.35, 1.25]	−1.41 [−3.36, 0.55]	−0.19 [−1.13, 0.75]
	p-value	.270	.156	.693
ESS change	Coefficient [95% CI]	−0.20 [−0.66, 0.26]	0.18 [−0.96, 1.33]	0.64 [0.10, 1.18]
	p-value	.398	.752	.020
FFS change	Coefficient [95% CI]	−0.57 [−1.57, 0.43]	−0.87 [−3.36, 1.61]	1.93 [0.76, 3.09]
	p-value	.259	.489	.001
PHQ-9 change	Coefficient [95% CI]	0.19 [−0.41, 0.79]	−0.26 [−1.76, 1.24]	0.60 [−0.11, 1.30]
	p-value	.536	.734	.095
SF-12vs physical health change	Coefficient [95% CI]	−0.63 [−1.97, 0.70]	1.42 [−1.89, 4.72]	0.09 [−1.46, 1.65]
	p-value	.348	.397	.905
SF-12vs mental health change	Coefficient [95% CI]	−0.12 [−1.43, 1.19]	−2.00 [−5.25, 1.26]	−0.37 [−1.89, 1.16]
	p-value	.855	.227	.636

DBAS, Dysfunctional Beliefs and Attitudes about Sleep; PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; sleep efficiency-D, sleep diary measured sleep efficiency; WASO-D, sleep diary measured wake after sleep onset; sleep efficiency-A, actigraphy measured sleep efficiency; ESS, Epworth Sleepiness Scale; FFS, Flinders Fatigue Scale; PHQ-9, Patient Health Questionnaire-9 items; SF-12, Medical Outcomes Study 12-item Short-Form health-related quality of life.

between sleep diary and actigraphy-based metrics was reduced after CBTI compared to the control condition. Our current analysis suggests that this reduction in the discrepancy between subjectively and objectively measured sleep/wake patterns may be a result of changes in beliefs and attitudes about sleep that occurs with CBTI [55]. In contrast to our findings, some studies found significant relationships between sleep-related beliefs and sleep parameters [31, 33, 34]. Of these, only one study of young adults using an on-line CBTI platform investigated the relationship between change in beliefs with a subsequent change of sleep parameters (i.e., wake after sleep onset, sleep onset latency) [33], which suggests results may be different across age groups.

Although we found significant relationships between changes in sleep-related beliefs and subsequent change in perceived sleep quality, a mechanism underlying this relationship in regard to the role of CBTI is still unclear because CBTI contains both cognitive and behavioral components. A previous study found that both cognitive therapy and behavioral therapy significantly improved sleep-related beliefs, insomnia symptoms, and functional psychosocial impairment among adults with insomnia [27]. Altering dysfunctional beliefs about sleep through the cognitive component of CBTI may have directly challenged and altered unhelpful or inaccurate sleep-related beliefs resulting in more balanced views of insomnia-related consequences and expectations about

Table 6. Association between change of DBAS worry/helplessness subscale score and change of sleep and other outcomes

DBAS worry/helplessness subscale score change by treatment interaction on outcome change		DBAS worry/helplessness subscale score (baseline to posttreatment)	Treatment (CBTI)	DBAS worry/helplessness subscale score change (baseline to posttreatment) × treatment
PSQI change	Coefficient [95% CI]	−0.29 [−0.79, 0.21]	−1.63 [−2.85, −0.41]	0.87 [0.25, 1.48]
	p-value	.253	.009	.006
ISI change	Coefficient [95% CI]	−0.05 [−0.84, 0.73]	−2.91 [−4.83, −0.99]	1.10 [0.13, 2.06]
	p-value	.899	.003	.027
Sleep efficiency-D change	Coefficient [95% CI]	1.03 [−1.11, 3.17]	5.84 [0.49, 11.20]	−1.93 [−4.56, 0.71]
	p-value	.342	.033	.151
WASO-D change	Coefficient [95% CI]	−4.51 [−11.93, 2.90]	−5.69 [−24.24, 12.87]	8.05 [−1.09, 17.20]
	p-value	.231	.545	.084
Sleep efficiency-A change	Coefficient [95% CI]	0.27 [−0.50, 1.04]	−0.90 [−2.80, 1.00]	0.26 [−0.70, 1.21]
	p-value	.496	.349	.595
ESS change	Coefficient [95% CI]	−0.16 [−0.63, 0.32]	0.05 [−1.11, 1.22]	0.51 [−0.08, 1.09]
	p-value	.509	.927	.091
FFS change	Coefficient [95% CI]	−0.43 [−1.42, 0.56]	−0.44 [−2.88, 1.99]	2.27 [1.05, 3.50]
	p-value	.391	.721	<.001
PHQ-9 change	Coefficient [95% CI]	0.68 [0.09, 1.28]	−0.09 [−1.56, 1.37]	0.32 [−0.42, 1.05]
	p-value	.025	.900	.396
SF-12vs physical health change	Coefficient [95% CI]	−1.00 [−2.32, 0.31]	0.70 [−2.50, 3.90]	−0.19 [−1.81, 1.42]
	p-value	0.133	0.666	0.813
SF-12vs mental health change	Coefficient [95% CI]	−1.03 [−2.35, 0.28]	−1.26 [−4.47, 1.96]	0.99 [−0.63, 2.61]
	p-value	0.123	0.441	0.229

DBAS, Dysfunctional Beliefs and Attitudes about Sleep; PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; sleep efficiency-D, sleep diary measured sleep efficiency; WASO-D, sleep diary measured wake after sleep onset; sleep efficiency-A, actigraphy measured sleep efficiency; ESS, Epworth Sleepiness Scale; FFS, Flinders Fatigue Scale; PHQ-9, Patient Health Questionnaire-9 items; SF-12, Medical Outcomes Study 12-item Short-Form health-related quality of life.

sleep or sleep-promoting medications, thus improving perceived sleep quality [56]. Another alternative mechanism may be that improved sleep through the behavioral change components of CBTI may have eliminated sleep-disruptive habits and provided evidence for the individual's ability to achieve improved sleep quality. The reductions in maladaptive beliefs in conjunction with behavioral and relaxation components of CBTI likely worked together to improve sleep in older veterans. In addition to the benefits of our CBTI program to changes in sleep-related beliefs, we found that participants in the control condition showed patterns of improved beliefs about sleep and other health outcomes at follow-up assessments. This may suggest a potential impact of the control condition (i.e., general sleep information only) on changing beliefs and behaviors. Particularly, even general information about sleep and tracking of sleep via a daily sleep diary may have provided some participants in the control condition with motivation to change their behaviors to improve sleep. This is confirmed by the pattern of results showing essentially no group differences in specific sleep-related beliefs at the follow-up time points.

Our study has several strengths. First, we believe this is the first study of its kind to examine the cause and effect association between change in beliefs about sleep and subsequent change of multiple health measures among older veterans with insomnia. Second, we focused on specific versus global beliefs about sleep and multiple domains of health outcomes, including subjective and

Table 7. Association between change of DBAS expectations subscale score and change of sleep and other outcomes

DBAS expectations subscale score change by treatment interaction on outcome change		DBAS expectations subscale score (baseline to posttreatment)	Treatment (CBTI)	DBAS expectations subscale score change (baseline to posttreatment) × treatment
PSQI change	Coefficient [95% CI]	0.03 [−0.42, 0.48]	−1.95 [−3.19, −0.71]	0.20 [−0.31, 0.72]
	p-value	.894	.002	.434
ISI change	Coefficient [95% CI]	0.02 [−0.69, 0.72]	−3.07 [−5.01, −1.14]	0.55 [−0.25, 1.35]
	p-value	.961	.002	.177
Sleep efficiency-D change	Coefficient [95% CI]	0.66 [−1.30, 2.63]	6.33 [0.93, 11.74]	−1.08 [−3.31, 1.16]
	p-value	.505	.022	.341
WASO-D change	Coefficient [95% CI]	−5.32 [−12.06, 1.43]	−5.36 [−23.89, 13.18]	8.03 [0.36, 15.71]
	p-value	.121	.568	.040
Sleep efficiency-A change	Coefficient [95% CI]	0.02 [−0.66, 0.71]	−1.12 [−3.03, 0.79]	0.09 [−0.70, 0.88]
	p-value	.949	.247	.824
ESS change	Coefficient [95% CI]	−0.06 [−0.48, 0.36]	0.10 [−1.05, 1.25]	0.34 [−0.14, 0.81]
	p-value	.786	.864	.161
FFS change	Coefficient [95% CI]	−0.33 [−1.24, 0.58]	−0.93 [−3.42, 1.55]	1.31 [0.28, 2.34]
	p-value	.471	.459	.013
PHQ-9 change	Coefficient [95% CI]	−0.16 [−0.72, 0.40]	−0.22 [−1.76, 1.32]	0.55 [−0.09, 1.19]
	p-value	0.566	0.778	0.093
SF-12vs physical health change	Coefficient [95% CI]	0.97 [−0.22, 2.15]	1.23 [−2.02, 4.49]	−1.05 [−2.40, 0.30]
	p-value	.110	.456	.126
SF-12vs mental health change	Coefficient [95% CI]	0.08 [−1.09, 1.26]	−2.19 [−5.40, 1.02]	−0.42 [−1.75, 0.91]
	p-value	.887	.179	.531

DBAS, Dysfunctional Beliefs and Attitudes about Sleep; PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; sleep efficiency-D, sleep diary measured sleep efficiency; WASO-D, sleep diary measured wake after sleep onset; sleep efficiency-A, actigraphy measured sleep efficiency; ESS, Epworth Sleepiness Scale; FFS, Flinders Fatigue Scale; PHQ-9, Patient Health Questionnaire-9 items; SF-12, Medical Outcomes Study 12-item Short-Form health-related quality of life.

objective sleep, daytime function (daytime sleepiness, fatigue), depressive symptoms, and health-related quality of life.

Despite these strengths, the findings of our study should be interpreted with the following limitations in mind. First, the study participants were older veterans and mostly White men. Thus, findings may not be generalizable to non-veterans, women, younger adults, or veterans from racial/ethnic minority groups. The range of ages in our study was relatively broad with a minimum age of 60 years. Thus, some of the older participants (i.e., those over age 80) might be different from those who are younger (i.e., under age 65); however, age was not a predictor of treatment response. In addition, the risk of reporting bias was not avoidable because improvements in sleep-related beliefs might affect participants' perceived sleep quality and symptoms of insomnia (i.e., PSQI, ISI), not their objective sleep quality. For example, prior studies showed that changes in sleep-related beliefs were more strongly associated with subjective sleep than objective sleep [31]. The current study did not account for individual factors affecting sleep-related beliefs. Certain sleep-related beliefs may be more vital than others and differently important across individuals. For example, some individuals may need more CBTI sessions or a longer duration of CBTI to change their individual specific beliefs and behaviors. Additionally, we did not conduct a formal assessment for psychiatric diagnoses;

Table 8. Association between change of DBAS medication subscale score and change of sleep and other outcomes

DBAS medication subscale score change by treatment interaction on outcome change		DBAS Medication subscale score (baseline to posttreatment)	Treatment (CBTI)	DBAS medication subscale score change (baseline to posttreatment) × treatment
PSQI change	Coefficient [95% CI]	−0.01 [−0.54, 0.52]	−1.86 [−3.04, −0.68]	0.67 [0.02, 1.32]
	p-value	.961	.002	.044
ISI change	Coefficient [95% CI]	0.04 [−0.79, 0.88]	−3.23 [−5.10, −1.37]	1.03 [−0.00, 2.05]
	p-value	.917	.001	.050
Sleep efficiency-D change	Coefficient [95% CI]	0.19 [−2.02, 2.40]	5.65 [0.59, 10.72]	−2.44 [−5.18, 0.31]
	p-value	.868	.029	.081
WASO-D change	Coefficient [95% CI]	−1.70 [−9.57, 6.17]	−8.90 [−26.94, 9.15]	4.78 [−4.98, 14.54]
	p-value	.670	.331	.335
Sleep efficiency-A change	Coefficient [95% CI]	−0.48 [−1.30, 0.34]	−1.15 [−3.02, 0.71]	0.55 [−0.46, 1.57]
	p-value	.247	.223	.283
ESS change	Coefficient [95% CI]	−0.34 [−0.85, 0.17]	−0.18 [−1.31, 0.96]	0.51 [−0.11, 1.14]
	p-value	.188	.756	.107
FFS change	Coefficient [95% CI]	−0.24 [−1.37, 0.88]	−1.75 [−4.26, 0.77]	1.26 [−0.12, 2.64]
	p-value	.669	.171	.074
PHQ-9 change	Coefficient [95% CI]	0.22 [−0.44, 0.89]	−0.36 [−1.85, 1.13]	0.51 [−0.31, 1.33]
	p-value	.507	.632	.221
SF-12vs physical health	Coefficient [95% CI]	−0.32 [−1.75, 1.12]	1.46 [−1.75, 4.67]	0.22 [−1.53, 1.98]
	p-value	.665	.370	.801
SF-12vs mental health change	Coefficient [95% CI]	−0.50 [−1.88, 0.88]	−2.39 [−5.48, 0.69]	−0.64 [−2.33, 1.05]
	p-value	.478	.127	.455

DBAS, Dysfunctional Beliefs and Attitudes about Sleep; PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; sleep efficiency-D, sleep diary measured sleep efficiency; WASO-D, sleep diary measured wake after sleep onset; sleep efficiency-A, actigraphy measured sleep efficiency; ESS, Epworth Sleepiness Scale; FFS, Flinders Fatigue Scale; PHQ-9, Patient Health Questionnaire-9 items; SF-12, Medical Outcomes Study 12-item Short-Form health-related quality of life.

thus, it is possible that those with a comorbid psychiatric disorder may have responded differently to treatment as compared to participants with insomnia only. These moderating and mediating factors at the individual level may need to be explored in future work.

Conclusions

Significant reduction in dysfunctional sleep-related beliefs with CBTI across several DBAS subscales in older veterans predicted improvements in several outcomes of nighttime sleep and daytime consequences. These findings have important clinical implications and suggest that clinicians treating older veterans with insomnia should pay attention to addressing specific dysfunctional beliefs about sleep, particularly appraisals of the consequences of insomnia, issues of worry and helplessness about insomnia, and expectations about sleep requirements. Future clinical trials should assess specific sleep-related beliefs to identify the types of cognitions to target for insomnia treatment.

Acknowledgments

This work was presented in part at the Gerontological Society of America Annual Meeting, Austin, Texas, November 2019, and the SLEEP Annual Meeting, August 2020. This study was supported by the VA Health Services Research and Development (IIR 08-295, PI: Alessi and RCS 20–191, PI: Martin), National Institute on Aging (K23AG055668, PI: Song), (K23AG045937, PI: Fung), (K23AG049955, PI: Dzierzewski) and The Beeson Career Development in Aging Research Award Program, (PI: Fung), the National Heart Lung and Blood Institute (K24HL143055, PI: Martin) of the National Institutes of Health. Additional support includes VA Greater Los Angeles Healthcare System, Geriatric Research, Education and Clinical Center (GRECC) and the VA Office of Academic Affiliations through the Advanced Fellowship Programs in HSR&D and Advanced Geriatrics (Dr. Kelly). The content is solely the responsibility of the authors and does not necessarily represent the official views of the Department of Veterans Affairs, National Institutes of Health, or the U.S. Government.

Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards Dr Dzierzewski is a co-founder and a part owner of Better Sleep Foundation, LLC. Other authors declare that they have no conflict of interest.

Ethical Approval In the manuscript, we stated that the study was approved by our local institutional research ethics committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Our study involves human participants only. We obtained informed consent from individual participants for this study.

References

1. Foley DJ, Monjan AA, Brown SL, Simonsick EM, Wallace RB, Blazer DG. Sleep complaints among elderly persons: an epidemiologic study of three communities. *Sleep.* 1995;18:425–432.
2. Jaussent I, Dauvilliers Y, Ancelin ML, et al. Insomnia symptoms in older adults: associated factors and gender differences. *Am J Geriatr Psychiatry.* 2011;19:88–97.
3. Song Y, Dzierzewski JM, Fung CH, et al. Association between sleep and physical function in older veterans in an adult day healthcare program. *J Am Geriatr Soc.* 2015;63(8):1622–1627.
4. Song Y, Blackwell T, Yaffe K, Ancoli-Israel S, Redline S, Stone KL; Osteoporotic Fractures in Men (MrOS) Study Group. Relationships between sleep stages and changes in cognitive function in older men: the MrOS Sleep Study. *Sleep.* 2015;38:411–421.
5. Stone KL, Ancoli-Israel S, Blackwell T, et al. Actigraphy-measured sleep characteristics and risk of falls in older women. *Arch Intern Med.* 2008;168:1768–1775.
6. Schubert CR, Cruickshanks KJ, Dalton DS, Klein BE, Klein R, Nondahl DM. Prevalence of sleep problems and quality of life in an older population. *Sleep.* 2002;25:889–893.
7. Dew MA, Hoch CC, Buysse DJ, et al. Healthy older adults' sleep predicts all-cause mortality at 4 to 19 years of follow-up. *Psychosom Med.* 2003;65:63–73.
8. Spielman AJ, Caruso LS, Glovinsky PB. A behavioral perspective on insomnia treatment. *Psychiatr Clin North Am.* 1987;10:541–553.
9. Ohayon MM, Carskadon MA, Guilleminault C, Vitiello MV. Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. *Sleep.* 2004;27:1255–1273.
10. Beaulieu-Bonneau S, LeBlanc M, Mérette C, Dauvilliers Y, Morin CM. Family history of insomnia in a population-based sample. *Sleep.* 2007;30:1739–1745.
11. Williams J, Roth A, Vatthauer K, McCrae CS. Cognitive behavioral treatment of insomnia. *Chest.* 2013;143:554–565.
12. Bastien CH, Vallières A, Morin CM. Precipitating factors of insomnia. *Behav Sleep Med.* 2004;2:50–62.
13. Bélanger L, LeBlanc M, Morin CM. Cognitive behavioral therapy for Insomnia in older Adults. *Cogn Behav Pract.* 2012;19:101–115.
14. Ellis J, Hampson SE, Cropley M. The role of dysfunctional beliefs and attitudes in late-life insomnia. *J Psychosom Res.* 2007;62:81–84.
15. Hertenstein E, Nissen C, Riemann D, Feige B, Baglioni C, Spiegelhalder K. The exploratory power of sleep effort, dysfunctional beliefs and arousal for insomnia severity and polysomnography-determined sleep. *J Sleep Res.* 2015;24:399–406.
16. Carney CE, Edinger JD, Morin CM, et al. Examining maladaptive beliefs about sleep across insomnia patient groups. *J Psychosom Res.* 2010;68:57–65.
17. Qaseem A, Kansagara D, Forciea MA, Cooke M, Denberg TD; Clinical Guidelines Committee of the American College of Physicians. Management of chronic Insomnia disorder in Adults: a clinical practice guideline from the American College of Physicians. *Ann Intern Med.* 2016;165:125–133.
18. Wilson S, Anderson K, Baldwin D, et al. British association for Psychopharmacology consensus statement on evidence-based treatment of insomnia, parasomnias and circadian rhythm disorders: an update. *J Psychopharmacol.* 2019;33:923–947.
19. Department of Veterans Affairs, Department of Defense. VA/DoD Clinical practice guideline for the management of chronic insomnia disorder and Obstructive Sleep Apnea: Provider summary, 2019. Available at https://www.healthquality.va.gov/guidelines/CD/insomnia/index.asp
20. Alessi C, Martin JL, Fiorentino L, et al. Cognitive behavioral therapy for Insomnia in older veterans using nonclinician sleep coaches: randomized controlled trial. *J Am Geriatr Soc.* 2016;64:1830–1838.
21. Sivertsen B, Omvik S, Pallesen S, et al. Cognitive behavioral therapy vs zopiclone for treatment of chronic primary insomnia in older adults: a randomized controlled trial. *JAMA.* 2006;295:2851–2858.
22. Irwin MR, Cole JC, Nicassio PM. Comparative meta-analysis of behavioral interventions for insomnia and their efficacy in middle-aged adults and in older adults 55+ years of age. *Health Psychol.* 2006;25:3–14.
23. Rybarczyk B, Stepanski E, Fogg L, Lopez M, Barry P, Davis A. A placebo-controlled test of cognitive-behavioral therapy for comorbid insomnia in older adults. *J Consult Clin Psychol.* 2005;73:1164–1174.
24. Lovato N, Lack L, Wright H, Kennaway DJ. Evaluation of a brief treatment program of cognitive behavior therapy for insomnia in older adults. *Sleep.* 2014;37:117–126.
25. Schwartz DR, Carney CE. Mediators of cognitive-behavioral therapy for insomnia: a review of randomized controlled trials and secondary analysis studies. *Clin Psychol Rev.* 2012;32:664–675.

26. Harvey AG, Bélanger L, Talbot L, et al. Comparative efficacy of behavior therapy, cognitive therapy, and cognitive behavior therapy for chronic insomnia: a randomized controlled trial. *J Consult Clin Psychol.* 2014;82:670–683.
27. Eidelman P, Talbot L, Ivers H, Bélanger L, Morin CM, Harvey AG. Change in dysfunctional beliefs about sleep in behavior therapy, cognitive therapy, and cognitive-behavioral therapy for Insomnia. *Behav Ther.* 2016;47:102–115.
28. Morin CM, Vallières A, Ivers H. Dysfunctional beliefs and attitudes about sleep (DBAS): Validation of a brief version (DBAS-16). *Sleep.* 2007;30:1547–1554.
29. Morin CM, Stone J, Trinkle D, Mercer J, Remsberg S. Dysfunctional beliefs and attitudes about sleep among older adults with and without insomnia complaints. *Psychol Aging.* 1993;8:463–467.
30. Thakral M, Von Korff M, McCurry SM, Morin CM, Vitiello MV. Changes in dysfunctional beliefs about sleep after cognitive behavioral therapy for insomnia: a systematic literature review and meta-analysis. *Sleep Med Rev.* 2020;49:101230.
31. Morin CM, Blais F, Savard J. Are changes in beliefs and attitudes about sleep related to sleep improvements in the treatment of insomnia? *Behav Res Ther.* 2002;40:741–752.
32. Edinger JD, Wohlgemuth WK, Radtke RA, Marsh GR, Quillian RE. Does cognitive-behavioral insomnia therapy alter dysfunctional beliefs about sleep? *Sleep.* 2001;24:591–599.
33. Chow PI, Ingersoll KS, Thorndike FP, et al. Cognitive mechanisms of sleep outcomes in a randomized clinical trial of internet-based cognitive behavioral therapy for insomnia. *Sleep Med.* 2018;47:77–85.
34. Lancee J, Eisma MC, van Straten A, Kamphuis JH. Sleep-related safety behaviors and dysfunctional beliefs mediate the efficacy of online CBT for insomnia: a randomized controlled trial. *Cogn Behav Ther.* 2015;44:406–422.
35. Grandner MA, Patel NP. Gooneratne NS: Difficulties sleeping: a natural part of growing older? *Aging Health.* 2012;8(3):219–221.
36. Colvonen PJ, Almklov E, Tripp JC, et al. Prevalence rates and correlates of insomnia disorder in post-9/11 veterans enrolling in VA healthcare. *Sleep.* 2020;43(12):zsaa119.
37. Trivedi RB, Post EP, Sun H, et al. Prevalence, comorbidity, and prognosis of mental health among US Veterans. *Am J Public Health.* 2015;105:2564–2569.
38. McKee AC, Robinson ME. Military-related traumatic brain injury and neurodegeneration. *Alzheimers Dement.* 2014;10:S242–S253.
39. Gauntlett-Gilbert J, Wilson S. Veterans and chronic pain. *Br J Pain.* 2013;7:79–84.
40. Bramoweth AD, Rodriguez KL, Klima GJ, Appelt CJ, Chinman MJ. Veterans' experiences with and perspectives on insomnia treatment: A qualitative study. *Psychol Serv*. 2020. doi:10.1037/ser0000494.
41. International Classification of Sleep Disorders. *Diagnostic and Coding Manual.* 2nd ed. Westchester, IL: American Academy of Sleep Medicine; 2005.
42. Ryden AM, Martin JL, Matsuwaka S, et al. Insomnia disorder among older Veterans: results of a postal survey. *J Clin Sleep Med.* 2019;15:543–551.
43. Schulz KF, Altman DG, Moher D; CONSORT Group. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *BMJ.* 2010;340:c332.
44. Carney CE, Edinger JD. Identifying critical beliefs about sleep in primary insomnia. *Sleep.* 2006;29:444–453.
45. Ancoli-Israel S, Martin JL, Blackwell T, et al. The SBSM Guide to Actigraphy monitoring: clinical and research applications. *Behav Sleep Med.* 2015;13 (Suppl 1):S4–S38.
46. Carney CE, Buysse DJ, Ancoli-Israel S, et al. The consensus sleep diary: standardizing prospective sleep self-monitoring. *Sleep.* 2012;35:287–302.
47. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. *Psychiatry Res.* 1989;28:193–213.
48. Morin CM, Belleville G, Bélanger L, Ivers H. The Insomnia severity index: psychometric indicators to detect insomnia cases and evaluate treatment response. *Sleep.* 2011;34:601–608.
49. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep.* 1991;14:540–545.
50. Gradisar M, Lack L, Richards H, et al. The Flinders Fatigue Scale: preliminary psychometric properties and clinical sensitivity of a new scale for measuring daytime fatigue associated with insomnia. *J Clin Sleep Med.* 2007;3:722–728.
51. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med.* 2001;16:606–613.
52. Ware J Jr, Kosinski M, Keller SD. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. *Med Care.* 1996;34:220–233.
53. Jansson-Fröjmark M, Linton SJ. The role of sleep-related beliefs to improvement in early cognitive behavioral therapy for insomnia. *Cogn Behav Ther.* 2008;37:5–13.
54. Van de Water AT, Holmes A, Hurley DA. Objective measurements of sleep for non-laboratory settings as alternatives to polysomnography—a systematic review. *J Sleep Res.* 2011;20:183–200.
55. Dzierzewski JM, Martin JL, Fung CH, et al. CBT for late-life insomnia and the accuracy of sleep and wake perceptions: results from a randomized-controlled trial. *J Sleep Res.* 2019;28:e12809.
56. Montserrat Sánchez-Ortuño M, Edinger JD. A penny for your thoughts: patterns of sleep-related beliefs, insomnia symptoms and treatment outcome. *Behav Res Ther.* 2010;48:125–133.