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Original Article

Insomnia treatment response as a function of objectively measured sleep duration

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ABSTRACT

Objectives: To examine the potential moderating effect of objectively measured sleep duration at baseline on the response to cognitive behavioral therapy for insomnia (CBT-I), administered singly or combined with medication (CBT-I + Med).

Methods: Based on the average PSG-derived sleep duration across two baseline nights and the type of treatment received, 159 adults with insomnia (50.3 ± 10.1 years; 61.0% women) were classified into one of four groups: participants with short sleep duration (ie, ≤ 6 h) treated with CBT-I ($n = 26$) or CBT-I+Med ($n = 25$), and participants with normal sleep duration (ie, > 6 h) treated with CBT-I ($n = 54$) or CBT-I+Med ($n = 54$). Primary outcome measures were sleep/wake parameters derived from a sleep diary and insomnia severity and secondary outcomes were beliefs about sleep, fatigue, depression and anxiety.

Results: Patients with both short and normal sleep durations at baseline improved significantly on most sleep continuity parameters with CBT-I administered singly or combined with medication. Irrespective of treatment received, participants with short sleep duration also showed significantly greater improvements in subjective sleep (ie, reduced wake after sleep onset, increased sleep efficiency) relative to those with normal sleep duration. Conversely, participants with normal sleep duration showed greater improvements on some measures of daytime functioning and sleep satisfaction.

Conclusions: There was no moderating effect of baseline sleep duration on treatment response to cognitive behavioral therapy. Despite some marginal differential treatment response on selected daytime functioning outcomes, the benefits from CBT-I were not significantly different as a function of short or normal sleep duration at baseline. Further prospective investigation of insomnia phenotypes taking into account other variables than sleep duration is warranted in order to develop more targeted insomnia therapies.

Trial registration: www.clinicaltrials.gov (#NCT 00042146).

Insomnia is characterized by subjective difficulties initiating or maintaining sleep along with significant distress or impairments of daytime functioning that occur despite adequate opportunity for sleep [1,2]. These subjective complaints may or may not be corroborated by objective measures derived from polysomnography (PSG) assessment. PSG assessment is not essential to make the diagnosis of insomnia and is generally not recommended for the routine evaluation of insomnia [3,4]. Nonetheless, objective sleep measures derived from PSG, particularly sleep duration, can be useful for identifying subtypes of insomnia [5].

Vgontzas and colleagues [5] have proposed two insomnia phenotypes based on objective sleep duration. According to this model, insomnia with short objective sleep duration (ie, <6 h) is more biologically rooted, as evidenced by increased activity of the hypothalamic-pituitary-adrenal axis [6–9], increased risk of cardiovascular morbidity (eg, type 2 diabetes, hypertension, reduced heart rate variability) [10–15], and greater cognitive deficits (eg, reduced processing speed and set-switching attention, poorer visual memory) [16]. In contrast, insomnia with normal objective sleep duration (ie, >6 h) is neither associated with physiological arousal nor with significant medical morbidity. Rather, it is characterized by psychological factors, such as elevated depressive and anxiety symptoms, poorer stress-related coping strategies, and a tendency

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to underestimate sleep duration [17]. Additionally, individuals with insomnia and normal objective sleep duration tend to report increased worry about falling asleep, greater distress and interference of sleep difficulties with daytime functioning, and lower sleep satisfaction than individuals with short objective sleep duration [18]. Although not all the evidence support such a clear distinction between these phenotypes, they have heuristic value. Furthermore, if proved valid and replicable, they could be particularly useful for matching treatment modality (psychological vs. pharmacotherapy) to the unique clinical presentation of individuals with insomnia.

Cognitive-behavioral therapy for insomnia (CBT-I) and pharmacotherapy are the only two treatment options with adequate evidence supporting their use for the management of insomnia [19–21]. CBT-I is a multimodal intervention encompassing cognitive (eg, cognitive restructuring) and behavioral components (eg, stimulus control, restriction of time in bed). The most widely used pharmacological treatments for insomnia are benzodiazepine receptor agonists, including traditional benzodiazepines (eg, temazepam) and related agents also acting on GABA receptors (eg, zolpidem, eszopiclone) [22]. Meta-analyses indicate that pharmacotherapy produces small to moderate effect sizes on several sleep parameters and CBT-I produces moderate to large effect sizes [23–26]. Compared to CBT-I, pharmacotherapy is associated with more rapid sleep improvement and greater benefits on sleep duration and number of awakenings. Conversely, CBT-I is associated with greater reductions in sleep onset latency (SOL), wake after sleep onset (WASO), and better long-term maintenance of sleep improvements [21,23,24,26,27].

Considering the distinct hypothesized profile of each insomnia phenotype, one would expect that they might respond differently to psychological and pharmacological therapies. Individuals with insomnia and short sleep duration, a more biologically-based phenotype, may respond more favorably to therapies that reduce physiological arousal and increase sleep duration. Hypnotic agents are known to reduce arousal to increase total sleep time (TST) [23,24,26]. Individuals with short sleep duration may not be the best candidates for behavioral interventions that include sleep restriction, which may consolidate sleep but not increase its duration. On the other hand, given their psychological profile (eg, sleep misperception, ruminations about sleep), individuals with insomnia and normal sleep duration may be better candidate for CBT-I, as one of its focus is on reducing worry and anxiety (cognitive arousal) via the alteration of unhelpful sleep-related beliefs and thoughts.

The few studies that have examined the association between objective sleep duration and response to insomnia treatment have yielded inconsistent results. One study examining response to brief behavioral treatment for insomnia (ie, stimulus control, sleep restriction) in 39 older adults showed a poorer treatment response for patients with short sleep duration (ie, $\leq$ 6 h based on in−home PSG and sleep diary) than those with normal sleep duration (ie, > 6 h) [28]. Follow-up assessment (four weeks) also showed increased odds of non-remission for patients with short sleep duration as measured by PSG ($OR = 4.8$, 95%CI: 1.04−21.79) and by sleep diary ($OR = 8.05$ 95%CI: 1.70−38.1). Three additional studies investigated response to CBT-I, one with 60 adults [29] another with 63 older adults [30], and one study with 96 adults [31]. In all studies, participants were split into two subgroups based on pre-treatment average sleep duration: short sleep duration (ie, <6 h) and normal sleep duration (ie, $\geq$6 h). Bathgate et al., [15] found that participants with normal sleep duration (based on actigraphy) achieved significantly better sleep diary outcomes and had higher rates of insomnia remission compared to those with short sleep duration [29]. Similarly, Miller et al., [31] found that participants with insomnia and normal sleep duration (based on one night of laboratory PSG) were more likely to respond to CBT compared to those with short sleep duration [31]. Conversely, Lovato and colleagues found that response to CBT-I were comparable for the two sleep duration subgroups (based on one home-based PSG) [30].

In summary, it is difficult to draw unequivocal conclusions from these few studies because the measures used to derive objective estimates of sleep duration were different across studies (ie, actigraphy, PSG). Nonetheless, two suggest that short objective sleep duration is associated with poorer treatment response [28,29]. As those studies focused exclusively on response to CBT-I, it is of interest to examine whether patients treated with medication would respond differently as a function of sleep duration as suggested by Vgontzas' phenotype model.

The aim of the present study was to examine treatment response as a function of baseline objective sleep duration among individuals treated with CBT-I, administered singly or combined with medication (ie, zolpidem; CBT-I+Med). According to Vgontzas' model, it was expected that individuals with insomnia and objective normal sleep duration would show greater improvements on sleep and daytime functioning parameters than those with objective short sleep duration, independent of the treatment received. Among those with objective short sleep duration, the subgroup treated with CBT-I+Med was expected to show greater improvements on sleep and daytime parameters than those treated with CBT-I only. A second, more exploratory aim was to compare baseline subjective sleep disturbances (as measured by sleep diary), insomnia severity and psychological symptoms (eg, fatigue, depressive/anxiety symptoms, beliefs about sleep) among individuals with insomnia and objective short or normal sleep duration. It was expected that nighttime and daytime insomnia symptoms would be more severe among individuals with objective normal sleep duration than those with short sleep duration.

1. Method

1.1. Study context and design

This study reports secondary analyses of data from a clinical trial examining the efficacy of CBT-I, administered singly or combined with zolpidem [32]. Study participants, procedures, and results pertaining to the original study and primary research questions have been described in more detail elsewhere [32]. Briefly, assessments were conducted throughout the study at baseline, at the end of a 6-week initial treatment phase (post-I), at the end of a six-month extended treatment phase (post-II), and at follow-up. Assessments included daily sleep diaries over a two-week period, laboratory sleep evaluations, and the completion of a battery of validated questionnaires (described in more detail below). Notably, the present study focuses specifically on changes during the six-week acute treatment phase (ie, baseline to post-I), in which eligible participants were randomized to CBT-I alone (CBT-I; $n = 80$) or CBT-I combined with zolpidem (CBT-I+Med; $n = 80$). The Institutional Research Board of Ethics from the Institut Universitaire en Santé Mentale de Québec approved the study protocol.

1.2. Participants

All participants were 30 years or older and diagnosed with chronic insomnia based on a combination of criteria from the Diagnostic and Statistical Manuel of Mental Disorder, fourth edition [DSM-IV] [33] and the International Classification of Sleep Disorders, second edition [ICSD-II] [34]. These criteria were operationalized as: (1) subjective SOL and/or WASO greater than 30 min, with a corresponding TST shorter than 6.5 h at least three nights per week; (2) insomnia duration longer than six months; and (3) significant distress or impairment in daytime functioning on item 5 of

the ISI (rating ≥ 2 on a scale from 0 to 4). Exclusion criteria were as follows: (1) presence of a progressive medical illness (eg, cancer, dementia); (2) use of medications known to alter sleep (eg, steroids); (3) lifetime diagnosis of any psychotic or bipolar disorder; (4) current diagnosis of major depression, unless treated and in remission; (5) more than two past episodes of major depression; (6) history of suicide attempt; (7) alcohol or drug abuse within the past year; (8) sleep apnea (apnea/hypopnea index >15); restless legs, or periodic limb movements during sleep (movement index with arousal >15/h); or (9) night-shift work or irregular sleep pattern. Participants with stable medical conditions (eg, hypertension) or psychiatric disorders (eg, dysthymia, anxiety) were included in the study provided that these conditions were not the primary cause of insomnia.

1.3. Measures

1.3.1. Sleep diary

Participants kept daily sleep diaries for two weeks at baseline and six weeks during the acute treatment phase. The primary dependent variables derived from the diaries were SOL, WASO, TST, and sleep efficiency [(SE) sleep time to the time spent in bed multiplied by 100]. The sleep diary is a standard assessment instrument in insomnia research that is used to monitor sleep patterns over extended periods [35].

1.3.2. Polysomnography (PSG)

Participants underwent three nights of PSG assessment at baseline and two nights at post-I. Bedtime and arising times during those nights were based on habitual sleep schedule at home (as determined by sleep diaries). Outcome variables were SOL, WASO, TST, and SE, which were averaged over two nights for each assessment phase (the first baseline night was a screening night and excluded from data analysis). Sleep stages were scored visually according to standardized criteria [36] by experienced technicians, who were blinded to participants' treatment conditions.

1.3.3. Questionnaires

Participants completed a morning questionnaire of subjective estimates of their previous night's sleep after each PSG assessment. A sleep perception index was computed as the ratio of perceived TST to PSG-derived TST (subjective TST/objective TST × 100) for each night. Participants also completed the following questionnaires at each assessment phase: the Insomnia Severity Index (ISI), a seven-item self-reported outcomes assessing the severity of insomnia symptoms, sleep satisfaction, and severity of daytime functioning [37,38], the Dysfunctional Beliefs and Attitudes About Sleep Scale (DBAS) [39], the Multidimensional Fatigue Inventory (MFI) [40], the Beck Depression Inventory-II (BDI) [41], and the Beck Anxiety Inventory (BAI) [42].

1.4. Treatment conditions

1.4.1. Cognitive-Behavioral Therapy (CBT)

CBT is a multi-modal intervention that features behavioral, educational, and cognitive components [43]. The behavioral intervention included restriction of time in bed to the actual time slept and gradually increasing it back to an optimal sleep time. Each participant was prescribed an individualized sleep window, which was adjusted weekly. In addition, patients received the following stimulus control instructions: (1) go to bed only when sleepy at night; (2) use the bed and bedroom only for sleep and sex (ie, no reading, TV watching, worrying); (3) get out of bed and go to another room when unable to fall asleep or return to sleep within 20 min and return to bed only when feeling sleepy again; and (4) arise at the same time every morning. A short daytime nap before 3 PM was optional during the early phase of the acute six-week treatment (for more specific information on these procedures, please see original report by Morin et al., [32]).

Sleep hygiene education was also provided, including information about the effects of caffeine, alcohol, and exercise on sleep, as well as the effects of noise, light, and excessive room temperature. Cognitive therapy aimed to alter maladaptive beliefs and misconceptions about sleep such as unrealistic sleep expectations (eg, the absolute need to sleep 8 h each night) and amplification of the consequences of insomnia (eg, all daytime impairments are due to poor sleep). Using treatment manuals, master's level clinical psychologists delivered CBT-I sessions.

1.4.2. CBT and Medication (CBT-I + Med)

Participants received CBT-I (as described above) and 10 mg of zolpidem. They were instructed to take the medication 30 min before bedtime each night. Zolpidem is a non-benzodiazepine-receptor agonist and has a rapid onset of action and a short half-life (mean of 2.5 h). Its therapeutic benefits are similar to benzodiazepine hypnotic drugs with potentially fewer daytime residual effects and little impact on sleep architecture [44]. Participants had brief (15–20 min), weekly consultation sessions with a physician. These sessions focused on reviewing sleep diaries, changes in insomnia symptoms during the previous week, conducting a pill count, as well as monitoring potential adverse effects of zolpidem. The physician used a treatment manual with standardized guidelines to deliver treatment according to the study protocol.

1.5. Data management and analysis

Analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC). All analyses used an intent-to-treat paradigm to avoid imputation of missing data. Thus, participants with incomplete data were included in the analysis using linear mixed models, which are robust to non-informative missing data.

One-way analyses of variance (ANOVAs) and chi-square analyses were conducted to compare groups (short vs. normal sleep durations) on socio-demographic, sleep, and clinical variables at baseline. Variables that were significantly different between groups were entered as covariates in subsequent analyses.

Factorial 2 groups (short vs. normal sleep durations) × 2 treatments (CBT-I vs. CBT-I+Med) × 2 times (baseline vs. post-I) linear mixed model analyses were estimated to examine the moderating effect of baseline sleep duration on treatment response on sleep and clinical variables. Adjusted alpha using family-wise error rate [45] was used to control for alpha inflation due to multiple tests. The simultaneous test procedure for factorial design [45] was used to compute the appropriate corrected alpha level for sleep duration × time interaction (0.05) and third order interaction (0.025).

2. Results

2.1. Sample characteristics

The sample included 159 adults (61.0% female) with a mean age of 50.31 years (SD = 10.14) and a mean education of 14.71 years (SD = 3.56). One participant had missing PSG data at baseline and was excluded from analyses since PSG data were used to classify participants into subgroups. All participants were Caucasian; 68.6% were married or in a common-law relationship. Average insomnia duration was 16.28 years (SD = 13.63) (see Table 1). The overall attrition rate was 6.9% (n = 11) after acute six-week treatment and it was not different between treatment conditions. Men were more likely than women to drop out of the study; no other

Table 1
Participants sociodemographic and clinical characteristics at baseline ($N = 159$).

	Total ($N = 159$)	Short sleep duration ($n = 51$)	Normal sleep duration ($n = 108$)	F^1 or χ^2 (dl)	p
	M (SD)	*M (SD)*	*M (SD)*		
Age (years)	50.31 (10.14)	50.71 (9.93)	50.12 (10.27)	0.12	0.74
Education (years)	14.71 (3.56)	14.12 (3.54)	14.98 (3.55)	2.02[a]	0.16
Gender (%, *n*)				3.17 (1)	0.08
Female	61.0 (97)	51.0 (26)	65.7 (71)		
Male	39.0 (62)	49.0 (25)	34.3 (37)		
Marital status (%, *n*)				1.77 (3)	0.62
Single	8.8 (14)	11.8 (6)	7.4 (8)		
Married/common law	68.6 (109)	62.7 (32)	71.3 (77)		
Divorced/separated	17.0 (27)	17.6 (9)	16.7 (18)		
Widowed	5.7 (9)	7.8 (4)	4.6 (5)		
Insomnia duration (years)	16.28 (13.63)	18.53 (14.85)	15.22 (12.95)	2.05	0.15
Medical condition (%, *n*)					
Hypertension (yes)	10.7 (17)	9.8 (5)	11.1 (12)	0.06 (1)	0.80
Cardiovascular (yes)	2.5 (4)	3.9 (2)	1.9 (2)	0.61 (1)	0.44
Sleep diary					
Sleep onset latency (SOL)	33.44 (31.57)	34.69 (28.18)	32.85 (33.16)	0.12	0.73
Wake after sleep onset (WASO)	63.43 (37.33)	73.18 (42.36)	58.83 (33.95)	5.26	0.02
Total sleep time (TST)	345.80 (69.90)	328 (73.86)	354.21 (66.66)	4.99	0.03
Sleep efficiency (SE)	68.72 (13.84)	65.92 (14.56)	70.04 (13.36)	3.11	0.08
Polysomnography					
Sleep onset latency (SOL)	15.64 (11.69)	19.60 (16.14)	13.77 (8.31)	9.06	<0.001
Wake after sleep onset (WASO)	58.64 (36.48)	81.28 (42.97)	47.96 (27.26)	35.14	<0.001
Total sleep time (TST)	374.50 (46.10)	322.67 (33.46)	398.98 (27.01)	236.18	<0.001
Sleep efficiency (SE)	83.00 (8.71)	75.71 (9.68)	86.45 (5.56)	78.48	<0.001
Questionnaires					
Insomnia Severity Index (ISI)	17.54 (3.75)	17.76 (3.85)	17.43 (3.71)	0.26[b]	0.61
ISI components					
Severity of sleep symptoms	7.18 (1.92)	7.36 (1.83)	7.10 (1.96)	0.61[b]	0.44
Sleep satisfaction	3.36 (0.74)	3.30 (0.91)	3.39 (0.64)	0.54	0.46
Severity of daytime symptoms	6.99 (2.05)	7.10 (2.04)	6.93 (2.06)	0.22[b]	0.63
Beck Depression Inventory (BDI)	8.01 (5.63)	7.00 (4.22)	8.49 (6.16)	2.38[c]	0.13
Beck Anxiety Inventory (BAI)	7.24 (5.76)	7.42 (5.71)	7.15 (5.81)	0.07[d]	0.80
Multidimensional Fatigue Inventory	49.98 (12.55)	49.55 (12.43)	50.18 (12.66)	0.09	0.77
Dysfunctional Beliefs about Sleep	5.14 (1.32)	5.14 (1.27)	5.14 (1.35)	0.00	0.99

All F(1,157), except aF(1,156), bF(1,155), cF(1,153), dF(1,136).

socio-demographic, sleep, or clinical variable were associated with attrition.

Based on average PSG-derived sleep duration across two baseline nights, participants were classified into short or normal sleep duration groups. The short sleep condition (ie, ≤ 6 h) included 51 participants (50.98% female; $M_{age} = 50.71$, $SD = 9.93$) and their average objective TST was 322.67 min ($SD = 33.46$). The normal sleep duration group (ie, > 6 h) included 108 participants (65.74% females; $M_{age} = 50.12$, $SD = 10.27$) and their average objective TST was 398.98 min ($SD = 27.01$). No significant between-group differences (short vs. normal sleep durations) were observed for socio-demographic variables, medical comorbidities, insomnia duration and insomnia symptoms severity, depression, anxiety, fatigue, and dysfunctional beliefs about sleep (see Table 1).

For sleep diary parameters, the normal sleep group had significantly shorter WASO (58.83 min vs. 73.18 min, $p = 0.02$), and longer TST (354.21 min vs. 328 min, $p = 0.03$). No significant group differences were observed for the sleep perception index at any of the baseline PSG nights (Fig. 1).

2.2. Treatment response

Participants were classified into one of four conditions based on sleep duration and treatment received: participants with normal sleep duration treated with CBT-I ($n = 54$) or CBT-I+Med ($n = 54$) and participants short sleep duration treated with CBT-I ($n = 26$) or CBT-I+Med ($n = 25$). Averaged changes from baseline to post-treatment were examined first for all participants combined (CBT-I and CBT-I+Med) according to sleep duration and then separately for each treatment condition.

2.2.1. Sleep diary

Table 2 summarizes data on sleep diary parameters according to sleep duration groups, treatment, and time. Significant group × time interactions were observed for WASO, $F(1,153) = 7.55$, $p = 0.01$ and SE, $F(1,150) = 5.37$, $p = 0.02$. Simple effects showed significant reductions in WASO for both participants with normal (−32.15 min) and those with short sleep duration (−47.70 min), with the improvement being significantly larger among the latter group. Both participants with normal and short sleep durations reported significant increases in SE (13.73% and 18.24%, respectively) and this improvement was significantly larger ($p = 0.02$) for the latter condition. There were no significant interactions for SOL, $F(1,153) = 0.38$, $p = 0.54$ and TST, $F(1,148) = 2.18$, $p = 0.14$.

Within the CBT-I subgroup, simple effects showed that participants with normal sleep duration had smaller, albeit non-significant improvements in WASO and in SE (−25.19 min and 13.23%, respectively) relative to those with short sleep duration (−42.41 min and 16.77%, respectively). Within the CBT-I+Med subgroup, participants with normal duration also had smaller, but non-significant improvements in WASO and in SE (−39.10 min and 14.22%, respectively) compared to those with short sleep duration (−52.98 min and 19.70%, respectively).

2.2.2. Polysomnography (PSG)

Table 3 summarizes data on PSG parameters according to sleep duration groups, treatment, and time. Significant group × time interactions were observed for WASO, $F(1,153) = 21.47$, $p < 0.001$, TST, $F(1,153) = 40.64$, $p < 0.001$, and SE, $F(1,152) = 27.31$, $p < 0.001$. Simple effects revealed significant reductions in WASO for

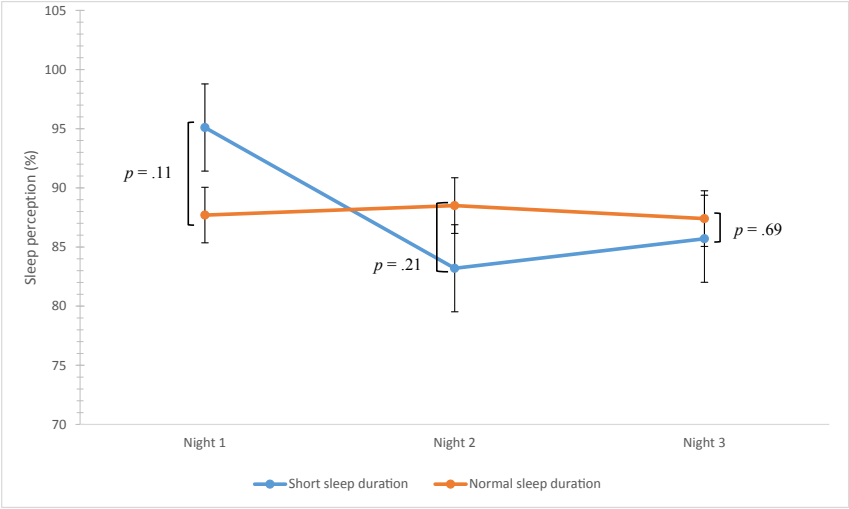

Fig. 1. Ratio of Perceived TST to PSG-derived TST for each PSG night According to Objective Sleep Duration Groups at Baseline.

participants with both normal (−17.36 min) and short sleep durations (−42.38 min), with the latter group showing significantly larger changes ($p < 0.001$). There was a significant reduction (ie, worsening) in TST among participants with normal sleep duration (−34.72 min) but no significant change (4.63 min) for short duration condition. Both groups of participants with normal and with short sleep duration showed significant improvements in SE (3.20% and 9.51%, respectively), and the improvement was significantly larger ($p < 0.001$) among the latter group. There was no significant group × time interaction for SOL, F (1,154) = 1.29, $p = 0.26$.

Within treatment subgroups, simple effects showed that participants with normal sleep duration had a significantly smaller improvement ($p < 0.001$ and $p = 0.02$, respectively) in WASO, regardless of whether they received CBT-I or CBT-I+Med (−17.28 min and −17.45 min, respectively) relative to those with short sleep duration (−48.32 min and −36.44 min, respectively). CBT-I participants with normal duration showed a significant reduction (ie, worsening) in TST (−38.98 min, $p < 0.001$). However, no change was observed for those with short duration (1.82 min). CBT-I+Med participants with normal sleep duration had a significant reduction in TST (−30.46 min, $p < 0.001$), while those with short sleep duration showed a small, non-significant increase in sleep time (7.44 min). For SE, participants with normal sleep duration had significantly smaller improvements in SE after CBT-I or CBT-I + Med (3.35% and 3.06%, respectively) relative to those with short sleep duration (9.83% and 9.19%, respectively).

2.2.3. Insomnia severity and daytime impairments

Table 4 summarizes data on insomnia severity, daytime symptoms, sleep satisfaction, BDI, BAI, MFI, and DBAS. There were significant group × time interactions on daytime symptoms, F (1,147) = 5.23, $p = 0.02$ and sleep satisfaction, F (1,153) = 5.78, $p = 0.02$. Participants with normal and short sleep durations reported significant improvements ($ps < 0.001$) in daytime functioning (−3.58 units and −2.67 units, respectively) and sleep satisfaction (−2.15 units and −1.66 units, respectively). Moreover, improvements were significantly greater among participants with normal duration ($ps = 0.02$). There were no significant interactions in severity of insomnia symptoms, F (1,152) = 0.28, $p = 0.60$, BDI, F (1,154) = 3.0, $p = 0.09$, BAI, F (1,131) = 0.03, $p = 0.85$, MFI, F (1,148) = 2.18, $p = 0.14$ and DBAS, F (1,149) = 3.0, $p = 0.09$.

Table 2
Means (SE) and changes on sleep parameters as measured by sleep diary according to objective sleep duration and treatment.

Time (or change)	Overall			CBT-I			CBT/Med		
	Short sleep duration ($n = 51$)	Normal sleep duration ($n = 108$)	p (d)	Short sleep duration ($n = 26$)	Normal sleep duration ($n = 54$)	p (d)	Short sleep duration ($n = 25$)	Normal sleep duration ($n = 54$)	p (d)
Sleep Onset Latency (min)									
Baseline	34.61 (3.40)	32.86 (2.33)	0.67	38.38 (4.75)	36.61 (3.30)	0.76	30.84 (4.85)	29.10 (3.30)	0.77
Post	16.67 (3.56)	17.91 (2.39)	0.77	17.88 (4.93)	17.06 (3.38)	0.89	15.45 (5.13)	18.76 (3.38)	0.59
Change	−17.94*** (4.03)	−14.94*** (2.73)	0.54 (0.12)	−20.50*** (5.61)	−19.55*** (3.86)	0.89 (0.04)	−15.39** (5.81)	−10.34** (3.86)	0.47 (1.06)
Wake After Sleep Onset (min)									
Baseline	73.24 (4.07)	58.83 (2.80)	0.00***	70.58 (5.70)	53.36 (3.96)	0.01**	75.91 (5.82)	64.30 (3.96)	0.10
Post	25.54 (4.26)	26.68 (2.87)	0.83	28.16 (5.90)	28.17 (4.06)	0.99	22.93 (6.15)	25.19 (4.06)	0.76
Change	−47.70*** (4.69)	−32.15*** (3.17)	0.01** (0.53)	−42.41*** (6.51)	−25.19*** (4.48)	0.03[a] (0.59)	−52.98*** (6.75)	−39.10*** (4.48)	0.09 (0.48)
Total Sleep Time (min)									
Baseline	327.96 (8.76)	354.21 (6.02)	0.01**	330.05 (12.26)	350.68 (8.51)	0.17	325.86 (12.50)	357.74 (8.51)	0.04[a]
Post	338.69 (8.98)	352.96 (6.10)	0.19	329.49 (12.50)	342.70 (8.62)	0.39	347.89 (12.89)	363.22 (8.62)	0.32
Change	10.73 (6.74)	−1.25 (4.53)	0.14 (0.19)	−0.57 (9.33)	−7.98 (6.41)	0.51 (0.12)	22.03[a] (9.72)	5.48 (6.41)	0.16 (0.26)
Sleep Efficiency (%)									
Baseline	65.90 (1.65)	70.04 (1.13)	0.04*	66.74 (2.31)	70.07 (1.60)	0.24	65.06 (2.36)	70.01 (1.60)	0.08
Post	84.14 (1.71)	83.76 (1.16)	0.85	83.51 (2.38)	83.30 (1.64)	0.94	84.76 (2.47)	84.23 (1.64)	0.86
Change	18.24*** (1.61)	13.73*** (1.09)	0.02* (0.38)	16.77*** (2.24)	13.23*** (1.54)	0.19 (0.30)	19.70*** (2.33)	14.22*** (1.54)	0.05[a] (0.46)

Note. CBT-I = cognitive behavioral therapy for insomnia, CBT/Med = cognitive behavioral therapy for insomnia combined with medication.
[a] These comparisons were no longer significant after applying a correction (P values between 0.025 and 0.05). *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 3
Means (SE) and changes on sleep parameters as measured by polysomnography according to objective sleep duration and treatment.

Time (or change)	Overall			CBT-I			CBT/Med		
	Short sleep duration ($n = 51$)	Normal sleep duration ($n = 108$)	*p (d)*	Short sleep duration ($n = 26$)	Normal sleep duration (n = 54)	*p (d)*	Short sleep duration ($n = 25$)	Normal sleep duration ($n = 54$)	*p (d)*
Sleep Onset Latency (min)									
Baseline	19.54 (1.37)	13.77 (0.94)	00***	22.42 (1.91)	14.72 (1.33)	0.00***	16.66 (1.95)	12.81 (1.33)	0.10
Post	13.40 (1.43)	9.93 (0.97)	0.05*	12.61 (1.98)	9.95 (1.37)	0.27	14.19 (2.07)	9.91 (1.36)	0.09
Change	−6.14*** (1.68)	−3.84*** (1.14)	0.26 (0.24)	−9.81*** (2.33)	−4.78** (1.62)	0.08 (0.52)	−2.47 (2.42)	−2.90 (1.61)	0.88 (0.04)
Wake After Sleep Onset (min)									
Baseline	81.10 (3.88)	47.96 (2.67)	0.00***	90.10 (5.43)	49.07 (3.77)	0.00***	72.10 (5.54)	46.85 (3.77)	0.00***
Post	38.72 (4.06)	30.60 (2.74)	0.98	41.77 (5.62)	31.79 (3.90)	0.15	35.66 (5.85)	29.40 (3.86)	0.37
Change	−42.38*** (4.45)	−17.36*** (3.03)	0.00*** (0.90)	−48.32*** (6.20)	−17.28*** (4.30)	0.00*** (1.12)	−36.44*** (6.44)	−17.45*** (4.27)	0.02** (1.95)
Total Sleep Time (min)									
Baseline	322.82 (4.46)	398.98 (3.06)	0.00***	315.50 (6.24)	398.35 (4.33)	0.00***	330.14 (6.36)	399.60 (4.33)	0.00***
Post	327.45 (4.66)	364.26 (3.15)	0.00***	317.32 (6.46)	359.37 (4.47)	0.00***	337.58 (6.72)	369.14 (4.44)	0.00***
Change	4.63 (5.11)	−34.72*** (3.46)	0.00*** (1.24)	1.82 (7.09)	−38.98*** (4.92)	0.00*** (1.28)	7.44 (7.36)	−30.46*** (4.88)	0.00*** (1.19)
Sleep Efficiency (%)									
Baseline	75.73 (0.92)	86.45 (0.64)	0.00***	74.33 (1.29)	86.13 (0.90)	0.00***	77.14 (1.32)	86.76 (0.90)	0.00***
Post	85.24 (0.96)	89.65 (0.65)	0.00***	84.16 (1.34)	89.48 (0.93)	0.00***	86.32 (1.39)	89.82 (0.92)	0.04[a]
Change	9.51* (0.10)	3.20* (0.68)	0.00*** (0.96)	9.83*** (1.39)	3.35*** (0.96)	0.00*** (0.98)	9.19*** (1.44)	3.06*** (0.95)	0.00*** (0.93)

Note. CBT-I = cognitive behavioral therapy for insomnia, CBT/Med = cognitive behavioral therapy for insomnia combined with medication.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
[a] These comparisons were no longer significant after applying a correction (P values between 0.025 and 0.05).

Simple effects showed that after CBT-I+Med, participants with normal sleep duration had a significantly greater improvement in daytime functioning relative to those with short sleep duration (−3.63 unit vs. −1.80 unit, $p < 0.001$). However, no difference between sleep duration condition for participants treated with CBT-I was found. For sleep satisfaction, there was no group difference for either CBT-I or CBT-I+Med.

We also examined changes in ISI total scores as well as rates of remission and response across sleep duration groups and treatments (Table 5). Significant reductions of ISI total scores were observed for both short (reduction of 7.86) and normal (reduction of 9.03) sleep duration groups (ps < 0.001) for the two treatment conditions pooled, as well as for each treatment taken separately. There was no interaction between treatment and sleep duration

Table 4
Means (SE) and changes on insomnia severity and daytime functioning according to objective sleep duration and treatment.

Time (or change)	Overall			CBT-I			CBT/Med		
	Short sleep duration ($n = 51$)	Normal sleep duration ($n = 108$)	*p (d)*	Short sleep duration ($n = 26$)	Normal sleep duration ($n = 54$)	*p (d)*	Short sleep duration ($n = 25$)	Normal sleep duration ($n = 54$)	*p (d)*
ISI - Severity of Nighttime Symptoms									
Baseline	7.36 (0.28)	7.10 (0.19)	0.43	7.41 (0.39)	6.93 (0.27)	0.31	7.32 (0.39)	7.27 (0.27)	0.92
Post	3.86 (0.29)	3.81 (0.20)	0.90	4.21 (0.40)	4.14 (0.28)	0.88	3.50 (0.41)	3.49 (0.28)	0.98
Change	−3.51*** (0.35)	−3.29*** (0.24)	0.60 (0.11)	−3.20*** (0.48)	−2.79*** (0.45)	0.49 (0.21)	−3.82*** (0.50)	−3.79*** (0.33)	0.96 (0.02)
ISI - Sleep Satisfaction									
Baseline	3.30 (0.12)	3.39 (0.08)	0.53	3.12 (0.17)	3.35 (0.12)	0.26	3.48 (0.17)	3.43 (0.12)	0.82
Post	1.64 (0.13)	1.24 (0.09)	0.01**	1.55 (0.18)	1.24 (0.12)	0.15	1.73 (0.18)	1.24 (0.12)	0.03[a]
Change	−1.66*** (0.17)	−2.15*** (0.12)	0.02* (0.56)	−1.57*** (0.24)	−2.11*** (1.62)	0.06 (0.62)	−1.76*** (0.24)	−2.19*** (0.16)	0.13 (0.49)
ISI - Severity of Daytime Symptoms									
Baseline	7.09 (0.30)	6.92 (0.21)	0.64 0.00**	7.50 (0.43)	6.74 (0.29)	0.14	6.68 (0.43)	7.10 (0.29)	0.42 0.01**
Post	4.42 (0.31)	3.34 (0.21)	0.02*	3.96 (0.43)	3.20 (0.30)	0.15	4.88 (0.45)	3.47 (0.30)	0.00***
Change	−2.67*** (0.33)	−3.58*** (0.22)	(0.43)	−3.54*** (0.46)	−3.54*** (0.32)	0.99 (0)	−1.80*** (0.47)	−3.63*** (0.32)	(0.86)
Beck Depression Inventory									
Baseline	6.97 (0.76)	8.50 (0.52)	0.10	6.91 (1.07)	8.07 (0.73)	0.37	7.04 (1.07)	8.93 (0.75)	0.15
Post	5.68 (0.78)	5.55 (0.53)	0.89	3.59 (1.08)	4.19 (0.75)	0.65	7.77 (1.13)	6.91 (0.76)	0.53
Change	−1.30 (0.79)	−2.95*** (0.54)	0.09 (0.31)	−3.32** (1.11)	−3.88*** (0.75)	0.67 (0.10)	0.73 (1.13)	−2.02** (0.78)	0.05[a] (0.51)
Beck Anxiety Inventory									
Baseline	7.52 (0.79)	7.22 (0.55)	0.75	8.41 (1.10)	6.05 (0.77)	0.08	6.64 (1.12)	8.39 (0.77)	0.20
Post	5.75 (0.81)	5.26 (0.53)	0.61	5.24 (1.10)	3.34 (0.76)	0.16	6.27 (1.19)	7.18 (0.75)	0.52
Change	−1.77* (0.85)	−1.96*** (0.57)	0.85 (0.04)	−3.17*** (1.15)	−2.71*** (0.81)	0.75 (0.09)	−0.36 (1.25)	−1.21 (0.79)	0.57 (0.16)
Multidimensional Fatigue Inventory									
Baseline	49.58 (1.85)	50.18 (1.27)	0.79	48.09 (2.60)	48.04 (1.80)	0.99	51.08 (2.65)	52.32 (1.80)	0.70
Post	49.27 (1.92)	46.66 (1.30)	0.26	44.67 (2.67)	42.97 (1.84)	0.60	53.89 (2.77)	50.36 (1.85)	0.29
Change	−0.31 (1.80)	3.52*** (1.22)	0.14 (0.29)	−3.42 (2.49)	−5.08** (1.71)	0.59 (0.13)	2.81 (2.59)	−1.96 (1.73)	0.13 (0.36)
Dysfunctional Beliefs About Sleep (short)									
Baseline	5.13 (0.19)	5.14 (0.13)	0.98	5.32 (0.27)	4.92 (0.19)	0.22	4.94 (0.27)	5.36 (0.19)	0.21
Post	3.15 (0.20)	2.76 (0.13)	0.11	3.02 (0.27)	2.51 (0.19)	0.13	3.27 (0.28)	3.01 (0.19)	0.44
Change	−1.98*** (0.19)	−2.38*** (0.13)	0.09 (0.29)	−2.30*** (0.26)	−2.41*** (0.18)	0.74 (0.08)	−1.67*** (0.27)	−2.35*** (0.18)	0.04[a] (0.50)

Note. CBT-I = cognitive behavioral therapy for insomnia, CBT/Med = cognitive behavioral therapy for insomnia combined with medication.
ISI = Insomnia Severity Index.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
[a] These comparisons were no longer significant after applying a correction (P values between 0.025 and 0.05).

Table 5
Means (SE) and Changes on ISI (raw, remission, response) According to Objective Sleep Duration and Treatment.

Time (or change)	Overall			CBT-I			CBT/Med		
	Short sleep duration ($n = 51$)	Normal sleep duration ($n = 108$)	p (d)	Short sleep duration ($n = 26$)	Normal sleep duration ($n = 54$)	p (d)	Short sleep duration ($n = 25$)	Normal sleep duration ($n = 54$)	p (d)
ISI − Total									
Baseline	17.75 (0.58)	17.41 (0.40)	0.62	18.03 (0.82)	17.02 (0.56)	0.31	17.48 (0.82)	17.81 (0.57)	0.74
Post	9.89 (0.60)	8.38 (0.41)	0.04[a]	9.71 (0.84)	8.57 (0.58)	0.26	10.10 (0.87)	8.19 (0.58)	0.07
Change	−7.86*** (0.71)	−9.03*** (0.48)	0.17 (d = 0.29)	−8.33*** (0.99)	−8.45*** (0.68)	0.95 (d = 0.03)	−7.38*** (1.01)	−9.62*** (0.68)	0.07 (d = 0.51)
ISI - % of remission (ISI < 8) [b]									
Post	30.43 (6.78)	47.00 (4.99)	0.06	25.00 (8.84)	46.00 (7.05)	0.09	36.36 (10.26)	48.00 (7.07)	0.36
ISI - % of response (change ≥ 8)[b]									
Post	56.52 (7.31)	62.00 (4.85)	0.53	58.33 (10.06)	60.00 (6.93)	0.89	54.55 (10.62)	64.00 (6.79)	0.45

Note. CBT-I = cognitive behavioral therapy for insomnia, CBT/Med = cognitive behavioral therapy for insomnia combined with medication.
ISI = Insomnia Severity Index.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
[a] These comparisons were no longer significant after applying a correction (P values between 0.025 and 0.05).
[b] These indices are computed only at post-treatment.

subgroups, all subgroups reporting ISI reductions ranging from 7.38 to 9.62. Remission and response rates at posttreatment were generally higher for those with normal sleep durations compared to those with short sleep durations, but none of the differences were statistically significant. Nonetheless, among those treated with CBT-I alone, there were 21% fewer remitted cases in the short sleep duration subgroup relative to the normal sleep duration (25% vs. 46%).

2.2.4. Do participants with insomnia and short sleep duration respond better to treatment when medication is added to CBT?

Further analyses examined the hypothesis that individuals with short sleep duration may respond better to when medication is added to CBT-I relative to CBT-I alone. There was no significant group (sleep duration) × treatment × time interaction in any sleep diary parameters (Fig. 2). For PSG parameters, there was a significant three-way interaction for SOL, F (1,154) = 1.81, $p = 0.03$. As shown in Fig. 3, participants with short sleep duration treated with CBT-I had a significantly greater reduction in SOL relative to those treated with CBT-I+Med (−9.81 min vs. −6.14 min, $p = 0.03$). No other significant interactions were found for PSG variables WASO, TST, or SE. Thus, the addition of medication to CBT did not improve treatment response among those with short sleep duration.

There were significant interactions in daytime functioning, F (1,147) = 6.98, $p = 0.01$ and depressive symptoms, F (1,146) = 6.56, $p = 0.01$ (Fig. 4). Participants with short sleep duration treated with CBT-I reported significantly greater improvements relative to those treated with CBT-I+Med on daytime functioning (−3.54 units vs. −1.80 units) and depressive symptoms (−3.32 units vs 0.73 units). No significant interactions were found for insomnia severity, sleep satisfaction, BAI, MFI, or DBAS.

3. Discussion

The present study was aimed at investigating whether insomnia treatment response was different as a function of baseline objective sleep duration among participants treated with CBT-I and CBT-I+Med. We hypothesized that participants with normal sleep duration would show greater improvements in sleep and daytime functioning relative to those with short sleep duration, irrespective of treatment received. This hypothesis was based on the theoretical work of Vgontzas and colleagues [5] and previous studies suggesting that the insomnia phenotype with normal sleep duration was associated with better treatment response to brief behavioral treatment and CBT-I [28,29] relative to the insomnia phenotype with short sleep duration.

Results from the present study showed significant reductions in self-reported and PSG-derived WASO and increases in self-reported and PSG-derived SE when participants for both treatment conditions were combined. However, contrary to our hypothesis, these improvements were larger among participants with short sleep duration. Participants with normal sleep duration did not show any

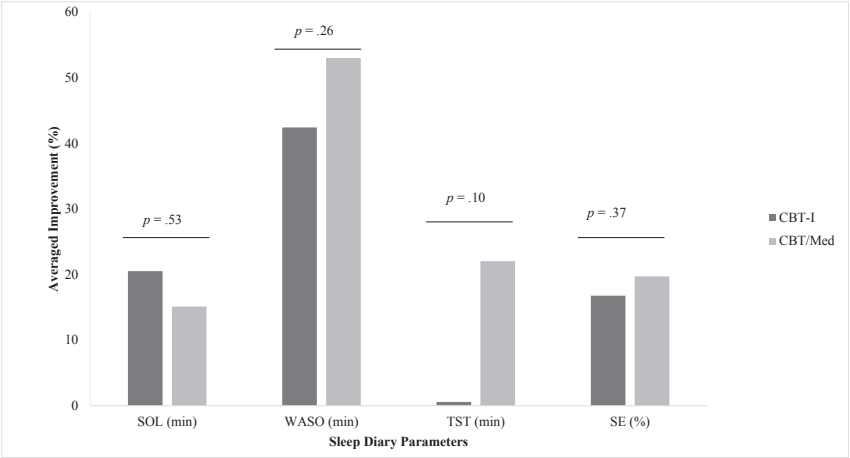

Fig. 2. Changes on sleep parameters as measured by sleep diary for participants with short sleep duration according to treatment.

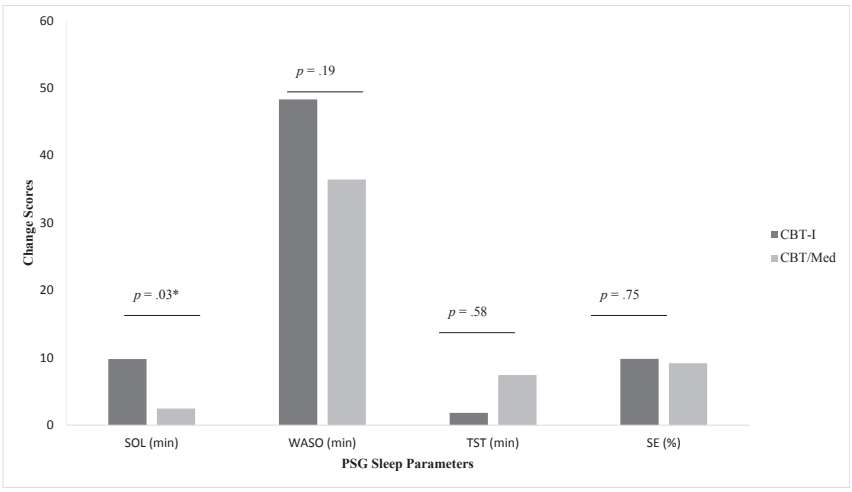

Fig. 3. Changes on sleep parameters as measured by PSG for participants with short sleep duration according to treatment.

meaningful change in perceived TST, whereas those with short sleep duration achieved a slight increase in TST. Together, these findings indicate that the baseline PSG-derived sleep duration did not moderate the treatment response on either subjective or PSG-defined sleep variables. The only exception to these findings was for some trends for the short sleepers group to achieve lower remission rates on the Insomnia Severity Index.

The few studies that have examined this same research question before have also yielded mixed findings. The present results are inconsistent with three of those studies [28,29,31] and in agreement with one study [30]. Unlike some previous studies [28,29,31], which reported better treatment responses to CBT among insomnia patients with normal rather than short sleep duration (eg, sleep quality improvement, reduced insomnia severity), the present study found that sleep duration phenotypes did not moderate treatment response to either CBT-I or CBT-I+MED. On the other hand, the present findings are consistent with those of Lovato and colleagues, which also observed comparable sleep improvements following CBT-I in participants with *either* short or normal sleep duration [30], and consistent with the follow-up findings from Troxel et al. who reported greater odds of non-remission among short sleepers [28]. Such discrepancies among studies may be partly explained by important methodological differences. For example, unlike the current study which relied on data derived from two nights of PSG assessment in the sleep laboratory (not including the screening night), Bathgate and colleagues [29] used

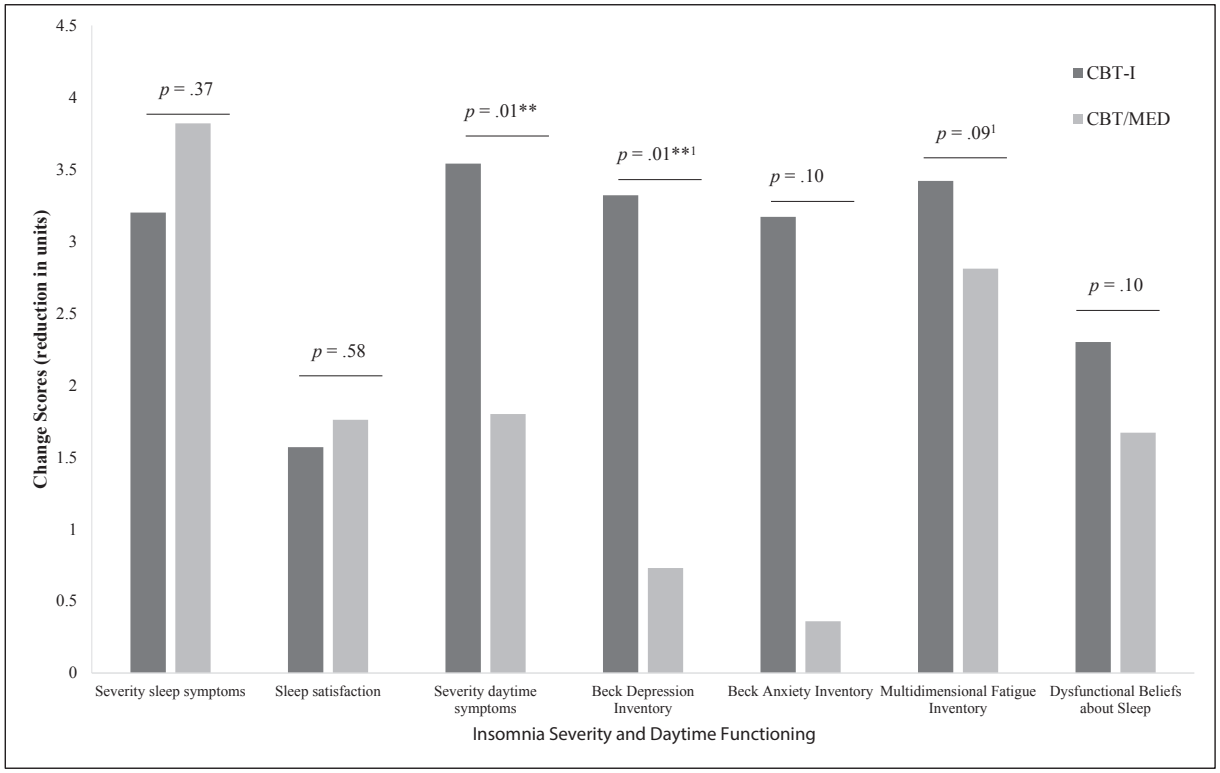

Fig. 4. Changes on Insomnia Severity and Daytime Functioning for Participants with Short Sleep Duration According to Treatment. [1]Changes in CBT/Med are positive.

the average sleep duration across two weeks of actigraphy monitoring, Troxel et al., [28] used two nights of home-based PSG *and* sleep diaries over two weeks, Miller et al., [31] used one night of laboratory PSG, and Lovato et al., [30] used one night of ambulatory PSG.

Significant improvements in sleep satisfaction and reduced daytime symptoms severity were observed in all participants receiving CBT-I, either alone or combined with medication, and those improvements were generally greater among participants with normal sleep duration. These findings partially confirm our hypothesis that given the psychological profile of individuals with insomnia and normal sleep duration, they would show greater improvements than those with short sleep duration. However, this differential treatment response was observed on only a few daytime functioning outcomes.

Contrary to expectations, among participants with short sleep duration, the subgroup receiving medication in addition to CBT-I did not show greater improvements than those treated with CBT-I alone. In fact, participants with short sleep duration, whether treated with CBT-I or CBT-I+Med, achieved comparable improvements on measures of sleep (diary), anxiety, fatigue, and dysfunctional beliefs about sleep. It appears then that CBT-I therapeutic benefits were present in both treatment conditions received by individuals with insomnia and short sleep duration, possibly through some common mechanisms shared by patients in both treatment groups, such as enhancement of the homeostatic sleep drive through restriction of time spent in bed, reduction of arousal by altering unhelpful beliefs and attitudes about sleep, and enhancement of sleep-related self-efficacy [46,47]. These CBT-I mediators need to be further examined. Other than the physiological activation, a prominent feature of individuals with insomnia and objective short sleep duration, future research may explore whether the presence of psychological factors (eg, dysfunctional beliefs about sleep, reduced sleep-related self-efficacy) also contribute to the maintenance of sleep difficulties in this insomnia phenotype group.

Participants with short sleep duration treated with CBT-I improved more on measures of daytime functioning and depressive symptoms than those treated with CBT-I+Med. This finding, which is contrary to our hypothesis, may be explained by the presence of negative attitudes toward medication use for insomnia and/or by common side effects of zolpidem, such as headache, dizziness and drowsiness [48–51]. In this study, the prescribed dose of zolpidem was 10 mg, although the FDA now recommends a lower initial dose of zolpidem (ie, 5 mg for women and either 5 or 10 mg for men). A 10 mg dose of zolpidem may impair alertness in some individuals upon arising in the morning [51,52], which might explain why participants with short sleep duration and treated with CBT-I+Med reported worst daytime functioning than those treated with CBT-I alone. These post hoc explanations remain tentative, however, as we have no data to substantiate them.

The interpretation of the current findings should be made with caution due to some methodological issues. First, this was not a prospective study and the results might have been different with a larger sample and more balanced numbers of participants with short and normal sleep durations in each of the four subgroups. Second, participants were classified based on PSG data and our results might be explained by a simple regression to the means (ie, at baseline, participants with short sleep duration had significantly larger WASO and smaller SE relative to those with normal sleep duration). However, the smaller improvements among participants with normal sleep duration relative to those with short sleep duration were observed for both PSG and sleep diary outcomes, suggesting that these results were not entirely explained by our classification method. Another limitation was the absence of a condition treated with medication only, which made it impossible to isolate the effect of medication alone. The inclusion of a medication alone treatment condition would have allowed to examine more precisely whether participants with short sleep duration respond better to pharmacological interventions than those with normal sleep duration. No study has yet examined this question.

The 6 h cut-off used for classifying participants was consistent with typical practices in previous studies [14,28–31,53,54]. Nevertheless, the use of a specific cut-off to classify individuals presents some limitations. Indeed, it is possible that participants with more extreme sleep durations (ie, sleep duration less than 5 h or more than 7 h) might present different clinical profiles and treatment responses compared to those with sleep durations falling near the 6 h-cut-off, although supplementary analyses using a different cut-off score (ie, 5 h) did not support this possibility in the current study. Nevertheless, future studies should continue examining the impact of using different cut points. Another limitation is the lack of a no-treatment control group, which precludes unequivocal conclusions as to whether sleep changes were a result of treatment per se or the by-products of other nonspecific factors (eg, regression to the mean, spontaneous recovery). A final issue was that the analyses focused exclusively on baseline-to-post treatment changes, and one might argue that a different pattern of results might emerge at follow ups. For instance, medication typically produces more rapid improvements, whereas CBT may take more time but usually produces more stable improvements over time [32,55,56]. While we were unable to examine this issue in the present study due to its treatment extension phase, it may be possible that participants with short sleep duration experienced more rapid sleep improvements, whereas those with near normal sleep duration might have a slower response, thus altering the pattern of the treatment response over time. The Lovato et al., [30] study, however, showed that the findings did not change over a one year period, thus arguing against this possibility.

In conclusion, our results suggest that baseline objective sleep duration does not moderate treatment response to CBT-I, when used singly or in combination with medication, on nighttime sleep parameters. Nevertheless, the results indicate a differential treatment response between sleep duration groups on selected outcomes, including sleep satisfaction and daytime functioning. Additional studies are needed to examine further these potential differences in treatment response among individuals with different sleep durations and treated with psychological or pharmacological therapies. Future studies should examine changes on sleep and daytime functioning not only at the end of treatment, but also at follow-ups. Vgontzas and colleagues [5] propose that the phenotype with short sleep duration is characterized by increased physiological arousal. In order to better capture this feature, it would be useful to include measures of physiological arousal (eg, salivary cortisol) to improve our understanding and classification of these phenotypes. Finally, another relevant issue for future research concerns the development of an adequate method to quantify treatment response. Until now, there have been no clear guidelines on whether it is more important to aim for insomnia remission (ie, regardless of endpoint sleep duration), or to develop treatments that seek to increase sleep duration to a degree that is normal or satisfying for patients [57].

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Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2019.01.021.

References

[1] American Academy of Sleep Medicine. International classification of sleep disorders: diagnostic and coding Manuel, 3rd ed (ICSD-3). 3rd ed. Westchester, IL: American Academy of Sleep Medicine; 2014.
[2] American Psychiatric Association. Diagnostic and statistical manual of mental disorders, 5th edition (DSM-5). 5th ed. Washington, DC: American Psychiatric Publishing; 2013.
[3] Littner M, Hirshkowitz M, Kramer M, et al. Practice parameters for using polysomnography to evaluate insomnia: an update. Sleep 2003;26(6):754–60.
[4] Schutte-Rodin S, Broch L, Buysse D, et al. Clinical guideline for the evaluation and management of chronic insomnia in adults. J Clin Sleep Med 2008;4(5):487–504.
[5] Vgontzas AN, Fernandez-Mendoza J, Liao D, et al. Insomnia with objective short sleep duration: the most biologically severe phenotype of the disorder. Sleep Med Rev 2013;17(4):241–54.
[6] Roehrs TA, Randall S, Harris E, et al. MSLT in primary insomnia: stability and relation to nocturnal sleep. Sleep 2011;34(12):1647–52.
[7] Vgontzas AN, Tsigos C, Bixler EO, et al. Chronic insomnia and activity of the stress system: a preliminary study. J Psychosom Res 1998;45(1 Spec No):21–31.
[8] Vgontzas AN, Bixler EO, Lin HM, et al. Chronic insomnia is associated with nyctohemeral activation of the hypothalamic-pituitary-adrenal axis: clinical implications. J Clin Endocrinol Metab 2001;86(8):3787–94.
[9] Huang L, Zhou J, Li Z, et al. Sleep perception and the multiple sleep latency test in patients with primary insomnia. J Sleep Res 2012;21(6):684–92.
[10] Fernandez-Mendoza J, Vgontzas AN, Liao D, et al. Insomnia with objective short sleep duration and incident hypertension: the Penn State Cohort. Hypertension 2012;60(4):929–35.
[11] Jarrin DC, Ivers H, Lamy M, et al. Cardiovascular autonomic dysfunction in insomnia patients with objective short sleep duration. J Sleep Res 2018;27(3):1–9.
[12] Meng L, Zheng Y, Hui R. The relationship of sleep duration and insomnia to risk of hypertension incidence: a meta-analysis of prospective cohort studies. Hypertens Res 2013;36(11):985–95.
[13] Vasisht KP, Kessler LE, Booth 3rd JN, et al. Differences in insulin secretion and sensitivity in short-sleep insomnia. Sleep 2013;36(6):955–7.
[14] Vgontzas AN, Liao D, Pejovic S, et al. Insomnia with objective short sleep duration is associated with type 2 diabetes: a population-based study. Diabetes Care 2009;32(11):1980–5.
[15] Bathgate CJ, Edinger JD, Wyatt JK, et al. Objective but not subjective short sleep duration associated with increased risk for hypertension in individuals with insomnia. Sleep 2016;39(5):1037–45.
[16] Fernandez-Mendoza J, Calhoun S, Bixler EO, et al. Insomnia with objective short sleep duration is associated with deficits in neuropsychological performance: a general population study. Sleep 2010;33(4):459–65.
[17] Fernandez-Mendoza J, Calhoun SL, Bixler EO, et al. Sleep misperception and chronic insomnia in the general population: role of objective sleep duration and psychological profiles. Psychosom Med 2011;73(1):88–97.
[18] Jarrin DC, Rochefort A, Lamy M, et al. Perceptions of insomnia and daytime symptoms as a function of objective sleep duration. J Sleep Res 2014;23(Suppl. 1):211.
[19] National Institutes of Health. National institutes of health state of the science conference statement on manifestations and management of chronic insomnia in adults, June 13-15, 2005. Sleep 2005;28(9):1049–57.
[20] Qaseem A, Kansagara D, Forciea MA, et al. Management of chronic insomnia disorder in adults: a clinical practice guideline from the American College of Physicians. Ann Intern Med 2016;165:125–33.
[21] Riemann D, Arnardottir ES, Baglioni C, et al. European guideline for the diagnosis and treatment of insomnia. J Sleep Res 2017;26(6):675–700.
[22] Krystal A. Sleep disorders: neuropharmacology. In: Sleep research society. 2nd ed. Basics of Sleep Guide; 2009.
[23] Sateia MJ, Buysse D, Krystal AD, et al. Clinical practice guideline for the pharmacologic treatment of chronic insomnia in adults: an American Academy of Sleep Medicine clinical practice guideline. J Clin Sleep Med 2017;13(2):307–49.
[24] Smith MT, Perlis ML, Park A, et al. Comparative meta-analysis of pharmacotherapy and behavior therapy for persistent insomnia. Am J Psychiatr 2002;159(1):5–11.
[25] van Straten A, Lancee J, Kleiboer A, et al. Cognitive and behavioral therapies in the treatment of insomnia: a meta-analysis. Sleep Med Rev 2017;38:3–16.
[26] Winkler A, Auer C, Doering BK, et al. Drug treatment of primary insomnia: a meta-analysis of polysomnographic randomized controlled trials. CNS Drugs 2014;28(9):799–816.
[27] van Straten A, van der Zweerde T, Kleiboer A, et al. Cognitive and behavioral therapies in the treatment of insomnia: a meta-analysis. Sleep Med Rev 2018;38:3–16.
[28] Troxel WM, Conrad TS, Germain A, et al. Predictors of treatment response to brief behavioral treatment of insomnia (BBTI) in older adults. J Clin Sleep Med 2013;9(12):1281–9.
[29] Bathgate CJ, Edinger JD, Krystal AD. Insomnia patients with objective short sleep duration have a blunted response to cognitive behavioral therapy for insomnia. Sleep 2017;40(1).
[30] Lovato N, Lack L, Kennaway DJ. Comparing and contrasting therapeutic effects of cognitive-behavior therapy for older adults suffering from insomnia with short and long objective sleep duration. Sleep Med 2016;22:4–12.
[31] Miller CB, Espie CA, Bartlett DJ, et al. Acceptability, tolerability, and potential efficacy of cognitive behavioural therapy for Insomnia Disorder subtypes defined by polysomnography: a retrospective cohort study. Sci Rep 2018;8(1):6664.
[32] Morin CM, Vallières A, Guay B, et al. Cognitive behavioral therapy, singly and combined with medication, for persistent insomnia: a randomized controlled trial. J Am Med Assoc 2009;301(19):2005–15.
[33] American Psychiatric Association. Diagnostic and statistical manual of mental disorders (DSM-IV-TR). Washington, DC: American Psychiatric Association; 2000.
[34] American Academy of Sleep Medicine. International classification of sleep disorders: diagnostic and coding manuel. 2nd ed. Westchester, IL: American Academy of Sleep Medicine; 2005.
[35] Buysse DJ, Ancoli-Israel S, Edinger JD, et al. Recommendations for a standard research assessment of insomnia. Sleep 2006;29(9):1155–73.
[36] Rechtschaffen A, Kales A. A manual of standardized terminology, techniques and scoring system for sleep stages in human subjects. Washington DC: US Government Printing Office: National Institute of Health Publication; 1968.
[37] Bastien CH, Vallières A, Morin CM. Validation of the Insomnia Severity Index as an outcome measure for insomnia research. Sleep Med 2001;2(4):297–307.
[38] Morin CM, Belleville G, Belanger L, et al. The Insomnia Severity Index: psychometric indicators to detect insomnia cases and evaluate treatment response. Sleep 2011;34(5):601–8.
[39] Morin CM, Vallieres A, Ivers H. Dysfunctional beliefs and attitudes about sleep (DBAS): validation of a brief version (DBAS-16). Sleep 2007;30(11):1547–54.
[40] Smets EM, Garssen B, Bonke B, et al. The Multidimensional Fatigue Inventory (MFI) psychometric qualities of an instrument to assess fatigue. J Psychosom Res 1995;39(3):315–25.
[41] Beck AT, Steer RA, Brown GK. Manual for the Beck depression inventory-II. San Antonio, TX: The Psychological Corporation; 1996.
[42] Beck AT, Epstein N, Brown G, et al. An inventory for measuring clinical anxiety: psychometric properties. J Consult Clin Psychol 1988;56(6):893–7.
[43] Morin CM, Espie CA. Insomnia: a clinical guide to assessment and treatment. New York: Kluwer Academic/Plenum; 2003.
[44] Curry DT, Eisenstein RD, Walsh JK. Pharmacologic management of insomnia: past, present, and futurevol. 29. The Psychiatric Clinics of North America; 2006. p. 871–93.
[45] Kirk RE. Experimental design: procedures for the behavioral sciences. 3rd ed. Pacific Grove, CA: Brooks/Cole Publishing Company; 1995.
[46] Cheung JM, Bartlett DJ, Armour CL, et al. Treating insomnia: a review of patient perceptions toward treatment. Behav Sleep Med 2016;14(3):235–66.
[47] 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(7):664–75.
[48] Holm KJ, Goa KL. Zolpidem: an update of its pharmacology, therapeutic efficacy and tolerability in the treatment of insomnia. Drugs 2000;59(4):865–89.
[49] Stranks EK, Crowe SF. The acute cognitive effects of zopiclone, zolpidem, zaleplon, and eszopiclone: a systematic review and meta-analysis. J Clin Exp Neuropsychol 2014;36(7):691–700.
[50] Zammit GK, Corser B, Doghramji K, et al. Sleep and residual sedation after administration of zaleplon, zolpidem, and placebo during experimental middle-of-the-night awakening. J Clin Sleep Med 2006;2(4):417–23.
[51] U.S. Food and Drug Administration. FDA approves new label changes and dosing for zolpidem products and a recommendation to avoid driving the day after using Ambien CR. 2013. https://www.fda.gov/drugs/drugsafety/ucm352085.htm.
[52] Kuehn BM. FDA warning: driving may be impaired the morning following sleeping pill use. J Am Med Assoc 2013;309(7):645–6.
[53] Lauderdale DS, Knutson KL, Yan LL, et al. Objectively measured sleep characteristics among early-middle-aged adults: the CARDIA study. Am J Epidemiol 2006;164(1):5–16.
[54] Silva GE, Goodwin JL, Sherrill DL, et al. Relationship between reported and measured sleep times: the sleep heart health study (SHHS). J Clin Sleep Med 2007;3(6):622–30.
[55] Harvey AG, Belanger 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(4):670–83.
[56] Morin CM, Culbert JP, Schwartz SM. Nonpharmacological interventions for insomnia: a meta-analysis of treatment efficacy. Am J Psychiatry 1994;151(8):1172–80.
[57] Edinger JD. Is short objective sleep duration the insomnia assay we have been seeking? Sleep Med Rev 2013;17(4):239–40.