Health Psychology
2006, Vol. 25, No. 1, 3–14

0278-6133/06/$12.00 DOI: 10.1037/0278-6133.25.1.3

Comparative Meta-Analysis of Behavioral Interventions for Insomnia and Their Efficacy in Middle-Aged Adults and in Older Adults 55+ Years of Age

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Meta-analyses support the effectiveness of behavioral interventions for the treatment of insomnia, although few have systematically evaluated the relative efficacy of different treatment modalities or the relation of old age to sleep outcomes. In this meta-analysis of randomized controlled trials ($k = 23$), moderate to large effects of behavioral treatments on subjective sleep outcomes were found. Evaluation of the moderating effects of behavioral intervention type (i.e., cognitive–behavioral treatment, relaxation, behavioral only) revealed similar effects for the 3 treatment modalities. Both middle-aged adults and persons older than 55 years of age showed similar robust improvements in sleep quality, sleep latency, and wakening after sleep onset. A research agenda is recommended to examine the mechanisms of action of behavioral treatments on sleep with increased attention to the high prevalence of insomnia in older individuals.

Keywords: insomnia, behavioral treatment, aging, sleep disorders, randomized controlled trials

Poor sleep is one of the most common complaints in adults, with between 9% and 12% reporting sleep difficulties on a persistent basis. In older adults, the prevalence rates of insomnia exceed 20% to 30%, greater in frequency and severity than in any other age group (Ancoli-Israel, 2000; Foley et al., 1995; Petit, Azad, Byszewski, Sarazan, & Power, 2003). *Persistent insomnia* is defined as problems initiating and/or maintaining sleep at least 3 nights per week, which is accompanied by daytime distress or impairment (American Psychiatric Association, 2000; World Health Organization, 1992). As such, insomnia is a heterogeneous subjective complaint that can reflect poor sleep quality or lack of restful sleep, reduced duration of sleep, or problems falling asleep or waking repeatedly through the night. Of importance, diagnostic assessment of insomnia considers that the sleep disturbance does not occur exclusively during the course of another mental or sleep disorder and is not due to the direct effects of a substance (e.g., alcohol) or a medical condition (American Psychiatric Association, 2000; World Health Organization, 1992).

Insomnia is increasingly implicated as a predictor of cardiovascular and noncardiovascular disease mortality over and above the contribution of other known factors (e.g., age, gender, and baseline medical burden; Althuis, Fredman, Langenberg, & Magaziner, 1998; Ayas et al., 2003; Dew et al., 2003; Foley et al., 1995; Kripke, Garfinkel, Wingard, Klauber, & Marler, 2002; Mallon, Broman, & Helta, 2002; Newman et al., 2000; Pollak, Perlick, Linsner, Wenston, & Hsieh, 1990; Schwartz et al., 1999). In older adults who are at risk for medical morbidity, the consequences of insomnia for impairments of health are especially significant. Chronic sleep disturbance also leads to disturbances in mood, energy, and performance during the day and is associated with declines in quality of life and health functioning (Ancoli-Israel, 2000; Breslau, Roth, Rosenthal, & Andreski, 1996; Morin, Blais, & Savard, 2002). In addition to these human costs, sleep disturbance contributes significantly to health care costs, lost productivity, and accidents with costs estimated to be $77 to $92 billion annually (Stoller, 1994).

The majority of individuals with insomnia remain untreated, despite the striking health burden of persistent sleep problems. In the primary care setting where over 50% of patients experience insomnia, only 5% seek treatment (Ancoli-Israel & Roth, 1999). The lack of treatment-seeking and/or treatment adherence is of further concern given findings from six recent meta-analyses that support the efficacy of pharmacological and behavioral interventions for primary insomnia (Holbrook, Crowther, Lotter, Cheng, & King, 2000; Montgomery & Dennis, 2003; Morin, Culbert, & Schwartz, 1994; Murtagh & Greenwood, 1995; Nowell et al., 1997; Smith et al., 2002). Meta-analyses of pharmacotherapy for insomnia show, for example, that short-term (2–4 weeks) treatment with benzodiazepine receptor agonists such as zolpidem yield improvements in total sleep time (TST) and reductions in sleep latency (Holbrook et al., 2000; Nowell et al., 1997). However, data on the maintenance of these effects in the long term are limited, with clinical management hampered by reasonable concerns about tolerance or dependence (Kupfer & Reynolds, 1997). Moreover, following withdrawal of pharmacotherapy, rebound insomnia can occur (Dement, 1992; Soldatos & Whitehead, 1999)

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This work was supported in part by General Clinical Research Centers Program Grants AA13239, DA16541, MH55253, AG18367, T32-MH19925, AR/AG41867, 1 R01 AR 49840–01, and M01-RR00865, and the Cousins Center for Psychoneuroimmunology.

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and there is evidence that improvements in sleep are not sustained (Kupfer & Reynolds, 1997). Other risks with use of hypnotics include daytime residual effects, particularly in older adults, with attendant increases in the risks for falls and fractures (Wettstein, 1992).

Behavioral interventions are increasingly being viewed as an effective alternative to medication treatment of insomnia. Three recent meta-analyses support the efficacy of these behavioral approaches (Montgomery & Dennis, 2003; Morin et al., 1994; Murtagh & Greenwood, 1995), and one comparative meta-analysis found that behavior therapy and pharmacological treatments yielded similar improvements in sleep maintenance, TST, and sleep quality, with some advantage for behavior treatments in improving sleep latency (Smith et al., 2002). The strategies used in these various behavioral treatments are heterogeneous, including a range of approaches: relaxation; sleep scheduling such as stimulus control and sleep restriction, and cognitive–behavioral therapy along with sleep hygiene. Briefly, sleep hygiene teaches persons about the impact of lifestyle habits on sleep, stimulus control aims to help individuals renew the association of bed and bedtime stimuli with sleep rather than sleep disruption, sleep restriction limits the time spent in bed at night and obviates sleep during the day, and cognitive therapy breaks dysfunctional beliefs and attitudes about sleep that lead to emotional distress and further sleep problems. Gains from these various behavioral treatments are sustained for months to years following treatment, and behavioral treatment can be administered without the risk of side effects found with pharmacotherapy, making the use of these behavioral approaches highly salient for older adults (Montgomery & Dennis, 2003). Despite evidence of the demonstrated clinical benefit of these behavioral treatments, less is known about differences in the efficacy of various behavioral strategies for the management of insomnia. Only two studies, to our knowledge, have statistically assessed the comparative efficacy of treatment modalities (Morin et al., 1994; Murtagh & Greenwood, 1995). Whereas Morin et al. (1994) found that stimulus control and sleep restriction were the most effective therapy procedures, Murtagh and Greenwood (1995) found that various treatments were equally efficacious as compared with placebo, although the statistical power of the latter review to detect differences was limited.

Patient characteristics may also influence sleep outcomes following behavioral treatment. Indeed, an American Academy of Sleep Medicine review of nonpharmacological treatment of chronic insomnia raised the possibility that older adults may be less responsive to behavioral treatments than are middle-aged or younger adults (Morin, Hauri, et al., 1999), although few studies have directly compared the differential response of older versus middle-aged adults. Lacks and Powlishta (1989) reported that younger aged persons with persistent insomnia were more likely to have better treatment response in their analysis of seven treatment studies involving more than 200 adults, although no specific information about responses in older adults was collected. Similarly, Pallesen and colleagues (Pallesen, Nordhus, & Kvale, 1998) also suggested that beneficial effects are not as great for these treatments in older adults as compared with the findings reported in younger persons. In contrast, others have suggested that treatment benefit is comparable between older adults with late-life insomnia and younger patients (Morin, Hauri, et al., 1999). One meta-analyses of adults older than 60 years of age concluded that cognitive–behavioral interventions were mildly effective in the treatment of sleep problems in the older individuals with improvement in sleep maintenance (Montgomery & Dennis, 2003).

The objective of the present study was to provide a systematic evaluation of the relative efficacy of different behavioral treatments and of the relation of age to sleep outcomes by comparing responses in studies that exclusively enrolled persons who were 55 years of age or older versus outcomes in randomized controlled trials that enrolled adults who were, on average, younger than 55 years of age. To maximize comparisons between studies, we selected investigations that reported similar sleep outcomes.

Method

Search Strategy

Appropriate randomized control trials (RCTs) were searched during an exhaustive process, similar to that recommended by Lefebvre and Clarke (2001). The search for RCTs began in the Cochrane Controlled Trials Register. These results were supplemented by searches from 1966 to 2004 in PsycINFO, PubMed, and Social Science Citation Index (standard and expanded versions). Search terms were allowed to be present in the keywords, title words, or abstract words, and included the following search parameters: sleep* disorder*, insomnia*, tired*, sleep* problem* (where the asterisk serves as a wildcard and brings up all searches that begin with the prefix, so that tired* would bring up words like tired, tiredness, tiredly, and the like). After searches were completed among the major databases, reference lists from acquired studies and recent meta-analyses (Montgomery & Dennis, 2002, 2003; Morin, Hauri, et al., 1999) were examined to find additional RCTs. In addition, database searches were conducted again, examining the works by authors with multiple published RCTs for behavioral interventions for sleep disorders. Although there are benefits to including studies that have not undergone peer review, it was our goal to maintain a basal quality check by including only results from peer reviewed journals. Furthermore, all studies came from English-language journals.

Selection Strategy

Various inclusion criteria were implemented for the 51 studies retrieved during the literature search. Primarily, each study must have included at least one of five sleep outcomes, including sleep quality (quality), sleep latency (latency), TST, sleep efficiency, and wakenings after sleep onset (WASO). Further inclusion criteria were as follows: study enrolled participant with a diagnosis of primary insomnia; study was an RCT; participants were not replicated in another study already included in the current meta-analysis; at least one intervention was a cognitive–behavioral therapy (CBT) intervention or some recognized variant, including omnibus CBT, progression relaxation, sleep restriction, stimulus control, imagery training, paradoxical intention, and biofeedback; no participants were children, and data were not markedly nonnormal (mean was larger than the standard deviation, per criterion from Montgomery & Dennis, 2003). In addition to these selection criteria, an assessment of study quality was made following the recommendations of *The Cochrane Library*, which provides objective criteria for inclusion of studies in a meta-analysis (Antes & Oxman, 2001; Montgomery & Dennis, 2003). These quality criteria included such variables as assessment of allocation concealment, blinding of investigators, blinding of outcome assessment, use of intent-to-treat analyses, completeness of follow-up, measures of sleep outcome used, and psychometric validity of outcome measures. In addition, sufficient information must be provided in each study from which to calculate an effect size (ES). According to Lipsey and Wilson (2001), ESs can be obtained from (a) descriptive data that allow for the calculation of means and standard

Table 1
Studies Included in the Meta-Analysis Categorized by Age Cohort, Intervention Type, and Outcome

	Behavioral intervention					
	Omnibus CBT		Relaxation training		Behavioral only	
Outcome	Adult	Older adult	Adult	Older adult	Adult	Older adult
Quality			Edinger et al. (2001)[a] Lick & Heffler (1977) Turner & Ascher (1979)[a] Turner & Ascher (1982)	Lichstein et al. (2001)	Edinger et al. (2001) Edinger & Sampson (2003) Turner & Ascher (1979) Turner & Ascher (1982)[a]	Lichstein et al. (2001)[a] Riedel et al. (1995)
Latency	Espie et al. (2001) Morawetz (1989) medicated Morawetz (1989) unmedicated	Morin & Azrin (1988)[a] Morin et al. (1993) Rybarczyk et al. (2002) Woolfolk & McNulty (1983)[a]	Carr-Kaffashan & Woolfolk (1979) Espie et al. (1989)[a] Lacks, Bertelson, Gans, & Kunkel (1983)[a] Lick & Heffler (1977) Morawetz (1989)[a] Nicassio & Bootzin (1974) Nicassio et al. (1982) Stanton (1989)[a] Turner & Ascher (1979)[a] Turner & Ascher (1982) Woolfolk & McNulty (1983)	Lichstein et al. (2001) Pallesen et al. (2003) Rybarczyk et al. (2002)[a]	Edinger & Sampson (2003) Espie et al. (1989) Lacks, Bertelson, Gans, & Kunkel (1983) Stanton (1989) Turner & Ascher (1979) Turner & Ascher (1982)[a]	Lichstein et al. (2001)[a] Morin & Azrin (1988) Pallesen et al. (2003)[a] Puder et al. (1983) Riedel et al. (1995)
TST	Espie et al. (2001) Morawetz (1989) medicated Morawetz (1989) unmedicated	Morin & Azrin (1988)[a] Morin et al. (1993) Morin, Colecchi, et al. (1999) Riedel et al. (1995) Rybarczyk et al. (2002)	Edinger et al. (2001)[a] Espie et al. (1989)[a] Lick & Heffler (1977) Morawetz (1989)[a] Turner & Ascher (1979)[a] Turner & Ascher (1982)	Lichstein et al. (2001) Pallesen et al. (2003) Rybarczyk et al. (2002)[a]	Edinger et al. (2001) Edinger & Sampson (2003) Espie et al. (1989) Turner & Ascher (1979) Turner & Ascher (1982)[a]	Lichstein et al. (2001)[a] Pallesen et al. (2003)[a] Morin & Azrin (1988) Riedel et al. (1995) Lichstein et al. (2001)[a] Pallesen et al. (2003)[a] Riedel et al (1995)
Sleep efficiency		Morin et al. (1993) Morin (1999) Rybarczyk et al. (2002)	Edinger et al. (2001)[a]	Lichstein et al. (2001) Pallesen et al. (2003) Rybarczyk et al. (2002)[a]	Edinger et al. (2001) Edinger & Sampson (2003)	
WASO	Espie et al. (2001)	Morin & Azrin (1988)[a] Morin et al. (1993) Morin (1999) Rybarczyk et al. (2002)	Edinger et al. (2001)[a] Lacks, Bertelson, Sugerman, & Kunkel, (1983) Lick & Heffler (1977) Morawetz (1989) Turner & Ascher (1979)[a] Tursner & Ascher (1982)	Lichstein et al. (2001) Pallesen et al. (2003) Rybarczyk et al. (2002)[a]	Edinger et al. (2001) Edinger & Sampson (2003) Turner & Ascher (1979) Turner & Ascher (1982)[a]	Lichstein et al. (2001)[a] Morin & Azrin (1988) Riedel et al. (1995) Pallesen et al. (2003)[a]

Note. CBT = cognitive-behavioral therapy; TST = total sleep time; WASO = wakenings after sleep onset.
[a] Study used multiple behavioral treatments; behavioral treatment was excluded in the meta-analysis.

deviations (or means and standard deviations for each group at posttreatment directly noted); (b) complete information for significance tests, including the test statistic and appropriate degrees of freedom; moreover, the test statistic must compare only a single intervention (e.g., progressive relaxation) to the control group at posttreatment rather than using an omnibus *F* statistic for multiple treatment interventions along with the control; (c) an exact probability value from a test statistic and sample sizes for each group. ESs were only obtained from comparison between posttreatment outcomes, unadjusted for baseline differences. Most of the studies on behavioral interventions for sleep disorders have not provided posttreatment outcomes that have been adjusted for baseline values. Given that Glass and Vevea (per Glass, Pigott, & Vevea, 2004) have recommended against combining ESs from adjusted and unadjusted outcomes, all papers must have included a means to obtain an ES unadjusted for baseline differences.

To determine whether a study fulfilled both selection and quality criteria, a two-tiered evaluation was completed. Each of the authors of the present study reviewed the 51 obtained studies for the selection and quality criteria, providing coding and/or ratings of the key methodological factors as described earlier. Inclusion of the study then followed a consensus meeting of the three authors. A qualitative score (e.g., see Jadad et al., 1996) for each of the included studies was not provided, as the utility of such a scale has been limited (Egger, Smith, & Altman, 2001; McGuire et al., 1985).

Search Results and Organization of Selected Studies

Twenty-three studies (45.1% of the original pool of 51 studies) were selected for inclusion in the current meta-analysis. These studies were organized on three independent dimensions: age cohort, behavioral intervention type, and sleep outcome. Table 1 presents the details of the dimensional classifications for the 23 studies. The age cohort consisted of two groups, one for studies with a mean age less than 55 years (adults; $k = 15$, where k is the number of studies) and one for studies where all participants were at least 55 years old (older adults; $k = 8$). There was necessarily some overlap in ages between these groups, but restricting the adult group to participants under 55 would have yielded too few studies.

Behavioral interventions were grouped into at least one of three broad categories, including omnibus CBT, relaxation-based therapy, and behavioral only. Omnibus CBT included interventions with a behavioral and cognitive component, such as true CBT, imagery training, and interventions with a behavioral component combined with a cognitive reframing component. Relaxation-based therapy included interventions that focused exclusively on progressive relaxation and similar strategies such as biofeedback and hypnosis. The behavioral-only category included interventions that were focused exclusively on managing sleep behavior and sleep scheduling such as stimulus control and sleep compression. Paradoxical intention approaches that involved asking the person to remain awake rather than to continue to try to fall asleep were also included in this category.

The main focus of the meta-analysis was to examine the overall effect of behavioral interventions in RCTs, including testing for moderating effects of treatment type and age cohort. However, many of the studies used multiple active treatments, which would require a modeling of the dependency between groups to yield accurate ESs across the three intervention categories (Gleser & Olkin, 1994). Because necessary information was not available in the obtained studies to model such dependencies, it was not possible to include all treatment conditions in the meta-analysis. Thus, any study that had multiple treatments was subjected to a randomization process whereby only one treatment was selected for inclusion in the meta-analysis. As recommended by Lipsey and Wilson (2001), a randomized selection of one condition removes the problems of nonindependent ESs (as each ES from the same study involves the same sample in the control group).

Table 1 also indicates those treatments within the individual studies that were omitted from the analyses; no study was used that measured a

Table 2
Summary of Meta-Analytic Findings

Outcome	*k*	Total *N*	Adjusted ES range	Adjusted median *d*	Fixed effects				Random effects					
					ES_M	95% CI	*Z*	*p*	ES_M	95% CI	*Z*	*p*	*Q*	*p*
Quality	7	224	0.16 to 1.35	0.90	0.76	0.48 to 1.03	5.42	<.001	0.79	0.46 to 1.1	4.77	<.001	7.92	.244
Latency	21	676	−2.08 to 1.44	−0.52	−0.52	−0.68 to −0.82	−6.50	<.001	−0.50	−0.82 to −0.19	−3.11	.002	74.66	<.001
TST	16	643	−0.89 to 1.23	0.16	0.17	0.01 to 0.33	2.07	.038	0.17	−0.13 to 0.48	1.11	.266	50.27	<.001
Sleep efficiency	8	308	−0.68 to 2.58	0.99	0.52	0.28 to 0.75	4.27	<.001	0.74	0.11 to 1.38	2.29	.022	47.85	<.001
WASO	15	551	−0.64 to −0.82	−0.64	−0.64	−0.82 to −0.47	−7.28	<.001	−0.69	−0.91 to −0.45	−5.79	<.001	21.65	.086

Note. k = number of studies; ES = effect size; d = Cohen's (1988) effect size; ES_M = mean effect size; CI = confidence interval; Q = homogeneity of studies; TST = total sleep time; WASO = wakenings after sleep onset.

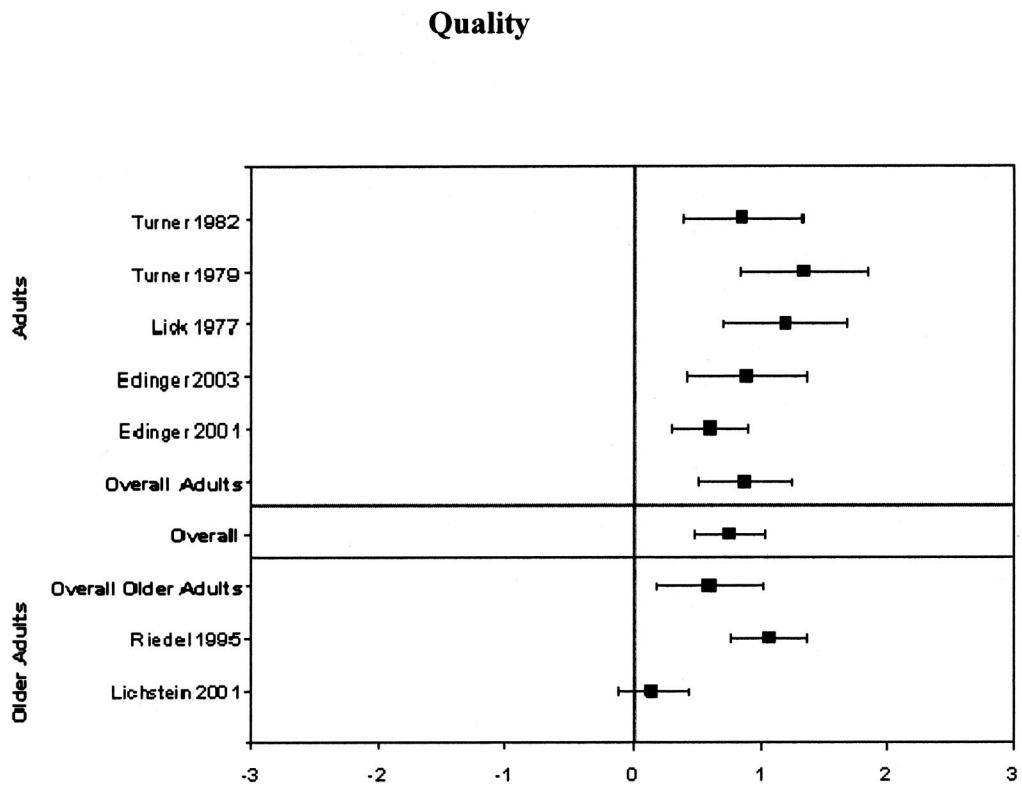

Figure 1. Study specific, age cohort, and overall effect size and confidence interval for quality.

particular sleep outcome (e.g., quality, latency, TST, sleep efficiency, WASO) from two different treatments. For example, for the outcome sleep quality, Edinger, Wohlgemuth, Radtke, Marsh, and Quillian (2001) contained a relaxation training and a behavioral-only treatment; both treatments were contrasted to the same control group. Thus, to remove dependency between the treatments for the sleep outcome quality, randomized selection identified the behavioral-only treatment for inclusion in the analyses. The relaxation training treatment for the Edinger et al. trial was not included, and Table 1 notes the exclusion of the treatment relaxation. One notable exception in this process occurred. For the Morawetz (1989) study, relaxation therapy was randomly selected for removal but was left in for the WASO outcome, as it was not measured in the omnibus CBT group (i.e., no dependency remained). Furthermore, Morawetz's study also had medicated and unmedicated groups. Each was included, as both the intervention and control groups were different samples (medication was not an experimental condition in their study; rather, this was used as a blocking variable).

Finally, some of the studies adopted both self-report and polysomnography outcomes. As just three studies used polysomnography, only self-report measures were included in the meta-analyses.

Statistical Analyses

The goal of the current study was to examine the overall impact of the reviewed behavioral treatments, including moderator analyses for intervention type and age cohort. Moderator analyses allow one to conduct analysis-of-variance-like statistics wherein the pooled ESs are tested for significant differences between groups. All ESs were calculated using posttreatment means and standard deviations, or *t* test values, between a specific treatment and the control group at posttreatment. ES calculations were conducted in Effect Size Determination Program (Wilson, 2001) and were based on Cohen's *d* (Cohen, 1988)—a measure of effect that may be thought of as determining how many standard deviations separate the means of two groups. After all ESs were calculated and entered into SPSS, data were checked for accuracy (see Lipsey & Wilson, 2001). As most ESs from small sample sizes are biased estimates, an adjustment for this bias was made to all ESs (and their standard errors) per the formula from Hedges (1981). This adjustment allows for more a proper contrast between studies with small and large sample sizes.

Two of the more popular techniques for conducting meta-analyses are fixed and random effects models. There are theoretical and statistical reasons for selecting which of these processes to use. With respect to the theoretical realm, Rosenthal (1995) noted fixed effects analyses are appropriate for describing the appropriately weighted average effect for all studies under examination (i.e., what is happening among these studies but cannot extrapolate to other studies) whereas a random effects model allows for extrapolation of this effect to future studies (e.g., if the studies included are a good sample of the studies in the field, then random effects determines what is going on with the field as a whole and what trends will likely remain). The necessary downside to random effects models is that they have smaller power. With respect to the statistical realm, fixed effects meta-analysis only models one type of error: subject-level error. It would be appropriate to implement such a model when one can justify that studies have little differences among them (and thus have a nonsignificant study-level error). Random effects models do not make an assumption regarding the studywide error and include this as a second error term in the calculation (Lipsey & Wilson, 2001). For generalizability, both techniques were considered for the current meta-analyses. The *Q* statistic was calculated through a jackknifelike process that takes multiple subsamples of the current pool of studies to determine the error of each study in contrast to the rest in the pool. As described in Lipsey and Wilson, the *Q* statistic was used to determine the actual level of heterogeneity between studies. When

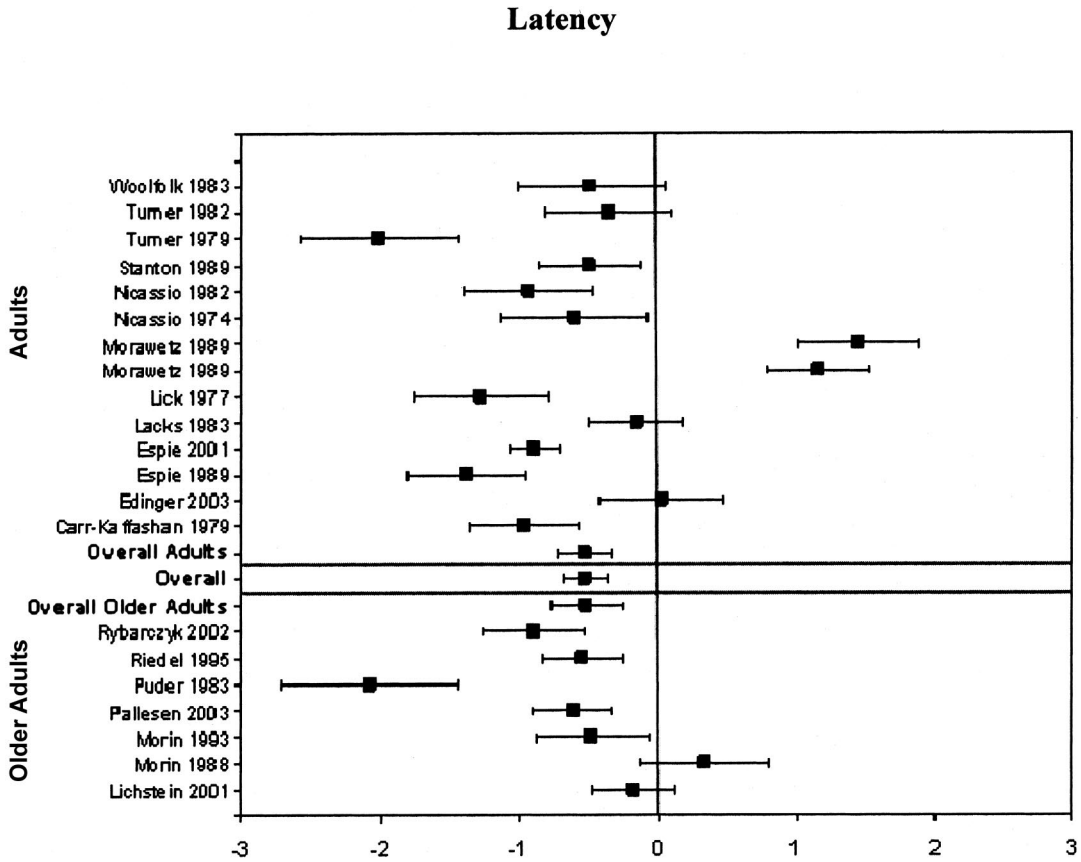

Figure 2. Study specific, age cohort, and overall effect size and confidence interval for latency.

this statistic is significant, results from the random effects analyses are interpreted. Otherwise, both statistics are interpreted (because the power of the *Q* statistic was rather low given the relatively small number of studies contained herein).

Mean ESs (ES_M), 95% confidence intervals, *z*-score equivalents of the ES_M, and a related probability value were calculated for the meta-analysis on each of the five outcomes. Subsequently, moderation effects were examined to evaluate the ES_M differences between the three interventions, and then among the two age cohorts. As noted, meta-analysis results were examined in fixed and random effects processes. Calculations were conducted in SPSS meta-analysis modules from Wilson detailed in Lipsey and Wilson (2001), as well as in Stata (StataCorp, 2004) modules detailed in Sterne, Bradburn, and Egger (2001). ES_M magnitudes were compared using criteria from Cohen (1988): An ES_M of .20 is a small effect, .50 is a medium effect, and .80 is a large effect.

Moderation effects of intervention type and age cohort were examined in a similar manner for each of the five outcomes, including using the *Q* test for homogeneity between the groups. When *Q* is significant (based on chi-square distributions), the groups in the moderation analysis were deemed to be significantly different and subsequent examination of each group's ES_M and standard error were conducted for interpretation (this process allows one to determine which groups led to the overall difference suggested by the *Q* statistic). It should be noted that moderating analyses are conducted within the fixed effects modeling. Thus, moderation is a means to try to explain interstudy variation rather than assuming the variation is error, which is done in random effects models (Lipsey & Wilson, 2001). This process of mediation analysis provides substantial power compared with previous meta-analyses (e.g., Morin et al., 1994; Murtagh & Greenwood, 1995) as the *Q* test differentiates pooled within-subject variance from variance due to the independent variable (Lipsey & Wilson, 2001).

Results

Table 2 provides information on the overall meta-analysis for each of the five outcomes. Because the *Q* statistic, which provides a test of the level of heterogeneity between studies, was statistically significant for sleep efficiency, latency, and TST, analyses from the random effects model were used for these sleep outcomes. In contrast, quality and WASO were sufficiently similar to warrant interpretation of both fixed and random effects results.

The mean effect size (ES_M) was calculated for each of the sleep outcome variables to determine the average distance in standard deviation units between a patient with insomnia who was treated with a behavioral intervention and the average control patient. For TST, which should be interpreted only from the random effects results, the ES_M of 0.17 for this outcome was not significant and small in magnitude. In contrast, all other outcomes were significant with fixed and random effects models, indicating salutary effects of the behavioral treatments on sleep outcomes. For example, latency obtained a medium ES_M, WASO had a medium–large ES_M, and sleep efficiency and quality each had a large ES_M. Figures 1 through 5 (one for each outcome) present ESs for each

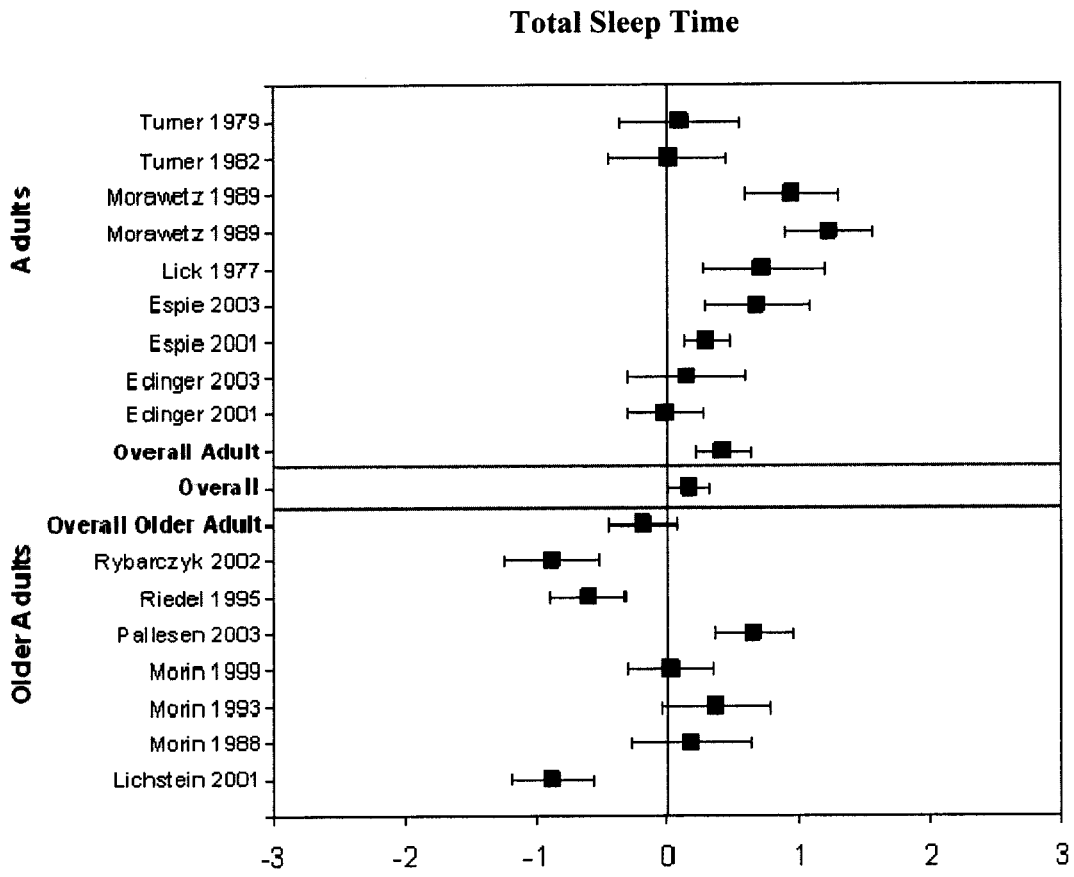

Figure 3. Study specific, age cohort, and overall effect size and confidence interval for total sleep time.

study with their respective 95% confidence interval, as well as the ES_M for each age cohort and the combination of all studies.

Results for the moderating impact of intervention type are displayed in Table 3. If the *Q* is significant in a moderation analysis, the groups are deemed to be significantly different in the effect sizes. As shown in Table 3, all three intervention groups yielded similar effects on sleep quality, latency, TST, and WASO.[1] In contrast, sleep efficiency received a significant *Q* value, indicating that it was the only outcome that differed in response to intervention type.[2] CBT and behavioral only each produced a significant ES_M for improvement, with CBT producing a very large ES_M of 1.47. For relaxation, on the other hand, ES_M for reduction on sleep efficiency was not significant. Indeed, the ES_M for relaxation was significantly lower than for CBT, but not for behavioral only. In sum, CBT may be superior to relaxation for improving sleep efficiency.

Finally, examination of the moderating impact for age cohort was conducted. These results are displayed in Table 4. Similar improvements in quality, latency, and WASO were found in adults and older adults 55 years of age and older.[3] In contrast, improvements in sleep efficiency and TST following behavioral treatments differed in the two age cohorts. Sleep efficiency obtained significantly different ES_M values between the age cohorts, with a significantly smaller ES_M for older adults, although this result should be interpreted with caution given the study size of two for the middle-aged adult group (especially given the nonsignificant difference between the age groups for WASO ES_M, a component

[1] The nonsignificant *Q* statistic for latency indicated a significant reduction in latency regardless of intervention group. Quality was similarly consistent, indicating that a significant ES_M for improvement in sleep quality occurred regardless of intervention type (only relaxation and behavioral-only studies were present). TST had very similar results between relaxation and behavioral only (neither demonstrating a significant ES_M for improvement), whereas CBT provided a significant ES_M for improvement (with a small to medium ES_M). Nevertheless for TST, the ES_M for CBT was not significantly different from the ES_M for either relaxation or behavioral only (as all confidence intervals overlapped). WASO was found to have a significant ES_M for reduction of wakenings among all three interventions. However, relaxation provided only a medium to small ES_M, whereas CBT and behavioral only each provided a large ES_M. Once again, the ES_M for relaxation was not significantly different from the ES_M for either of the other interventions.

[2] As the *Q* statistic is a variant of chi-square, it becomes less accurate when any group contains less than five studies. This caveat is relevant to the sleep efficiency results where there are three studies per CBT and behavioral-only intervention groups and two relaxation studies.

[3] Latency results revealed markedly similar ES_M values between the age cohorts. Quality and WASO results indicated nonsignificant ES_M differences between the age cohorts, though the degree of similarity was not as extreme as for latency.

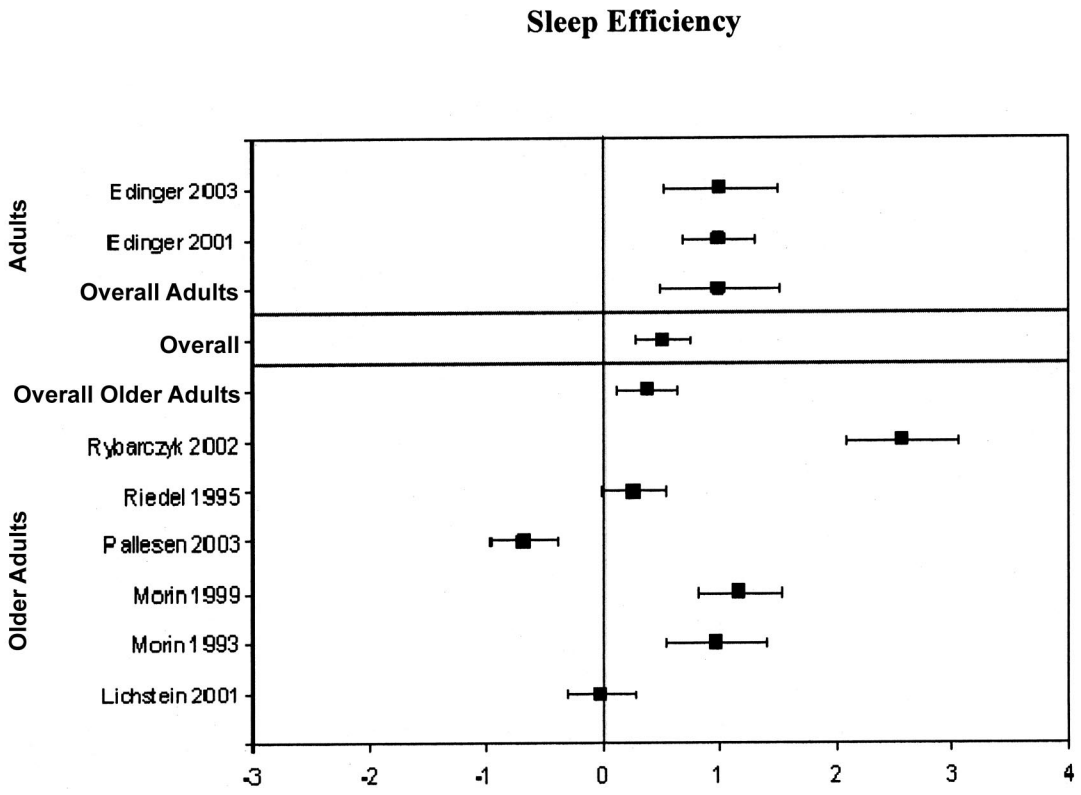

Figure 4. Study specific, age cohort, and overall effect size and confidence interval for sleep efficiency.

in sleep efficiency). TST ES_M values also differed significantly between the age cohorts, with adults showing a significant ES_M for improvement (with a medium to large magnitude) compared with controls whereas older adults had a nonsignificant ES_M (with a small magnitude) in TST compared with controls.

Discussion

The current meta-analysis adds to a growing body of evidence that confirms the efficacy of behavioral interventions for persons with chronic insomnia. The findings from this review of the literature converge with the results of previous meta-analyses (Montgomery & Dennis, 2003; Morin et al., 1994; Murtagh & Greenwood, 1995) that have documented the efficacy of nonpharmacological treatments, and they also provide new information on the benefits of behavioral interventions for older persons. The current meta-analysis included only RCT studies, thus establishing the causal efficacy of these approaches. ESs of the RCT interventions were summarized across five clinical criteria: sleep quality (quality), sleep latency (latency), TST, sleep efficiency, and WASO.

Of importance, the review supported the efficacy of behavioral interventions across all sleep outcomes with the exception of TST. The magnitudes of the effect sizes were substantial. Behavioral interventions produced medium effects for latency and WASO and large effects for efficiency and quality. The interventions thus influenced a spectrum of changes in sleep, ranging from difficulties in falling asleep to subjective reports of the quality of sleep reported the next morning. It is noteworthy that although the behavioral interventions emphasized different components of the sleep process, their effects were pervasively beneficial. The findings suggest that behavioral strategies may operate through some common mechanisms that lead to general improvement in sleep. The fact that the behavioral interventions did not significantly impact TST does not diminish the clinical impact of these strategies, which are designed to promote greater control over sleep behavior, reduce emotional distress, and enhance sleep efficiency. In addition, TST may be affected by other factors (e.g., work schedules, nighttime activities) that are not addressed by such interventions and have less clinical relevance.

With one notable exception, the meta-analysis did not reveal differences between behavioral intervention modalities. CBT, relaxation training, and behavioral only yielded highly similar effects on latency and quality, whereas CBT and behavioral only were slightly, but not significantly, superior to relaxation training in improving WASO. However, CBT proved to be substantially more effective than relaxation training in improving sleep efficiency. These data suggest that relaxation training may be the least effective (indeed, ineffective) of the behavioral intervention modalities, a finding consistent with earlier evidence (Morin, Hauri, et al., 1999). However, sleep efficiency results should be interpreted cautiously given the small number of studies in each of the behavioral intervention groups. Although the findings suggest that interventions emphasizing cognitive and other techniques aimed at sleep behavior may be needed to improve efficiency, further con-

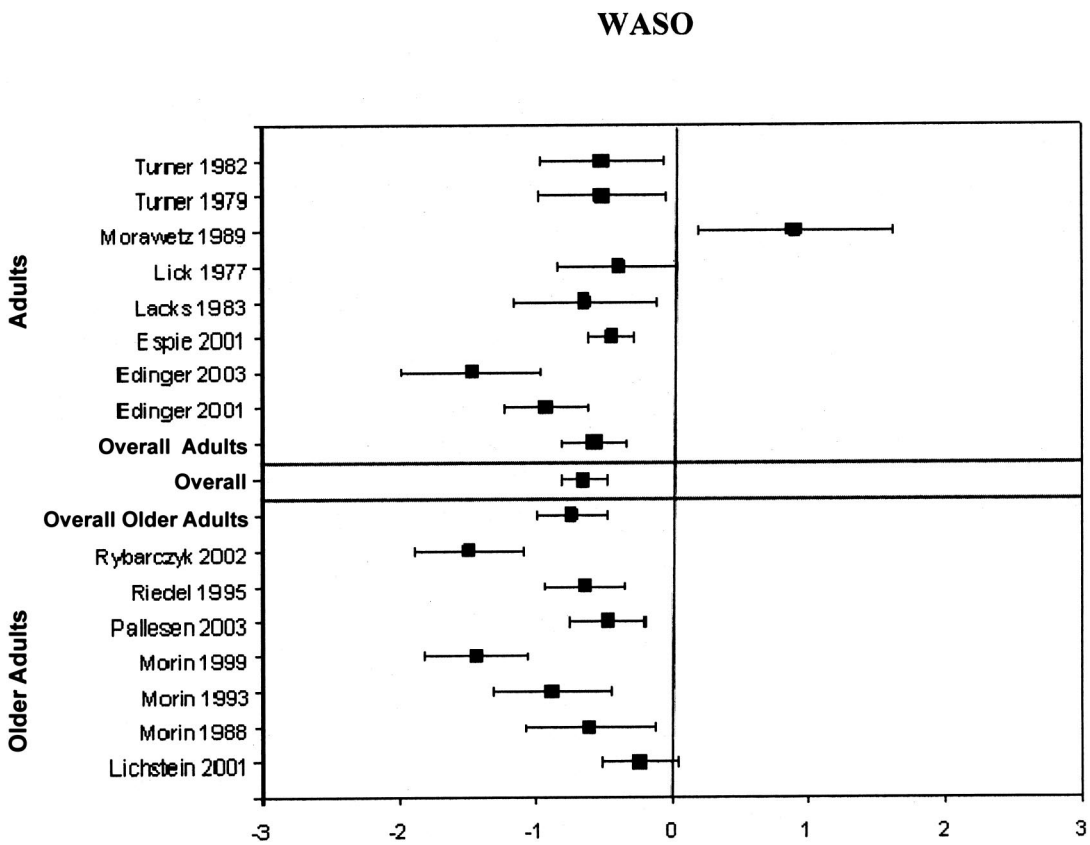

Figure 5. Study specific, age cohort, and overall effect size and confidence interval for wakenings after sleep onset (WASO).

trolled trial using efficiency as an entry criterion will clarify this result.

An important objective of our meta-analysis was to examine the importance of age as a potential moderator of the effectiveness of behavioral interventions for insomnia. Studies with a mean age of participants of less than 55 were compared with those in which all participants were 55 or older. Previous research had indicated a compromised response to behavioral interventions in older persons with insomnia (Pallesen et al., 1998). The potentially adverse impact of poor sleep on cardiovascular and noncardiovascular disease mortality in older individuals (Dew et al., 2003; Foley et al., 1995) increases the significance of examining this question. In general, the current meta-analyses confirmed the general efficacy of behavioral interventions across age cohorts with two exceptions. Behavioral interventions were more effective in the younger cohort in TST and efficiency than in the older cohort. Older adults with insomnia did not differ from their respective control groups on TST ($ES_M = -.19$), whereas the younger persons with insomnia had significant improvement compared with their respective control groups ($ES_M = .42$). In addition, older adults with insomnia did improve in efficiency ($ES_M = .38$) but not to the degree observed in the younger group ($ES_M = 1.00$).

The value of behavioral interventions for treating insomnia in older individuals is quite evident from the meta-analysis. Strategies encompassing cognitive–behavioral, relaxation training, and behavioral-only approaches led to significant improvement in latency, WASO, quality, and efficiency. Complaints of poor sleep in older individuals may be associated with increased mood disturbance and medical conditions that interfere with normal sleep, and it is encouraging that insomnia in older individuals may still respond to direct behavioral intervention. It is unclear if such comorbid problems moderate the efficacy of behavioral interventions, as such research on older individuals has yet to be conducted. However, with the efficacy of such interventions established, poor sleep in older individuals should not be considered an inevitable consequence of aging and accompanying physical declines. Behavioral interventions offer useful practical approaches to managing insomnia in older patients in medical settings and should be considered viable alternatives to pharmacological approaches that may impair functioning, create dependency, and worsen sleep after they are discontinued.

Findings from this meta-analysis add to a growing body of research on the efficacy of behavioral interventions in managing a variety of chronic health problems (Nicassio, Meyerowitz, & Kerns, 2004). However, the studies reviewed varied markedly along a number of methodological dimensions that affected the quality and significance of the results obtained. In many instances, it was difficult to determine how an investigator arrived at the diagnosis of insomnia and whether appropriate procedures were used to rule out sleep disturbances that resulted directly from an

Table 3
Moderation Meta-Analytic Results for Intervention Type

			Fixed effects					
Outcome	Intervention	*k*	ES_M	95% CI	*Z*	*p*	*Q*	*p*
Quality	Overall	7	0.76	0.48 to 1.03	5.42	<.001		
	CBT	0	—	—	—	—		
	Relaxation	3	0.53	0.09 to 0.96	2.40	.017	1.83	.176
	Behavioral only	4	0.91	0.56 to 1.27	5.05	<.001		
Latency	Overall	21	−0.52	−0.68 to −0.82	−6.50	<.001		
	CBT	5	−0.38	−0.64 to −0.12	−2.89	.004		
	Relaxation	8	−0.60	−0.88 to −0.33	−4.32	<.001	1.67	.434
	Behavioral only	8	−0.59	−0.87 to −0.31	−4.12	<.001		
TST	Overall	16	0.17	0.01 to 0.33	2.07	.038		
	CBT	6	0.33	0.11 to 0.56	2.86	.004		
	Relaxation	4	0.07	−0.28 to 0.41	0.37	.710	4.07	.131
	Behavioral only	6	−0.03	−0.32 to 0.27	−0.18	.856		
Sleep efficiency	Overall	8	0.52	0.28 to 0.75	4.27	<.001		
	CBT	3	1.47	1.00 to 1.94	6.11	<.001		
	Relaxation	2	−0.35	−0.75 to 0.05	−1.72	.086	34.27	<.001
	Behavioral only	3	0.67	0.29 to 1.05	3.49	<.001		
WASO	Overall	15	−0.64	−0.82 to −0.47	−7.28	<.001		
	CBT	4	−0.75	−1.02 to −0.48	−5.44	<.001		
	Relaxation	6	−0.35	−0.66 to −0.03	−2.17	.030	5.21	.074
	Behavioral only	5	−0.82	−1.15 to −0.49	−4.89	<.001		

Note. *k* = number of studies; ES = effect size; ES_M = mean effect size; CI = confidence interval; *Q* = homogeneity of studies; CBT = cognitive-behavioral therapy; TST = total sleep time; WASO = wakenings after sleep onset.

underlying medical condition. This was particularly true in the earlier outcome studies that were conducted before objective diagnostic procedures for primary insomnia were established. Moreover, many studies suffered from small sample sizes and the absence of a meaningful follow-up period. Information on maintenance of improvement in sleep was not sufficient to determine the long-term impact of the behavioral strategies evaluated in most studies. In general, the studies also did not address the effects of the behavioral interventions on daytime performance, a major indicator of the degree of clinical impairment and disruption caused by poor sleep.

This review also illustrates several gaps in researchers' understanding of the efficacy and clinical utility of these behavioral approaches. Above all, the relative paucity of research that has been conducted on behavioral interventions in older populations is striking, illustrating perhaps a bias in the way that health care providers conceptualize sleep problems in persons of advanced age. A total of only eight studies on older individuals met inclusion

Table 4
Moderation Meta-Analytic Results for Age Cohort

			Fixed effects					
Outcome	Intervention	*k*	ES_M	95% CI	*Z*	*p*	*Q*	*p*
Quality	Overall	7	0.76	0.48 to 1.03	5.42	<.001		
	Adults	5	0.89	0.52 to 1.25	4.72	<.001	1.03	.309
	Older adults	2	0.60	0.19 to 1.01	2.85	.004		
Latency	Overall	21	−0.52	−0.68 to −0.82	−6.50	<.001		
	Adults	14	−0.52	−0.72 to −0.33	−5.24	<.001	<0.01	.947
	Older adults	7	−0.51	−0.77 to −0.25	−3.85	<.001		
TST	Overall	16	0.17	0.01 to 0.33	2.07	.038		
	Adults	9	0.42	0.21 to 0.63	3.97	<.001	13.81	<.001
	Older adults	7	−0.19	−0.44 to 0.06	−1.52	.128		
Sleep efficiency	Overall	8	0.52	0.28 to 0.75	4.27	<.001		
	Adults	2	1.00	0.49 to 1.51	3.85	<.001	4.44	.035
	Older adults	6	0.38	0.12 to 0.65	2.80	.005		
WASO	Overall	15	−0.64	−0.82 to −0.47	−7.28	<.001		
	Adults	8	−0.57	−0.81 to −0.33	−4.68	<.001	0.87	.35
	Older adults	7	−0.73	−0.99 to −0.48	−5.65	<.001		

Note. *k* = number of studies; ES = effect size; ES_M = mean effect size; CI = confidence interval; *Q* = homogeneity of studies; TST = total sleep time; WASO = wakenings after sleep onset.

criteria for the meta-analysis, a frightfully low number in view of the high prevalence of insomnia complaints in this population. Unfortunately, the meta-analysis was not able to include objective polysomnographic evaluations of sleep outcomes, as only a small number of studies obtained electroencephalogram measures along with subjective assessments ($k = 3$). Although subjective and objective sleep measures have tended to be highly correlated in behavioral intervention research (Morin, Hauri, et al., 1999), little information exists on whether behavioral treatments promote objective changes in sleep. In the absence of such information, we do not know which factors mediate the effects of the interventions on subjective sleep parameters such as sleep latency and quality. It is possible, for example, that a reduction in mood disturbance may contribute to subjective improvement in sleep, independent of objective criteria. Moreover, despite the accumulating evidence of the importance of sleep to general health (e.g., Dew et al., 2003), research has not been conducted to evaluate the effects of behavioral interventions on health functioning, medical comorbidity, or immune system indices that may lead to health changes in at-risk groups. Accordingly, studies are needed that evaluate the efficacy of behavioral treatments in populations with chronic disease such as rheumatoid arthritis and cancer, given the high prevalence rates of insomnia in these groups.

Behavioral interventions constitute an important part of the arsenal of efficacious interventions for patients with chronic insomnia. However, future research would be significantly enhanced by adoption of standardized procedures for arriving at the diagnosis of insomnia, greater use of polysomnographic evaluation of sleep outcomes, increased reliance on health status measures to reflect the impact of these interventions on disability and disease activity in affected groups, and a broader consideration of the range of populations in which poor sleep compromises quality of life and poses a risk for adverse health changes.

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