Annals of Internal Medicine REVIEW

Cognitive Behavioral Therapy for Chronic Insomnia

A Systematic Review and Meta-analysis

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Background: Because psychological approaches are likely to produce sustained benefits without the risk for tolerance or adverse effects associated with pharmacologic approaches, cognitive behavioral therapy for insomnia (CBT-i) is now commonly recommended as first-line treatment for chronic insomnia.

Purpose: To determine the efficacy of CBT-i on diary measures of overnight sleep in adults with chronic insomnia.

Data Sources: Searches of MEDLINE, EMBASE, PsycINFO, CINAHL, the Cochrane Library, and PubMed Clinical Queries from inception to 31 March 2015, supplemented with manual screening.

Study Selection: Randomized, controlled trials assessing the efficacy of face-to-face, multimodal CBT-i compared with inactive comparators on overnight sleep in adults with chronic insomnia. Studies of insomnia comorbid with medical, sleep, or psychiatric disorders were excluded.

Data Extraction: Study characteristics, quality, and data were assessed independently by 2 reviewers. Main outcome measures were sleep onset latency (SOL), wake after sleep onset (WASO), total sleep time (TST), and sleep efficiency (SE%).

Data Synthesis: Among 292 citations and 91 full-text articles reviewed, 20 studies (1162 participants [64% female; mean age, 56 years]) were included. Approaches to CBT-i incorporated at least 3 of the following: cognitive therapy, stimulus control, sleep restriction, sleep hygiene, and relaxation. At the posttreatment time point, SOL improved by 19.03 (95% CI, 14.12 to 23.93) minutes, WASO improved by 26.00 (CI, 15.48 to 36.52) minutes, TST improved by 7.61 (CI, −0.51 to 15.74) minutes, and SE% improved by 9.91% (CI, 8.09% to 11.73%). Changes seemed to be sustained at later time points. No adverse outcomes were reported.

Limitation: Narrow inclusion criteria limited applicability to patients with comorbid insomnia and other sleep problems, and accuracy of estimates at later time points was less clear.

Conclusion: CBT-i is an effective treatment for adults with chronic insomnia, with clinically meaningful effect sizes.

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For author affiliations, see end of text.
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Insomnia is a prevalent condition, with 5% to 15% of adults meeting formal diagnostic criteria for chronic insomnia (1–5) (now termed insomnia disorder [6]) and one third reporting dissatisfaction with sleep. Insomnia is associated with both medical and psychiatric comorbidity, being linked to anxiety; depression (7); chronic health problems, such as hypertension (8, 9) and type 2 diabetes (10); health care use; non–motor vehicle accidents; pain (11); and use of medication and alcohol (12–15). Symptoms of insomnia have functional consequences even in the absence of a formal diagnosis (16), with the high economic burden of the condition largely mediated through the productivity cost of work absenteeism (17).

Hypnotics, such as benzodiazepines and related drugs, are the most commonly used treatment for insomnia, with around 6% to 10% of U.S. adults using hypnotics in 2010 (18) and 27 daily doses of such drugs being taken per 1000 U.S. persons (19). In Australia, around 90% of primary care encounters for insomnia result in hypnotic prescription (20). Furthermore, despite a lack of evidence, use of second-generation antipsychotics (such as quetiapine) is also increasing, possibly due to patient and physician dissatisfaction with available treatments and a perceived lack of alternatives (21, 22). In this context, considering nonpharmacologic treatment options for insomnia disorder is important.

Cognitive behavioral therapy for insomnia (CBT-i) is an effective nonpharmacologic treatment that improves sleep outcomes with minimal adverse effects (23) and is preferred by patients to drug therapy (24). The approach to CBT-i has been refined in recent years, and it is now most commonly studied as a combined cognitive and behavioral treatment incorporating some or all of 5 components. The components are described in Table 1, and although the precise efficacy of each has not been determined, the package of care is more effective than separate delivery of the cognitive or behavioral components (25). Although previous meta-analyses have been performed (26–29), no recent meta-analysis has assessed the efficacy of this now-established package of care. We present a meta-analysis of the efficacy of CBT-i on sleep diary outcomes, compared with control, for the treatment of adults with chronic insomnia.

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Table 1. Components of CBT-i

Component	Description
Cognitive therapy	Aims to identify, challenge, and replace dysfunctional beliefs and attitudes about sleep and insomnia. Such misconceptions may include unrealistic expectations of sleep, fear of missing out on sleep, and overestimation of the consequences of poor sleep.
Stimulus control	Behavioral instructions aimed at strengthening the association between bed and sleep and preventing conditioning of the patient to associate bed with other stimulating activities. Such instructions include avoiding nonsleep activities in the bedroom; going to bed only when sleepy; and leaving the bedroom when unable to sleep for 15–20 min, returning to bed only when sleepy.
Sleep restriction	Behavioral instructions to limit time in bed to match perceived sleep duration in order to increase sleep drive and further reduce time awake in bed. Time allowed in bed is initially restricted to the average time perceived as sleep per night and then adjusted to ensure sleep efficiency remains >85%.
Sleep hygiene	General recommendations relating to environmental factors, physiologic factors, behavior, and habits that promote sound sleep. Specific instructions include advice on control of the bedroom environment, including avoiding visual access to a clock; regular sleep scheduling and avoiding long daytime naps; and limiting alcohol, caffeine, and nicotine intake, especially before bed.
Relaxation	Any relaxation technique that the patient finds effective can be used to limit cognitive arousal and reduce muscular tension to facilitate sleep. Specific techniques that may be used include meditation, mindfulness, progressive muscle relaxation, guided imagery, and breathing techniques.

CBT-i = cognitive behavioral therapy for insomnia.

METHODS

We performed a systematic review and meta-analysis in accordance with the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines, using methods from the Cochrane Handbook for Systematic Reviews of Interventions. The predetermined methods were registered online with PROSPERO (CRD42012002863) (30), with full methods presented in section 1 of the **Supplement** (available at www.annals.org).

Data Sources and Searches

We searched MEDLINE, EMBASE, PsycINFO, CINAHL, the Cochrane Library, and PubMed Clinical Queries from inception to 31 March 2015 with the terms "sleeplessness," "chronic insomnia," "insomniac," "insomnia," "insomni*," "sleep initiation and maintenance disorders," "cognitive behavioural therapy," "cognitive behavioral therapy," "cognitive behavioural therapies," "cognitive behavioral therapies," "sleep hygiene," "stimulus control," "relaxation," "relaxation techniques," "behavior modification," "behavior therapy," "cognitive therapy," "imagery," and "psychotherapy" in any language. We also reviewed the reference lists of 4 review articles on the topic (26–28, 31) and briefly screened references by using the same search strategy without limitation to randomized, controlled trials.

Study Selection

Eligible studies were randomized, controlled trials involving CBT-i in adults (aged ≥18 years) with chronic insomnia. We defined CBT-i as multimodal therapy delivered in person on at least 2 occasions and incorporating at least 2 of the 5 most widely accepted components of CBT-i: cognitive therapy, stimulus control, sleep restriction, sleep hygiene, and relaxation therapy. For the primary analysis, acceptable control groups included sham therapy, waiting list, no treatment, sleep hygiene, or information provision.

Studies were excluded if medical, sleep, or psychiatric comorbid conditions were listed as inclusion criteria, but they were not excluded on the basis of the frequency of comorbid conditions in included patients. We adopted this approach because excluding all studies that allowed patients with comorbid conditions would have markedly depleted the number of included studies, and because patients with chronic insomnia seen in clinical practice are likely to have a range of noninteracting comorbid conditions. Moreover, because only a subgroup of included studies reported the proportion of patients with comorbid conditions, we wished to avoid penalizing studies that reported in greater detail.

Data Extraction and Quality Assessment

Two authors independently confirmed the eligibility of studies, with all discrepancies resolved by consensus. One of these 2 authors extracted data, which were verified by a third author. We contacted the corresponding author of all included studies published after 1 January 2000 to request clarification of data and methods. Study quality assessments were performed independently by the 2 authors who extracted and verified data using the Cochrane Collaboration tool for assessing risk of bias (32).

Data Synthesis and Analysis

Our main outcome measures of interest were sleep diary measures of sleep onset latency (SOL), wake after sleep onset (WASO), total sleep time (TST), and sleep efficiency (SE%) (**Table 2**). These end points were assessed at 3 time points that we defined for the purpose of this analysis: immediately after treatment, early follow-up (4 weeks to <6 months after completion of the intervention), and late follow-up (6 to 12 months after completion of the intervention). Because studies most frequently reported results as the mean and SD at a point in time rather than the SD of the mean change over time, the SD of the change over time was imputed in most cases. All analyses used random-effects models, with heterogeneity assessed using the I^2 statistic and publication bias assessed with funnel plots and the Egger test (33, 34).

Table 2. Glossary

Outcome Measure	Definition	Abbreviation	Unit
Sleep onset latency	Average time to enter sleep after lights out, over the diary period	SOL	Minutes
Wake after sleep onset	Average time spent awake during the night after first entering sleep, over the diary period	WASO	Minutes
Total sleep time	Average total nighttime sleep, over the diary period	TST	Minutes
Sleep efficiency	Total sleep time divided by average time spent in bed, over the diary period	SE%	Percentage

Six sensitivity analyses were performed that were limited to studies with particular intervention characteristics. First, we limited the analysis to studies incorporating sleep restriction because this may be among the most effective components of CBT-i (35). Second, because the optimal dosage of CBT-i is unknown but may be 4 sessions (36), we limited the analysis to studies involving at least 4 in-person contacts. Third, to consider the incremental effect of CBT-i incorporating a greater number of components, we limited the analysis to studies involving at least 4 components. Fourth, we limited the analysis to studies using a comparator group other than sleep hygiene because this may or may not be an effective stand-alone treatment (31). Fifth, we restricted the analysis to studies delivering treatment on an individual basis only, rather than in a group setting. Finally, to determine whether a tendency existed for studies with significant results to follow patients longer, we restricted the posttreatment analysis to studies with follow-up time points. In addition, we performed 3 sensitivity analyses in which we varied the correlation coefficients used to impute SDs.

All statistical tests were 2-tailed, with *P* values less than 0.05 considered statistically significant. Statistical analyses were performed using Stata, version 13.0 (StataCorp), and R, version 3.1.3 (R Foundation for Statistical Computing).

Role of the Funding Source

This study received no funding.

RESULTS

Our formal search strategy identified 292 references for review of the title and abstract. Of these, the full text was obtained and reviewed for 91 articles that were considered potentially appropriate for inclusion, and 20 studies met all inclusion criteria (although only 19 contributed data to the pooled estimates presented). The study flow diagram with reasons for exclusion is presented in Figure 1.

Study Characteristics

Table 3 shows descriptive data for the 20 included studies, which involved a total of 1162 patients (range, 20 to 201 patients), with values presented for only the groups that contributed data to this meta-analysis when possible. Most study populations were of late or middle age (mean age, 55.6 years), and 9 studies incorporated age restrictions as exclusion criteria. Sex was predominantly female (64.3%), and most studies were performed in developed countries (*n* = 19). Of the studies excluded on the basis of the population studied, 5 enrolled hypnotic-dependent patients, 1 enrolled obese persons, 3 enrolled patients with any comorbid condition, 1 enrolled patients with moderate to severe hot flashes, and 3 did not require a formal diagnosis of insomnia. Most studies referenced accepted definitions for insomnia (*n* = 17), most often an edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*n* = 13), the International Classification of Sleep Disorders (*n* = 7), or both (Table 3). Nineteen studies excluded patients on the basis of presence of comorbid conditions, with all of these excluding patients with psychiatric or sleep-related comorbid conditions, 17 excluding those with medical comorbid conditions, 17 excluding those with medication or drug use, 4 excluding pregnant women, and 3 excluding shift workers. However, approaches differed in whether any comorbid condition was sufficient for exclusion or whether only patients with severe, unstable, or treatment-requiring conditions were excluded. Fourteen studies screened all patients with polysomnography at baseline to detect unrecognized sleep disorders.

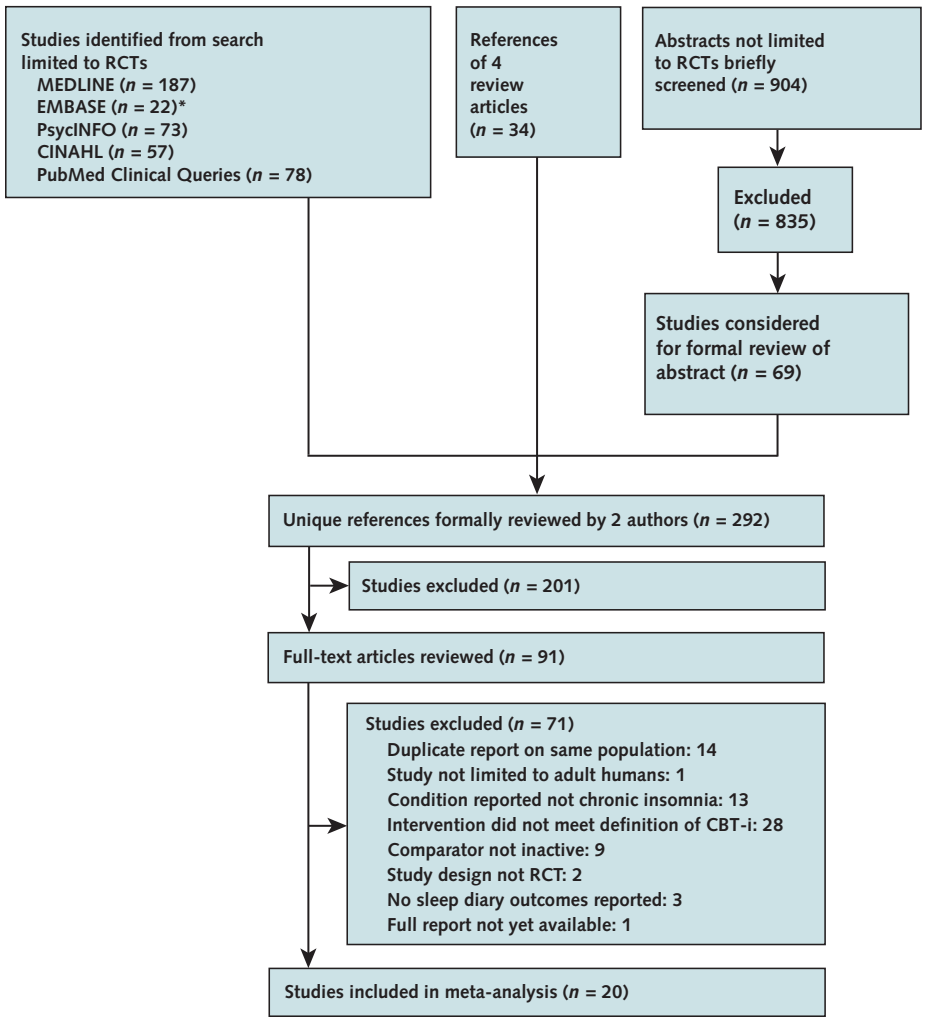
All studies investigated multimodal CBT-i with at least 3 components, even though only 2 were required for inclusion. Seven included studies delivered CBT-i in a group setting, and the remainder delivered it individually, some with adjunctive aids, such as telephone support, audiocassettes, or written material.

Comparator control groups consisted of a waiting list or usual treatment (*n* = 7), sleep hygiene instructions or education (*n* = 6), a sham behavioral intervention (*n* = 3), or placebo tablets (in studies in which a third group received pharmacotherapy [*n* = 4]).

Study Quality

Only 1 study was universally assessed as having low risk of bias across all domains (Table 4). Sequence generation generally followed accepted methods, although it was unreported in some studies, and allocation concealment was usually not reported. Many studies did not report blinding techniques in detail, possibly because the researchers assumed that blinding was not feasible due to the nature of the intervention, with no study describing complete blinding of all participants and personnel. Studies listed as low-risk on this domain usually described providing patients with general information that the trial was considering different behavioral treatments for insomnia. Risk of bias from incomplete outcome data is presented with regard only to those participant groups contributing data to this meta-analysis and only to the posttreatment time point. Risk was considered high on this domain if either a large proportion (>20%) of participants contributing data were lost to follow-up or if a significant proportion (>10%) of participants were lost without use of an ap-

Figure 1. Summary of evidence search and selection.



CBT-i = cognitive behavioral therapy for insomnia; RCT = randomized, controlled trial.
* Restricted to references not returned on MEDLINE search.

propriate statistical method to account for dropouts (for example, intention-to-treat analysis with last observation carried forward or imputation for missing data). Under these criteria, most included studies were assessed as low-risk on this domain, and no tendency was observed toward high risk of bias among studies not contributing follow-up data. Bias from selective outcome reporting was assessed as low if at least 3 standard sleep diary measures were reported in numerical form, and most studies consistently reported these outcomes.

Main Efficacy Meta-analysis

Results for the main outcomes of sleep diary measures of SOL, WASO, TST, and SE% are presented in Figures 2 to 5. Marked and statistically significant improvements in SOL (19.03 minutes [95% CI, 14.12 to 23.93 minutes; I^2 = 41.9%]), WASO (26.00 minutes [CI, 15.48 to 36.52 minutes; I^2 = 47.2%]), and SE% (9.91% [CI, 8.09% to 11.73%; I^2 = 47.1%]) were observed at the posttreatment time point. Although the magnitude of the change seemed to be similar at both the early and late time points for all 3 of these outcomes, statistical significance was generally borderline because fewer studies were available for meta-analysis at these time points. Total sleep time seemed to improve marginally at the posttreatment time point (7.61 minutes [CI, −0.51 to 15.74 minutes; I^2 = 3.1%]), and although this improvement seemed to augment at later time points, statistical significance was not achieved at any time point.

Secondary End Points

To compare the effect of CBT-i on sleep diary outcomes, with its effects on the same outcomes measured by different methods, measures of sleep time using polysomnography and actigraphy were considered at the posttreatment time point. The full results of these meta-analyses are presented in section 2 of the Supplement and are summarized in the Appendix Table (avail-

able at www.annals.org). For polysomnography, for which up to 5 studies were available for meta-analysis, estimates for effect sizes were similar to those seen for sleep diary measures of the same estimates. However, for actigraphy, for which up to 3 studies were analyzed, the effect size estimates were notably lower than for both sleep diary measures and polysomnography.

Although most studies reported questionnaire-based results for subjective outcomes, only 2 questionnaires were used consistently enough for meta-analysis at the posttreatment time point. The 4 studies by Edinger and colleagues (36, 40–42) presented results for the Insomnia Symptom Questionnaire (61), and the pooled results of these studies showed a significant improvement in subjective insomnia severity (12.35 points [CI, 8.28 to 16.43 points]). Five studies reported results for the Pittsburgh Sleep Quality Index (62), of which 4 assessed all items of this tool. Meta-analysis of this outcome revealed a significant improvement at the posttreatment time point (2.31 points [CI, 0.38 to 4.24

Table 3. Characteristics of Randomized, Controlled Trials Assessing the Efficacy of CBT-i

Study, Year (Reference)	Patients Contributing Data to Meta-analysis, *n**	Mean Age, *y**	Female, %*	Country	Insomnia Definition	CBT-i Components	Comparator	Additional Follow-up Time Points†	Funding Source
Morin et al, 1993 (49)	24	67‡	71	Canada	ICSD§	C, S, R, H‖	Waiting list	–	NIH
Morin et al, 1999 (50)	36	65‡	69	Canada	DSM-IV and ICSD§	C, S, R, H‖	Placebo tablets	3 and 12 mo	NIH
Edinger et al, 2001 (40)	50	56	48	United States	DSM-III-R§	S, R, H	Behavioral placebo	–	NIH
Espie et al, 2001 (43)	139	51	68	United Kingdom	ICSD§	C, S, R, H, X‖	Behavioral placebo	–	Gov
Guilleminault et al, 2002 (45)	68	63	100	United States	NS§	C, S, R, H	Hygiene	6 mo¶	NS
Edinger and Sampson, 2003 (41)	20	51	10	United States	DSM-IV	C, S, R, H	Hygiene	3 mo	VA
Waters et al, 2003 (54)	29	46‡	79	United States	Author-defined§	S, R, H, X	Hygiene	–	Phil
Jacobs et al, 2004 (46)	30	47‡	70	United States	DSM-IV and ICSD	C, S, R, X	Placebo tablets	1 mo	NIH
Sivertsen et al, 2006 (51)	30	61‡	53	Norway	DSM-IV§	C, S, R, H, X‖	Placebo tablets	–	Uni/Gov/Phil
Wu et al, 2006 (55)	36	38	53	China	DSM-IV and ICSD	C, S, R, H	Placebo tablets	3 and 8 mo	Gov
Edinger et al, 2007 (36)	70	55‡	50	United States	DSM-IV§	C, S, R, H	Waiting list	–	NIH
Espie et al, 2007 (44)	201	54	68	United Kingdom	DSM-IV and ICSD Revised	C, S, R, H, X‖	Usual treatment	6 mo	Gov
McCrae et al, 2007 (48)	20	77‡	65	United States	DSM-IV and ICSD-2	S, R, H	Hygiene	–	NIH/USGov
Altena et al, 2008 (37)	25	61	72	The Netherlands	DSM-IV§	C, R, H	Waiting list	–	Gov
Soeffing et al, 2008 (52)	47	64‡	64	United States	ICSD-2§	S, H, X	Behavioral placebo	–	NIH
Edinger et al, 2009 (42)	40	56	13	United States	DSM-IV-TR§ and RDC	C, S, R, H	Hygiene	6 mo	VA
Buysse et al, 2011 (39)	79	72‡	68	United States	DSM-IV-TR and ICSD-2§	S, R, H	Hygiene	–	NIH
Bothelius et al, 2013 (38)	66	51	86	Sweden	RDC	C, S, R, H, X‖	Waiting list	–	Gov
Lovato et al, 2014 (47)	118	64	53	Australia	Author-defined§	C, R, H‖	Waiting list	3 mo	Gov
Taylor et al, 2014 (53)	34	20	59	United States	DSM-5§	C, S, R, H, X	Waiting list	–	Uni

C = cognitive therapy; CBT-i = cognitive behavioral therapy for insomnia; DSM-III-R = *Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised* (56); DSM-IV = *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (1); DSM-IV-TR = *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (57); DSM-5 = *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*; Gov = non-U.S. government source; H = sleep hygiene; ICSD = International Classification of Sleep Disorders (58); ICSD-2 = International Classification of Sleep Disorders, Second Edition (59); NIH = National Institutes of Health, National Institute of Mental Health, or National Institute on Drug Abuse; NS = not stated; Phil = philanthropic foundation; R = sleep restriction; RDC = research diagnostic criteria for insomnia disorder (60); S = stimulus control; Uni = university grant; USGov = U.S. government (federal or state); VA = U.S. Department of Veterans Affairs; X = relaxation.

* Limited to participants included in our analysis rather than entire publication (when different).

† Included in meta-analysis in addition to posttreatment time point.

‡ Additional age restrictions in inclusion criteria.

§ Polysomnographic screening of all patients at baseline.

‖ Group delivery.

¶ Study presented 6-mo follow-up data for non–sleep diary outcomes only and therefore did not contribute data to pooled estimates.

Table 4. Risk-of-Bias Assessments*

Study, Year (Reference)	Sequence Generation	Allocation Concealment	Blinding of Participants and Personnel	Blinding of Outcome Assessment	Incomplete Outcome Data	Selective Outcome Reporting	Other Issues
Morin et al, 1993 (49)	Unclear	Unclear	Unclear	Unclear	Low	Low	Low
Morin et al, 1999 (50)	High	High	High	Unclear	Low	Low	High
Edinger et al, 2001 (40)	Low	Unclear	Low	Unclear	Low	Low	Low
Espie et al, 2001 (43)	Low	High	High	High	High	Low	Low
Guilleminault et al, 2002 (45)	Low	Unclear	Unclear	Low	Low	High	High
Edinger and Sampson, 2003 (41)	Unclear	Unclear	Low	Unclear	Low	Low	Low
Waters et al, 2003 (54)	High	Low	Low	Low	Unclear	Low	Low
Jacobs et al, 2004 (46)	Low	Unclear	High	Unclear	Low	Low	Low
Sivertsen et al, 2006 (51)	Low	Low	Low	Unclear	Low	Low	Low
Wu et al, 2006 (55)	Unclear	Unclear	Unclear	Unclear	Unclear	Low	High
Edinger et al, 2007 (36)	Low	Unclear	Low	Unclear	Low	Low	Low
Espie et al, 2007 (44)	Low	Low	High	High	Low	Low	Low
McCrae et al, 2007 (48)	Unclear	Unclear	Unclear	Unclear	Low	Low	Low
Altena et al, 2008 (37)	Unclear	Unclear	Unclear	Unclear	Low	High	Low
Soeffing et al, 2008 (52)	Unclear	Unclear	Unclear	Unclear	Unclear	Low	Low
Edinger et al, 2009 (42)	Low	Unclear	Low	Unclear	Low	Low	Low
Buysse et al, 2011 (39)	Low	Unclear	Unclear	Unclear	Low	Low	Low
Bothelius et al, 2013 (38)	Low	Low	High	High	Low	Low	Low
Lovato et al, 2014 (47)	Low	Low	Low	Low	Low	Low	Low
Taylor et al, 2014 (53)	Low	Low	High	High	Low	Low	Low

* Domains from the Cochrane Handbook for Systematic Reviews of Interventions (32).

points]). Five studies used the Dysfunctional Beliefs and Attitudes About Sleep Scale (63), but meta-analysis was not possible because of differences in the number of items this tool assessed. Similarly, although the Beck Depression Inventory was used in 5 studies (64) and the Epworth Sleepiness Scale was used in 4 (65), only 3 presented numerical results for each. Other tools used by multiple studies included the Insomnia Severity Index (3 studies) (66), the Profile of Mood States (3 studies) (67), the Short Form-36 (3 studies) (68), self-efficacy scales (4 studies) (69), and components of the State-Trait Anxiety Inventory (4 studies) (70). In addition, several studies used such scales as a component of the initial assessment but not at follow-up time points.

No study reported harms to participants in the CBT-i group, although only 5 explicitly stated that no harms occurred as a result of CBT-i.

Sensitivity Analysis and Publication Bias

None of the sensitivity analyses described earlier revealed consistent differences in effect across diary measures (section 3 of the **Supplement**). Exploratory meta-regression analyses were also performed using sex and the average age of participants, with neither found to be a significant effect modifier of any sleep diary outcome at the posttreatment time point (data not shown). To assess for publication bias, funnel plots were constructed and Egger tests were performed for each outcome variable at the posttreatment time point only, with no statistically significant results found (section 4 of the **Supplement**).

DISCUSSION

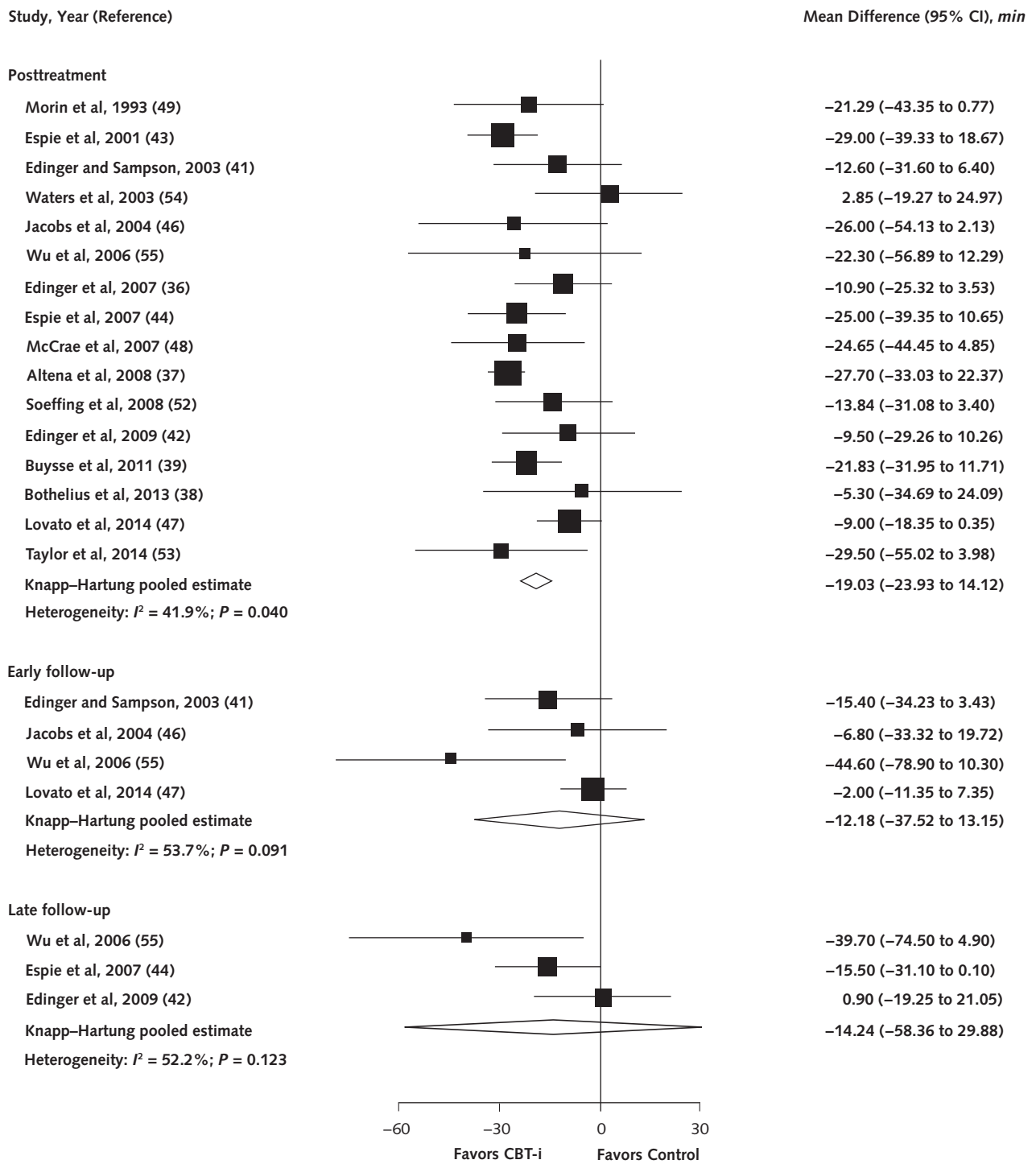
We found that CBT-i is an effective treatment for chronic insomnia that produces meaningful improvements in sleep diary outcomes. The marked effects on SOL, WASO, and SE% at the posttreatment time point seem to have been maintained at both early and late follow-up, and for TST, initially small improvements may augment over time. The sleep diary results are generally consistent with those measured by polysomnography but may be underestimated by actigraphy, for which fewer studies were available for meta-analysis. These improvements in sleep time variables are associated with significant alleviation of symptoms when measured with subjective tools.

We applied narrow inclusion criteria to minimize the heterogeneity of included studies, restricting to multimodal CBT-i compared with inactive comparators in patients with noncomorbid insomnia. This was done because of concern that high levels of heterogeneity may have been present due to differences in the approach to delivering CBT-i, such that allowing wide variation in participants, interventions, and comparators would have precluded meta-analysis. Therefore, although CBT-i, sometimes in an adapted form, is also likely to be effective for comorbid insomnia (71–73), we restricted our analysis to primary chronic insomnia. Although there are 2 well-recognized sets of diagnostic criteria for chronic insomnia, the definitions have increasingly converged with time (31). Meanwhile, a package of interventions incorporating behavioral, cognitive, and educational components has been developed for the condition (74, 75). Although other delivery formats have been shown to be equally effective and have the potential to markedly increase access to CBT-i (76, 77), further research is needed before such treatments can be confirmed to have equivalent long-term reliability and effectiveness (78).

Diary measures of sleep time variables are the most consistently used outcome measures for assessing sleep response in patients with chronic insomnia, partly due to ease of assessment. Many factors, including marked variation in sleeping time (79), limit data collec-

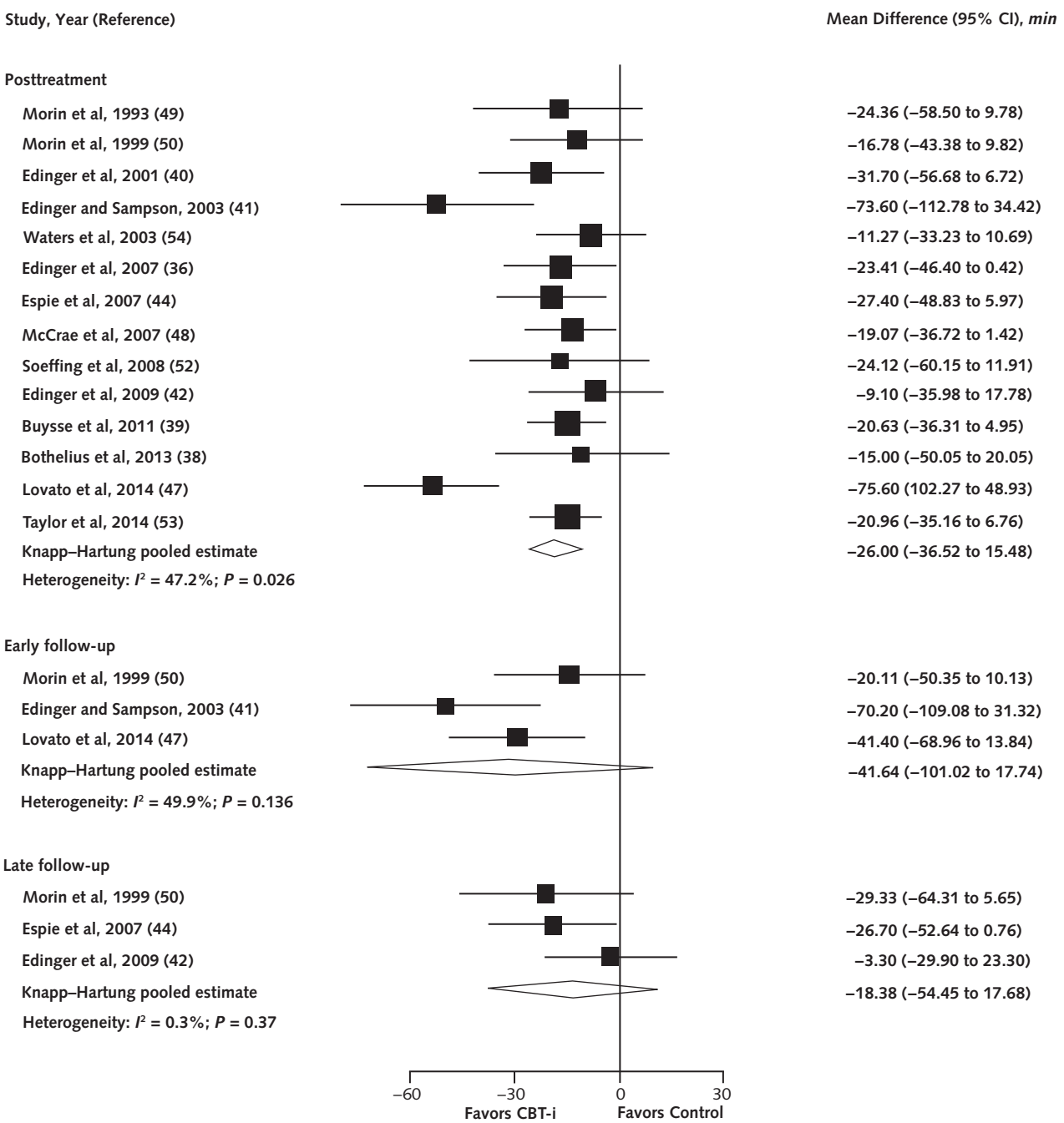
tion with other methods. Therefore, in the management of insomnia, the key outcomes for patients are the subjective sleep outcomes reported as main outcome measures in this analysis. We found significant improvements in 2 questionnaires assessing symptomatic response to treatment, which is consistent with the known correlation between sleep diary measures and daytime symptoms in persons with insomnia (66, 80, 81). Moreover, some studies found improvement in sleepiness, psychomotor vigilance, mood, anxiety, self-efficacy, beliefs and attitudes about sleep, health status, and daytime functioning.

Figure 2. Meta-analysis of the effect of CBT-i on SOL.



CBT-i = cognitive behavioral therapy for insomnia; SOL = sleep onset latency.

Figure 3. Meta-analysis of the effect of CBT-i on WASO.

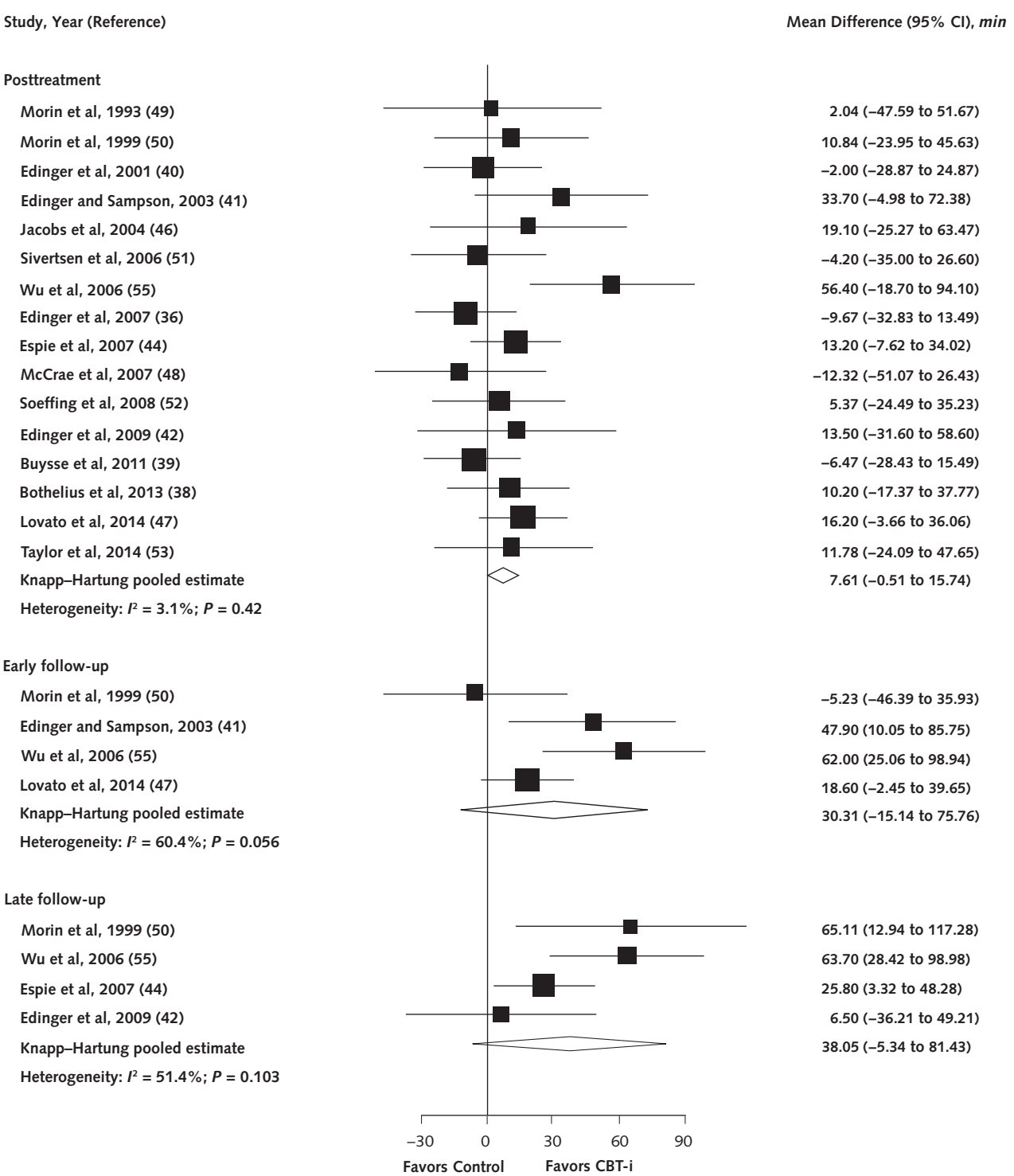


CBT-i = cognitive behavioral therapy for insomnia; WASO = wake after sleep onset.

Risk-of-bias assessments found only 1 study to have low risk of bias across all domains. Included studies were generally rigorous with patient follow-up and outcome reporting such that most studies were assessed as low-risk on these domains. Because sleep diary estimates of SOL, WASO, TST, and SE% are among the best-established outcome measures for CBT-i, most included studies reported data for all of these variables. However, allocation concealment and blinding were commonly unreported or not undertaken, probably because of the behavioral nature of the intervention. The risk of bias from incomplete blinding is significant, although complete blinding of all participants and personnel to the nature of a psychological intervention is difficult or impossible. This issue could be exacerbated by the subjective nature of the sleep diary outcomes, although the similar results for polysomnographic outcomes suggest that the improvements were real.

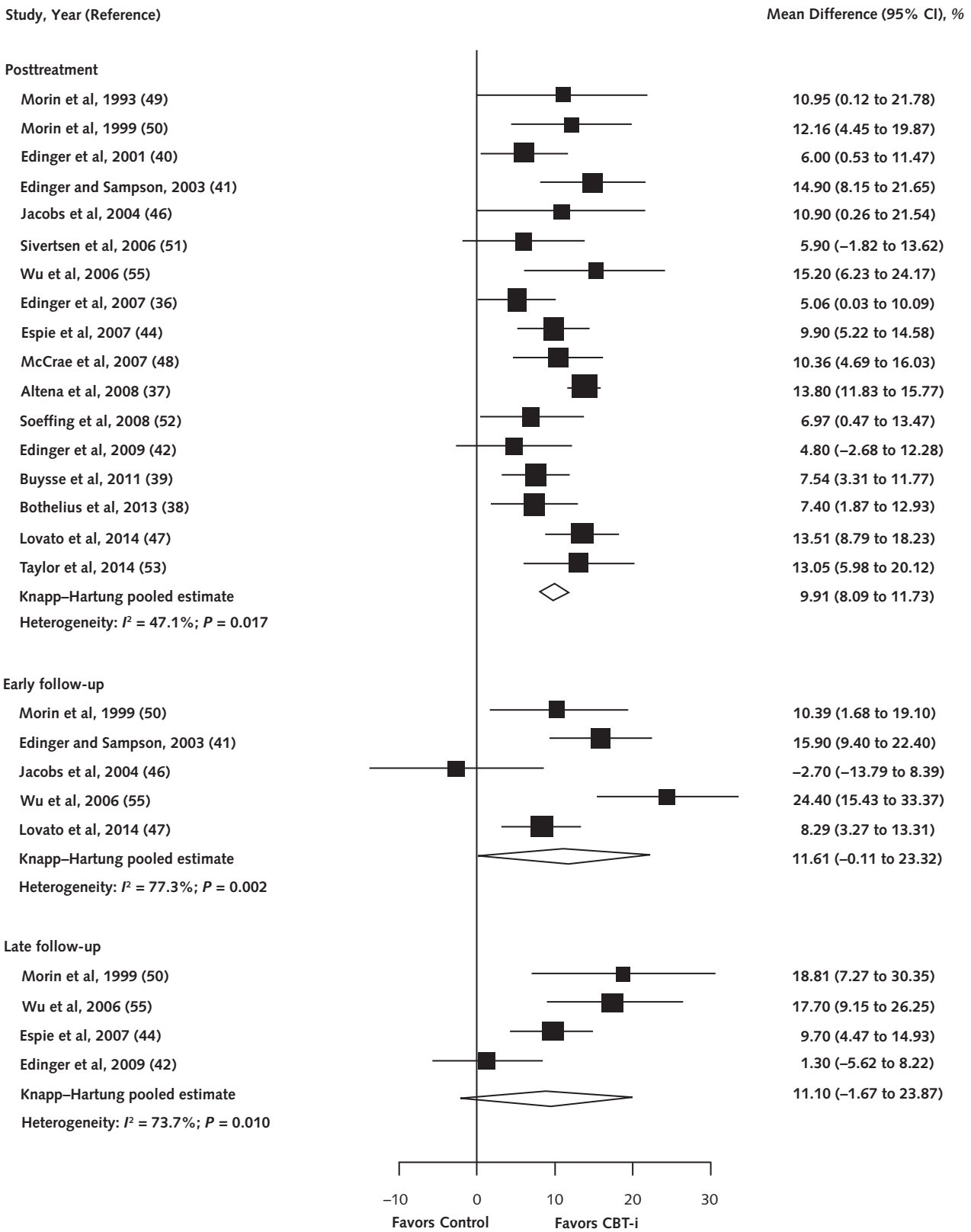
The degree of statistical heterogeneity observed was moderate in some analyses at the posttreatment time point, although sensitivity analyses that restricted by intervention characteristics did not find clear reasons for this heterogeneity. Heterogeneity seemed greater at follow-up time points, with Wu and associates (55) finding a slightly greater effect of treatment, whereas the results of Edinger and colleagues (42) suggested a lesser effect. This may relate to the treatment regimens used, given that Wu and associates delivered

Figure 4. Meta-analysis of the effect of CBT-i on TST.



CBT-i = cognitive behavioral therapy for insomnia; TST = total sleep time.

Figure 5. Meta-analysis of the effect of CBT-i on SE%.



CBT-i = cognitive behavioral therapy for insomnia; SE% = sleep efficiency.

twice-weekly sessions for 8 weeks, whereas Edinger and colleagues used 4 sessions. However, methodological differences could also have contributed because several bias domains were assessed as unclear for the study by Wu and associates and there were insufficient studies available at follow-up time points for sensitivity analyses to be performed. Despite the presence of moderate heterogeneity in some analyses, the consistency in estimates of effect was notable given the unavoidable differences in interventions that arise from individual therapists delivering a behavioral intervention. Publication bias is unlikely to have affected our estimates, given that our search strategy included gray literature and we found no statistical evidence of publication bias. Moreover, the labor-intensive nature of trials into behavioral interventions may further limit such bias. The 2 studies assessed as high-risk for selective outcome reporting described changes in sleep time in the text but did not provide figures for the results of at least 3 diary outcomes. However, the text of these studies suggests that the changes in the other sleep diary variables were similar to the results contributing to this review.

At baseline, the mean SOL, WASO, TST, and SE% in the included studies were 57.6 minutes, 76.0 minutes, 344.1 minutes, and 71.8%, respectively. Other studies have found that patients with insomnia differ from healthy control participants in these variables by around 23 minutes, 36 minutes, 95 minutes, and 16%, respectively (80), and that normal polysomnographic SE% is around 80% to 90%, depending on age (82, 83). Therefore, improvements in SOL, WASO, TST, and SE% of 19 minutes, 26 minutes, 7.6 minutes, and 9.9% from these baseline values represent major increases in 3 of these variables. Although CIs were wider because fewer studies were available for meta-analysis, these improvements seemed to be sustained at follow-up time points, which is consistent with patients acquiring the skills required to maintain the gains made earlier in therapy. The modest improvement in TST at the post-treatment time point is consistent with a previous meta-analysis of behavioral therapy versus pharmacotherapy (84), and although the improvements at the late follow-up time point were also not statistically significant, the magnitude of the change seemed to be more marked. This increase is probably a true treatment effect resulting from the sleep restriction intervention, given that initial instructions are to decrease time in bed to better match TST but later increases in time in bed are permitted as SE% improves (**Table 1**). These results should increase confidence that any treatment-related decrements in TST are likely to be temporary and to affect a minority of patients.

To better place our review in the context of previous ones, we performed a literature search with the same databases, date restrictions, and search terms as for the main analysis described earlier but limited it to systematic reviews and meta-analyses published in English. The results from this search were combined with the results from 2 reviews of reviews of the topic (85, 86). As well as the many descriptive systematic reviews in this area, quantitative meta-analyses have found behavioral interventions for sleep to be efficacious in children (87), CBT-i to be moderately efficacious for anxiety symptoms (88), and CBT-i to be efficacious when delivered in computerized or group-based formats (89, 90). Also, 6 meta-analyses have considered the efficacy of standard CBT-i. Of these, 3 were published in the mid-1990s and so included no more than 1 of the studies contributing to this review (27, 29, 91), and 2 were limited to studies of CBT-i in older adults (26, 92). The remaining meta-analysis by Okajima and coworkers included 14 studies published from 1990 to 2009, of which 9 are included in our review (28). This review differed from our study in that it was not prospectively registered, did not contain a PRISMA statement, and presented results with tables of mean effect sizes. This study also differed by having broader inclusion criteria, allowing inclusion of studies of comorbid insomnia (93), studies of CBT-i without in-person contact (94, 95), and studies with control groups likely to have significant efficacy (96, 97). Therefore, we believe our review is the most accurate current estimate of the efficacy of CBT-i delivered under standard conditions for patients with chronic insomnia compared with inactive control treatments.

The effect sizes we report are similar in magnitude to those seen in meta-analyses of hypnotics, such as benzodiazepines and "Z drugs" (98, 99), although such studies are often limited by the short duration of treatment and absence of long-term follow-up. However, unlike hypnotics, effects persist after treatment cessation (51). In a direct comparison, CBT-i has been found to be superior to hypnotics for the management of chronic insomnia, with effects sustained over 6 months of follow-up (51). In addition, although hypnotics are an effective treatment for insomnia, limitations include tolerance, adverse effects (100, 101), and rebound insomnia after discontinuation (102). Therefore, because chronic insomnia is a condition in which nearly half of patients remain symptomatic over 10 years (103) and behavioral treatments are likely to be associated with fewer adverse effects (24), CBT-i has several advantages over pharmacotherapy.

Our meta-analysis shows CBT-i to be a highly effective treatment for noncomorbid chronic insomnia, producing clinically meaningful responses. Its efficacy seems to be well-maintained over time and results in significant alleviation of symptoms. This supports recommendations that CBT-i should be used as the initial intervention for chronic insomnia when possible (104).

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Appendix Table. Secondary Outcomes

Outcome	Effect Size (95% CI)	Studies, *n*
Polysomnography		
SOL, *min*	No estimate*	2
WASO, *min*	−29.14 (−52.61 to −5.67)	2
TST, *min*	10.03 (−32.48 to 52.54)	5
SE%, *%*	6.46 (2.83 to 10.08)	5
Actigraphy		
SOL, *min*	−1.16 (−8.96 to 6.63)	3
WASO, *min*	−9.53 (−23.45 to 4.38)	4
TST, *min*	−38.13 (−103.79 to 27.54)	3
SE%, *%*	1.53 (−0.48 to 3.54)	4
Questionnaire		
Insomnia Severity Index	−12.35 (−16.43 to −8.28)	4
Pittsburgh Sleep Quality Index	−2.31 (−4.24 to −0.38)	4

SE% = sleep efficiency; SOL = sleep onset latency; TST = total sleep time; WASO = wake after sleep onset.
* Heterogeneity of 2 studies reporting this outcome was too great to report pooled estimate.