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Behavioral Strategies, Including Exercise, for Addressing Insomnia

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Apply It!

Cognitive-behavioral therapy for insomnia is superior to sleeping pills for treating insomnia, and its accessibility is rapidly improving. Exercise can also promote sleep in insomnia. A list of recommendations on good sleep practices can be applied prior to consulting with a clinician and can often resolve insomnia symptoms.

Summary Statement.—Insomnia is associated with negative psychological and physiological health outcomes. Established behavioral strategies for addressing insomnia such as adoption of good sleep habits and engagement in Cognitive Behavioral Therapy for Insomnia have documented efficacy. Exercise is also efficacious with unique health benefits.

Keywords

insomnia; sleep problems; cognitive behavioral therapy; health; exercise

In general, keeping a consistent sleep/wake schedule, even on the weekends, is important. Staying up and sleeping in much later on work days changes the pattern of light exposure and can delay the circadian clock, making it harder to fall asleep and wake up on subsequent work days.

Historically, exercise has been considered one of the most helpful behaviors for promoting sleep. Epidemiologic research has shown that regular light, moderate, or vigorous exercise or increased levels of daily physical activity are associated with better sleep and decreased risk of insomnia (46,47). Experimental research has supported that both acute (48) and chronic exercise are associated with significant improvements in sleep in individuals with insomnia (48–51). This has been shown predominantly for aerobic exercise of moderate or high intensity in individuals with insomnia, though other research has indicated that acute (52) and chronic resistance exercise (53) can improve sleep.

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Prevalence of Insomnia

Public awareness of the importance of sleep to health and human performance has increased. According to a 2011 Sleep in America Poll conducted by the National Sleep Foundation, approximately 43% of Americans report that they rarely or never get a good night's sleep (1). Although prioritizing sleep may be tough while balancing daily work, family, and social demands, many people experience difficulty sleeping even with a sufficient opportunity to get sleep. For some people, trouble sleeping may be the short-term consequence of changing life circumstances that resolve after a short period of adjustment. For others, difficulty sleeping is a chronic problem that can become debilitating. Insomnia is defined as difficulty falling asleep or maintaining sleep (either in duration or quality) that occurs despite adequate opportunity and circumstances for sleep, and causes some form of daytime impairment (such as, fatigue, low energy, difficulty concentrating, mood disturbances, and decreased performance in work or at school (2). Insomnia can be the consequence of various physiological, psychological and/or behavioral factors. The International Classification of Sleep Disorders (ICSD) classifies insomnia disorder as (a) chronic condition (at least 3 times per week for at least 3 months), (b) short-term condition (< 3 months), and (c) other insomnia (2).

Although the prevalence of insomnia disorder is estimated to be 10% to 20% of the population (3), the yearly adult incidence of some symptoms of insomnia is as high as 50% (4). Chronic insomnia with a sustained pattern of poor sleep can have health and safety consequences. Unaddressed insomnia is associated with daytime fatigue and sleepiness, cognitive impairment (5), poor mood (6), as well as physiological health issues such as injuries (7) illness involving pain (8), and cardiometabolic disease (9–15).

Although sleeping pills are commonly prescribed for insomnia, they are associated with multiple risks, including mortality, infections, "sleep driving," and falling and are therefore not recommended for chronic management of insomnia (16). Behavioral strategies are considered superior for chronic management of insomnia and are the focus of this discussion.

Sleep Regulation and Insomnia:

Many effective strategies for improving insomnia symptoms work, in part, through their impact on how sleep is regulated. Figure 1 depicts the two-process model of sleep regulation that governs the timing and quality of sleep through the coordination of a sleep homeostatic and circadian process (17). A homeostatic sleep drive builds across wakefulness, exerting an intensifying pressure on the brain to fall asleep, and this drive dissipates with sleep. Thus, the longer an individual remains awake, the higher the pressure to fall asleep.

Circadian rhythms are generated by a master clock located in the suprachiasmatic nucleus (SCN) of the anterior hypothalamus. The SCN receives light signals from the eyes via the retinohypothalamic tract and uses this information to coordinate the timing of all internal activities with the external light/dark cycle, including the sleep/wake rhythm. Light can either advance or delay a person's internal clock depending on when exposure occurs, and it

is primarily through this mechanism that adjustment to a new time zone and light/dark cycle occurs.

In an ideal situation, the internal clock is synchronized to the environmental light/dark cycle such that the internal clock promotes rest and sleepiness at a clock time when sleep is desired and when the homeostatic drive for sleep is high. Under this set of circumstances, sleep onset occurs quickly and sleep quality is high. Conversely, if synchronization between these systems is not optimal, individuals may attempt to sleep at a biologically inappropriate time for sleep. Insomnia can manifest in these situations as delayed sleep onset (trouble falling asleep), increased awakenings (trouble staying asleep) and early termination of sleep (waking up before desired).

Physiological and psychological states that result in elevated central nervous system (CNS) activity can override an otherwise well-coordinated sleep regulatory system. Physical pain and stress as well as excessive worry and anxiety can activate the hypopituitary axis (HPA) making it more difficult to fall or stay asleep. Thus, individuals suffering from physical injuries and/or stress or psychological trauma may experience symptoms of insomnia. These conditions and settings are considered as precipitating factors to the development of chronic sleep problems in Speilman's "3P" model of Insomnia (18). Predisposing factors and perpetuating attitudes or practices refer to the other two 'Ps' in Spielman's model of insomnia. Predisposing factors are acquired or inherited characteristics that render individuals more susceptible to develop a particular type of insomnia. Perpetuating attitudes or practices refer to the behavioral practices that maintain sleep difficulty, mental worrying about sleeplessness, etc.

With this background as a primer, the following sections discuss helpful strategies to improve sleep for those who may struggle with insomnia symptoms from time-to-time or are considering seeking clinical treatment for their insomnia. The focus is on behavioral approaches that are evidence-based. Special attention is given to the role of exercise in a behavioral approach to managing insomnia.

Sleep Hygiene Intervention:

Experts in the field have developed a set of recommendations for promoting sleep and preventing insomnia and these recommendations are often used as a behavioral insomnia intervention (19). These are available on the National Sleep Foundation website @www.sleepfoundation.org, American Sleep Association website @www.sleepassociation.org, and elsewhere. For someone initially struggling with insomnia these recommendations may be a good place to start for resolving sleep issues and are reviewed here in more depth. Many are rooted in sleep physiology and based upon the principles of cognitive-behavioral therapy for insomnia (CBT-I), which is discussed later. Table 2 includes a list of these recommendations.

In general, keeping a consistent sleep/wake schedule, even on the weekends, is important. Staying up and sleeping in much later on non-work days changes the pattern of light exposure and can delay the circadian clock, making it harder to fall asleep and wake up on subsequent work days. This desynchrony between biological and social time is like

switching back and forth between time zones and is often referred to as “social jet lag” (20) which is itself associated with a higher risk for cancer, obesity, impaired glucose regulation, and depressed mood (21–25). To assist with getting to sleep, establishing a bed time routine can help transition the brain for sleep by “winding-down” approximately 30 to 45 minutes before bedtime. This can be accomplished through the ritualization of activities that begin to slow down CNS activity and prepare the brain for transition to sleep. Examples of a bedtime routine include the following: turning off bright lights and disengaging from stimulating activities, meditating, reading, listening to relaxing music, brushing teeth and getting into sleeping clothes.

Light exposure is also critical to achieving high quality sleep. Exposure to sunlight helps anchor internal circadian rhythms to the environmental light/dark cycle. Early morning light exposure will advance circadian rhythms, making it easier to fall asleep at night (26). Reducing light at night is also important to maintaining healthy circadian rhythms. The internal clock responds to bright light at night by delaying the release of melatonin, an important hormone involved in priming the body for sleep (27,28). Further, if light exposure occurs after melatonin onset, melatonin levels are suppressed and these changes have been shown to increase the time it takes to fall asleep (27). In particular, light of the blue-green spectral band (such as that found in the afternoon sky, but also in high intensities from overhead lighting and in electronic devices), can more profoundly impact circadian rhythms. Sleep experts recommend putting away smartphone devices and computers, switching off TVs and turning down ambient lighting within an hour of bedtime. If electronics absolutely must be used, there are now a variety of downloadable blue light filters available for reducing blue light exposure.

Avoid stimulants and alcohol too close to bedtime. Caffeine and nicotine both increase CNS activity. Caffeine has been shown to cause sleep disruption if taken within 6 hours of bedtime (29). Although alcohol can make it easier to fall asleep, it can severely disrupt sleep by increasing awakenings and altering sleep stages. This can greatly reduce sleep quality, and increase next-day fatigue, particularly when consumed in high doses and close to bedtime (30).

Getting routine physical activity is helpful for obtaining high quality sleep. Further, when physical activity is conducted outside under a bright sky, the additional light exposure can help synchronize internal circadian rhythms. The role of exercise will be expanded upon in the next section.

Pay attention to the amount of time in bed (TIB) spent lying awake. Sleep experts advise that the bed should be used only for sleeping, and not for activities such as reading, watching television, browsing the internet, texting, and talking on the phone. It should be noted that for some people, reading or watching television in bed is an effective bedtime ritual that helps prepare them for sleep. For individuals with insomnia, however, these activities are not advised as they can strengthen a maladaptive association with the bed and wakefulness. If unable to sleep within 15 to 30 minutes, it is recommended to get out of bed both at the start of the sleep period as well as after an awakening during the night. Conditioning the brain to connect the bed with sleep and not with wake and/or struggling to fall asleep will facilitate

faster transition to sleep. Unfortunately, many individuals with insomnia believe that more TIB will lead to more sleep and thus move bedtime earlier, a practice that further perpetuates poor sleep since bedtime then occurs at a biological time not sufficient for sleep. Instead, engaging in a relaxing activity away from the bedroom such as reading or meditating, and heading to bed when sleepy, can help reinforce a positive association between the bed and falling asleep quickly. Avoiding prolonged time in bed is also good for physical health reasons. As NASA bedrest studies have shown, prolonged bedrest can also have negative health consequences including muscle wasting, decreases in bone density, and cardiovascular complications (31).

Cognitive Behavioral Therapy for Insomnia.

CBT-I was developed as a 6- to 8-week intervention requiring several face-to-face appointments with a trained clinician such as a cognitive psychologist or a physician. The efficacy is well-documented in the research literature [32] and it is recommended by the American Academy of Sleep Medicine [33] as well as the American College of Physicians [34] as the first-line treatment for addressing chronic insomnia. CBT-I is a multicomponent therapy that includes sleep education, sleep restriction therapy, stimulus-control principles, cognitive therapy, and relaxation strategies.

Sleep restriction therapy, first advanced by Arthur Spielman in 1987 (35), operates on the understanding that insomniacs often spend extended periods of time lying in bed awake during the night instead of sleeping. Using information from sleep diaries, the patient's actual total sleep time (TST) is subtracted from the TIB, and this extra time spent lying in bed is removed from future sleep opportunities. This helps re-associate the bed with sleep, and not with struggling to sleep. For example, an individual might spend 8 hours in bed, but if he/she is actually sleeping 5 hours, then TIB is restricted to 5 hours. This process can help consolidate sleep by increasing sleep efficiency (SE) through reductions in sleep onset and the number and duration of awakenings. After several days the clinician re-evaluates the person's SE (defined as the percentage of TST divided by TIB from lights out until lights on). If SE is ≥ 90%, then the TIB is extended by 15 to 30 minutes per night, and either the bed time or awakening time is adjusted. If, however, the SE remains less than 90%, then time TIB is decreased by 15–30 minutes per night and either the bed time or awakening time is adjusted. This progressive lengthening of TIB continues until patients feel they are getting adequate sleep, at which point TIB is not extended any further.

Stimulus-control treatment of insomnia, first advanced by Richard Bootzin in 1972 (36), involves the principle of conditioning, such that the bed is associated only with sleeping and not for other waking activities. For this reason, individuals are instructed to get out of bed if unable to fall sleep or return to sleep after 15 to 30 minutes. An interesting phenomenon observed in some people with insomnia is that they sleep better when away from home, presumably because they are removed from the home bed and bedroom factors that they have learned to associate with insomnia.

The cognitive therapy component of CBT-I involves addressing irrational concerns about the consequences of poor sleep and getting patients to focus less on trying to go to sleep. For example, some individuals with insomnia fear that poor sleep will render them completely

unable to function the next day. This worry contributes to their sleep problems. Cognitive therapy helps insomnia patients to restructure their thoughts. Patients are reminded that we all have poor sleep, at least occasionally, and we manage to function nonetheless.

In clinical trials, CBT-I has been found to be superior to sleeping pills for chronic treatment of insomnia (37–39). The drawbacks of this therapy are that it is expensive, labor intensive and skilled clinicians are in short supply. Fortunately, there has been much progress in making this treatment more accessible. Several studies have found that internet-delivered CBT-I is effective for improving insomnia symptoms in patients with diagnosed insomnia (for review see (40)). Further, modified versions of CBT-I can now be given over an accelerated time line and require less face-to-face meetings with providers (41,42). Some versions focus only on the behavioral components of the therapy and thus are able to be delivered by clinicians with less specialized education such as clinical nurses and junior-level therapists. One example is termed brief behavioral treatment for insomnia, and has been shown to be effective for resolving short-term insomnia in older adults (43,44). Versions of self-directed CBT-I are even available now via smart-phone and web-based applications as a non-clinical tool for addressing insomnia. One recent program was tested in a large sample of college students that screened positive for insomnia. In this population, internet-based CBT-I led to marked improvements in insomnia symptoms and mental health outcomes (45). Table 3 includes a list of online resources for learning more about CBT-I.

Exercise as a Behavioral Treatment for Insomnia.

Historically, exercise has been considered one of the most helpful behaviors for promoting sleep. Epidemiologic research has shown that regular light, moderate, or vigorous exercise or increased levels of daily physical activity are associated with better sleep and decreased risk of insomnia (46,47). Experimental research has supported that both acute (48) and chronic exercise are associated with significant improvements in sleep in individuals with insomnia (48–51). This has been shown predominantly for aerobic exercise of moderate or high intensity in individuals with insomnia, though other research has indicated that acute (52) and chronic resistance exercise (53) can improve sleep.

Mechanisms.

The mechanisms by which exercise promotes sleep are not clear. Exercise can have both acute and chronic effects that can promote sleep. The most tenable hypotheses include thermogenic and anxiety reduction effects. Other theories such as effects of exercise on serotonin levels, or effects of systemic inflammation are still being studied. The thermogenic effect was largely advanced by Horne and colleagues (54). They found an increase in deep sleep following acute exercise which was reversed when temperature elevation was blunted with body cooling. An important trigger for sleep onset is the decline in body temperature in the evening mediated primarily by increased blood flow and increased heat loss from the peripheral skin, an effect similar to that seen after acute exercise. Since there is some evidence that insomniacs have impaired nocturnal temperature regulation (55), a thermogenic effect may be a valid mechanism for improving sleep. The thermogenic effect includes the participation of neurons in the anterior hypothalamus/pre-optic area of the brain which have been associated with sleep onset and deep sleep. Anxiety reduction is another

plausible explanation for the sleep promoting effects of exercise. Insomnia has been linked to physiological hyperarousal as evidenced by increased sympathetic activation and cortisol excretion during sleep, elevated basal metabolic rate during wakefulness and sleep, and reports of distress and inability to stay calm when attempting to sleep (56). It is well-established that exercise has anxiolytic effects which could facilitate sleep (48, 57,58).

When to Exercise.

It is commonly stated that exercising at night will disturb sleep. Experimental studies have consistently shown that moderate or vigorous exercise completed within two hours of bedtime does not disturb sleep in most subjects (58,59). Moreover, results from surveys support these experimental studies (60–62). However, for those with insomnia, exercise too close to bedtime may have the potential to negatively impact sleep, possibly through activation of the HPA axis which can occur following high intensity exercise (63). It is for this reason that recommendations for good sleep habits usually discourage high-intensity exercise within 2 hours of bedtime. However, this hypothesis should be rigorously tested with experimental studies.

If exercise is conducted under bright lights, such as at a gym, this light exposure may further disrupt sleep by delaying the circadian clock and suppressing melatonin levels as discussed above. If insomnia and poor sleep is not a concern, then the recommendation to avoid exercise at night is not warranted. For many individuals the evening may be best time or the only time of day in which they can consistently exercise.

Type, Duration, and Intensity of Exercise.

Benefits of acute exercise on sleep have been observed for light, moderate and vigorous aerobic exercise. Chronic aerobic exercise has elicited significant sleep-promoting effects, including interventions which follow public health guidelines of 150 min/week of moderate/vigorous exercise (61). Chronic strength training has also had significant benefits for sleep. Moderate exercise training has also had significant benefits for sleep apnea (64,65) and restless legs syndrome (64), which are two sleep disorders that often interact with insomnia.

Summary and Conclusions.

For unresolved insomnia, CBT-I is a demonstrated effective intervention. Although it was developed to be delivered face-to-face by trained clinicians over 6 to 8 weeks, unguided CBT-I is now becoming available remotely via web- and smartphone-based applications and under accelerated time lines. For addressing initial insomnia symptoms, incorporating good sleep habits and practices (sleep hygiene recommendations) may be tried first before seeing a medical doctor. If symptoms are still unresolved a doctor visit is necessary to rule out the presence of other sleep disorders, such as sleep apnea, that may be causing some symptoms similar to insomnia. Exercise is another effective intervention for addressing insomnia. Future clinical trials are needed to directly compare the effects of CBT-I to exercise interventions for improving insomnia and to investigate the use of both interventions in parallel.

Bridging the Gap.

Cognitive-behavioral therapy for insomnia involves sleep restriction, stimulus-control, and cognitive restructuring and is demonstrated effective for improving sleep. Epidemiologic and experimental evidence indicate that exercise is also effective for insomnia, suggesting the need for comparative efficacy trials.

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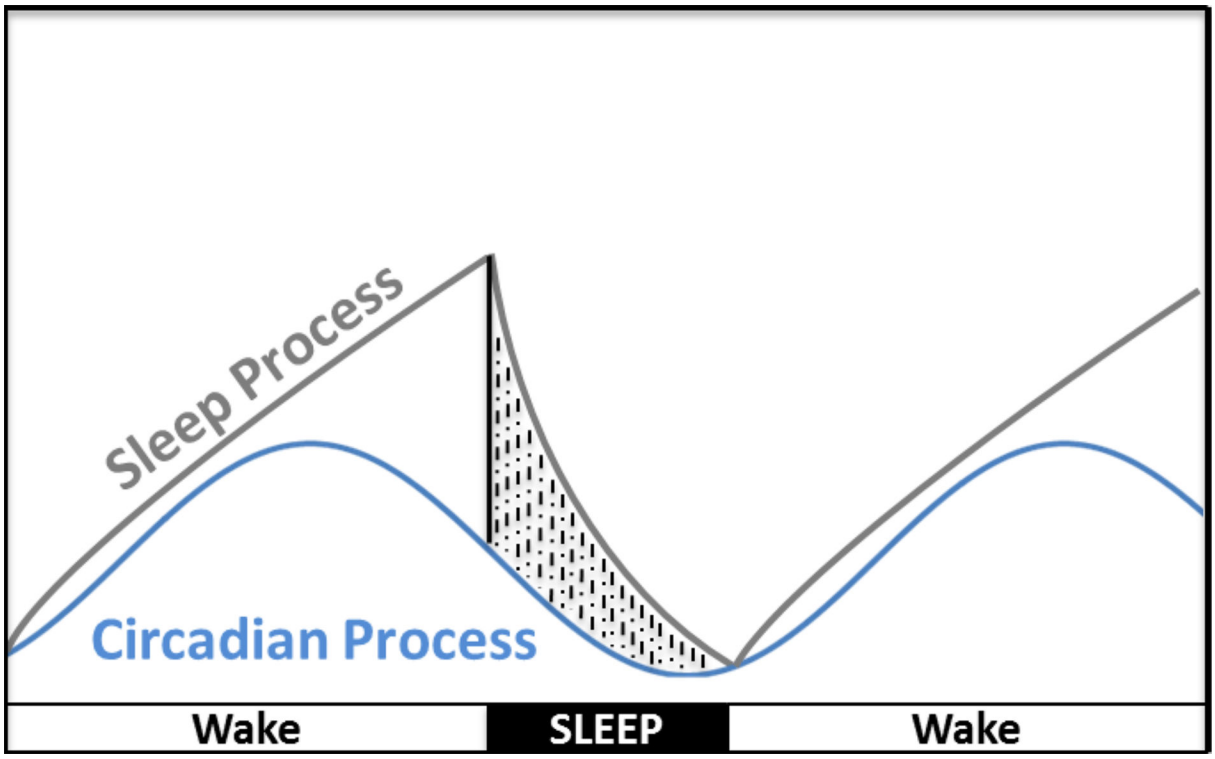

Figure 1.

Two Process Model of Sleep Regulation. A sleep process interacts with a circadian process to maintain approximately 16 hours of wakefulness and approximately 8 hours of consolidated sleep in humans. Light patterns and behavioral factors influence the timing of internal circadian rhythms relative to the environmental light dark cycle.

Table 1

Description of terms used in the article.

Term	Definition
Time in Bed (TIB)	The total time spent in bed during a sleep opportunity.
Total Sleep Time (TST)	The total amount of time actually slept during a sleep opportunity, measured objectively or by self-report (*e.g.*, sleep logs and surveys)
Sleep Efficiency (SE)	Total sleep time / Total time in bed, usually expressed as a percentage
Cognitive Behavioral Therapy for Insomnia (CBT-I)	A treatment for insomnia that involves several components including the following: **1** Sleep hygiene assessment and sleep education **2** Sleep restriction **3** Stimulus control **4** Cognitive therapy **5** Relaxation strategies

Table 2

Behavioral recommendations for achieving high quality sleep, sometimes referred to as recommendations for good sleep habits.

Sleep Hygiene Recommendations
Keep a consistent sleep schedule. Get up at the same time every day, even on weekends or during vacations.
Set a bedtime that is early enough for you to get at least 7 hours of sleep.
Don’t go to bed unless you are sleepy.
If you don’t fall asleep after 30 minutes, get out of bed.
Establish a relaxing bedtime routine.
Make your bedroom quiet and relaxing. Keep the room at a comfortable, cool temperature.
Limit exposure to bright light in the evenings.
Turn off electronic devices at least 30 minutes before bedtime.
Don’t eat a large meal before bedtime. If you are hungry at night, eat a light, healthy snack.
Exercise regularly. For some individuals intense exercise too close to bedtime can disrupt sleep. Find out what’s best for you.
Maintain a healthy diet. Heavy or spicy foods can cause indigestion for some people resulting in heartburn and disrupted sleep.
Avoid consuming caffeine in the late afternoon or evening.
Avoid consuming alcohol before bedtime.
Reduce your fluid intake before bedtime.

Table 3

Some examples of online resources that provide more information on CBT-I, are used to supplement face-to-face therapy, or deliver CBT-I remotely under the direction of a clinical provider. Self-directed programs are now becoming available for people interested in trying CBT-I in order to improve their sleep or address initial sleep issues before a clinical treatment is sought.

Examples of some online websites and internet programs:	Content/Platform	Evidence-based
http://www.sleepeducation.org/treatment-therapy/cognitive-behavioral-therapy	Educational Site for CBT-I	N/A
https://sleepfoundation.org/sleep-news/cognitive-behavioral-therapy-insomnia	Educational Site for CBT-I	N/A
CBTforInsomnia.com	Self-directed	None available
CBT-i Coach	Clinician-directed	None available
Cobalt Therapeutics' RESTORE	Clinician-directed	Yes
SHUTi	Clinician and Self-directed Versions	Yes
Sleepio		Yes
SleepTutor	Clinician-directed	Yes