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REVIEW ARTICLE

Cognitive Behavioral Treatment as a Digital Therapeutic for Insomnia

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Insomnia is a sleep disorder characterized by clinically significant distress caused by difficulty in initiating or maintaining sleep, or early-morning awakening. By definition, insomnia must affect important areas of functioning and occur more than three nights per week for at least 3 months. Insomnia is highly prevalent, with a high relapse rate and a tendency to become chronic. Therefore, the demand for insomnia treatment is high. The current first-line treatment recommended for insomnia is cognitive behavioral therapy for insomnia (CBTi). Conventional CBTi is a multicomponent intervention program that includes: 1) a behavioral component made up of stimulus control therapy, sleep restriction therapy, and muscle relaxation; 2) a cognitive component; and 3) an educational component focused on sleep hygiene. Despite considerable evidence of CBTi efficacy, accessibility and cost remain major barriers. Recently, internet-delivered digital CBTi (dCBTi) has emerged as a potential answer for the growing demand and poor treatment accessibility. This review will discuss the history of CBTi as a first-line treatment for insomnia, the current status and limitations of CBTi, the efficacy of dCBTi as an alternative, and the future of dCBTi in pioneering digital therapeutics.

Key Words: Insomnia; Sleep disorder; Cognitive behavioral therapy; Internet-based intervention

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INTRODUCTION

Insomnia is a disorder defined by dissatisfaction with the quantity or quality of sleep that occurs more than three nights per week for at least 3 months, and includes clinically significant distress in important areas of functioning. Sleep dissatisfaction is characterized by difficulty in initiating or maintaining sleep, or early-morning awakening with an inability to return to sleep despite adequate opportunity. Overall, 45–75% of insomnia patients are chronic sufferers [1] and there is a relatively high relapse rate after remission (12–33%) [2].

Increasing insomnia prevalence is a global problem [3,4]. In South Korea, a statistical analysis of Korea Health Insurance Claims data showed a 34% increase in the number of patients with insomnia between 2012 and 2016 [5]. As the prevalence of insomnia increases, so does the demand for treatment. The report estimated that the global market for sleep-related drugs will grow at an average annual rate of 5.2% by 2026 [6].

Cognitive behavioral therapy, the first-line treatment for insomnia, is also growing in popularity. Only 30 years have passed since cognitive behavioral therapy for insomnia (CBTi) became the predominant first-line treatment for insomnia. Fewer than 10 papers in PubMed discussed CBTi in the early 2000s, but by 2019, there were 119 papers on that subject in that year alone. Despite the explosive interest, widespread use of CBTi is limited by accessibility and cost. Internet-delivered digital CBTi (dCBTi) was introduced in 2004 [7] and offers an alternative to meet growing demand and poor treatment accessibility. This paper discusses the history of CBTi as a first-line treatment for insomnia, the current status and limitations of CBTi, the efficacy of dCBTi as an alternative, and the future of dCBTi in pioneering digital therapeutics.

HOW DID CBTi BECOME THE PREDOMINANT TREATMENT FOR INSOMNIA?

Muscle relaxation is the beginning of non-pharmacological

insomnia treatment. Progressive relaxation therapy was first developed by Jacobsen [8] in the 1930s and is effective for insomnia patients. Progressive muscle relaxation therapy reduces muscle tension and stops racing thoughts that affect sleep [9]. In subjective reporting, muscle relaxation therapy reduces sleep onset latency and increases total sleep time [10]. The first clinical study of insomnia treatment using relaxation therapy was published in the 1960s [11]. In the 1970s, Bootzin's stimulus control therapy for insomnia was introduced [12] as the first non-pharmacological treatment specifically developed for insomnia. Stimulus control therapy for insomnia is based on learning theory related to sleep, which is based on the assumptions that external or psychological factors that make it hard to fall asleep act as stimuli. These stimuli, which include bedroom and bed environments, may illicit stressful and fearful feelings that reinforce the difficulty of falling asleep. Stimulus control therapy develops a coherent sleep-wake pattern by reinforcing beds and bedrooms with conditioned sleep stimuli and dissociating conditioned stimuli with behaviors that are incompatible with sleep. Stimulus control therapy consists of the following guidelines: 1) sleep only when you are sleepy; 2) do not use your bed for anything other than sleep and sexual activity. Do not read, watch television, eat, or worry in bed; 3) if you cannot sleep, get up and go to another room. Stay up as long as you want and go back to your bedroom. Do not lie in bed for more than 10 minutes without falling asleep; 4) if you still cannot sleep, repeat the previous steps; 5) wake up at the same time each morning, no matter how much you slept. This helps establish a consistent sleep rhythm; and 6) do not take naps.

Sleep hygiene, now a well-known concept, was first introduced in 1977 by Hauri [13]. To promote good sleep, most doctors educate their patients about sleep hygiene, which includes: 1) going to bed at the same time and waking up at the same time; 2) maintaining a pleasant sleep environment; 3) reducing use of sleep-affecting substances, such as alcohol, coffee, and tobacco; and 4) exercising. These principles of sleep hygiene are the key elements of CBTi.

Sleep restriction therapy, developed around the same time as sleep hygiene, is also an important component of CBTi [14]. According to sleep restriction therapy theory, patients with insomnia spend too much time trying to sleep, which causes wakefulness, fragmented sleep, and variability in sleep and awake timing. Limiting sleep time and establishing a consistent sleep schedule is key to sleep restriction therapy. The therapist prescribes a sleep schedule based on a two-week sleep diary. Patients with insomnia often underestimate sleeping hours, so their sleeping time is generally less than what is actually needed. Partial sleep deprivation is thus induced, which increases homeostatic sleep drive and strengthens sleep the following night [14].

Spielman's 3P model, which best conceptualizes the mechanism by which insomnia becomes chronic, was published in 1986 [15]. The 3P model describes the mechanism of chronic insomnia on the basis of predisposing factors, precipitating circumstances, and perpetuating factors. Predisposing factors, including hyperarousal traits and a family history of insomnia, increase vulnerability to insomnia. Precipitating factors for acute insomnia are stressors that negatively affect sleep, such as illness, the burden of work or school, and interpersonal conflict. Perpetuating factors, such as worry about not being able to sleep, rumination, and behaviors such as waiting long hours in bed to sleep, irregular sleep schedules, naps, and activities in bed other than sleeping, cause acute insomnia to become chronic. Persistent insomnia is a vicious cycle in which maladaptive behavior and cognition increase over time, in turn increasing cognitive hyperarousal and preventing sleep even more. Maladaptive behaviors, dysfunctional thoughts, and excessive cognitive arousal all contribute to the mechanism of chronic insomnia. The goal of modifying these factors is to therapeutically influence circadian rhythm and sleep homeostatic processes.

Morin [16] developed a cognitive therapy for insomnia based on Beck's cognitive therapy for depression [17]. This insomnia therapy restructures cognition by focusing on dysfunctional attitudes about sleep, including unrealistic expectations of sleep, a false perception of the causes and consequences of insomnia, and a false belief in behaviors that improve sleep. A few years after the introduction of Morin's therapy, Harvey [18] proposed a new cognitive therapy to address five main cognitive processes that sustain insomnia: worry, selective attention and monitoring of sleep-related threats, misunderstandings about sleep and daytime problems, unhelpful beliefs about sleep, and unproductive safety behaviors. Harvey's cognitive therapy is different from the other therapies because it includes daytime thoughts and behaviors into the treatment focus.

A meta-analysis of CBTi effects was first published in 1994 [19]. The report included that conventional CBTi is a multicomponent intervention program consisting of: 1) a behavioral component, including stimulus control therapy, sleep restriction therapy, and muscle relaxation; 2) a cognitive component; and 3) an educational component focused on sleep hygiene. Therapy usually lasts 4 to 8 weeks, but can be as long as 16 weeks. Face-to-face sessions with a therapist are provided individually or in groups of up to eight people. In an analysis of 59 clinical trials, the average effect size was 0.88 for sleep onset latency and 0.65 for awake time after sleep onset, showing that CBTi is effective for easing difficulties in sleep initiation and maintenance. A meta-analysis of 21 prospective studies in the early 2000s showed that the short-term effect of CBTi on overall sleep-related variables was comparable to that of pharmacological treatment, and was also more effective at improving sleep onset latency. Stimulus control therapy and sleep restriction therapy were the most effective treatments, whereas sleep hygiene education was not effective when used alone [20]. Building on this evidence, the American Academy of Sleep Medicine published a systematic review of 48 clinical trials that included recommendations and supporting evidence for CBTi [21], followed by a review of 37 additional studies [22]. Both analyses indicated that CBTi was effective in easing difficulties in sleep ini-

tiation and maintenance, and remained effective for 6–24 months after treatment.

CBTi IN THE 21st CENTURY

No studies have shown the duration of CBTi effects or whether CBTi is effective as a maintenance therapy, although a 2-year follow-up study showed that use of sleeping pills decreased in a CBTi group compared to control insomnia patients [23]. Morin et al. [24] reported that CBTi is effective for treating insomnia, whether given alone or in combination with medication. Despite showing that CBTi effects were maintained for up to 24 months, the paper did not find that CBTi was beneficial as a maintenance therapy. This finding was also supported by a comparison of 2-year treatment outcomes for one-time CBTi versus 6 months of monthly CBT sessions in 160 chronic insomnia patients [25].

There were many studies on cognitive behavioral therapy for secondary insomnia in the early 2000s. Secondary insomnia refers to insomnia associated with psychiatric illness or non-psychiatric medical illness (pain, cancer, etc.). With the 2013 publication of the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5) [1], primary and secondary insomnia are no longer distinguished, but many studies have examined the effects of CBTi on comorbid conditions and insomnia in patients with psychiatric or medical comorbidities.

Evaluating the use of CBTi for concomitant psychiatric disorders has often targeted depression and post-traumatic stress disorder (PTSD). Either CBTi alone or CBTi with conventional depression treatment are equally effective in improving insomnia and depressive symptoms [26,27]. Taylor et al. [27] provided CBTi as a single treatment to depressed patients, finding that 87.5% of study participants normalized their depression scores and 100% reported normalized sleep. However, this study had only 10 participants and did not include patients with major depression. Manber et al. [26] reported 61.5% remission in major depressive disorders for participants who received a combination of escitalopram and CBTi, compared to 33.3% remission in participants who received escitalopram combined with a control insomnia therapy.

These studies are important because insomnia is a risk factor for depression relapse [28]. In cases of insomnia that persist for more than a year, the depression relapse risk is 16 times higher [29]. In this context, there is a great need to study the potential of CBTi to prevent depression relapse in patients who still have insomnia symptoms. One study showed that internet-delivered dCBTi improves both depression and insomnia symptoms, but no studies have reported a preventive effect for depression relapse [30]. Another study showed that providing CBTi along with behavioral therapy for trauma in patients with PTSD proved effective for improving both sleep efficiency (Cohen's d=1.01) and sleep onset latency (Cohen's d=0.89) [31].

CBTi is effective for treating insomnia with psychiatric or medical comorbidities. Insomnia has a 20% to 80% comorbidity with chronic medical illness [32]. Chronic pain and some therapeutic drugs can also interfere with sleep [33,34]. Pain and fatigue, which are common in chronic conditions, prevent patients from getting out of bed when they cannot sleep, which is the main recommendation for stimulation control therapy. Nevertheless, clinical trials have shown that CBTi is an effective insomnia treatment even for patients with chronic pain [35]. CBTi is also effective for insomnia symptoms associated with cancer and human immunodeficiency virus infection [36,37].

The many successful results of CBTi have led to its recommendation as the first-line treatment option for insomnia in nearly all guidelines [38-40]. But despite these successes, there are still many challenges for CBTi. The successful reports of CBTi have all been achieved by face-to-face therapy. Regardless of group or individual treatment, therapists check sleep diaries, provide feedback, and prescribe sleep schedules individually, which is time-consuming and costly. Moreover, lack of well-trained therapists specialized in CBTi is the biggest barrier to providing CBTi to many patients. These challenges are nearly insurmountable for patients living in rural areas with low access to medical institutions and older adults burdened by the difficulty of clinic visits, yet having the highest prevalence and severity of insomnia [41]. Thus, CBTi is not accessible to all individuals with insomnia.

To address these limitations, there has been growing interest in implementing CBTi using non-professional primary healthcare providers [42]. A six-week group CBTi trial for 139 insomnia patients, in which care was provided by primary care nurses, showed that sleep onset latency and wakefulness during the night were significantly reduced in the treatment group. The same research group showed favorable effects from five sessions of CBTi offered by primary care nurses for 201 people with insomnia [43]. However, these two studies cannot be applied to secondary insomnia because both studies excluded patients with comorbidity diagnosis.

Another limitation of CBTi is the difficulty of providing therapy to a large number of patients, because CBTi is only provided to 4–6 people at a time. In this context, self-help methods have also been evaluated as an alternative to conventional face-to-face CBTi. Self-help treatments are defined as standardized psychological treatments that can be independently conducted by the patients themselves. A meta-analysis included 10 studies of self-help CBTi implemented through a variety of methods, including books, internet, and audiotape. The analysis found a mild to moderate effect on sleep-related variables, including sleep efficiency (d=0.42), sleep onset latency (d=0.29), wake time after sleep onset (d=0.44), and sleep quality (d=0.33). However, subgroup analysis of studies with patients who had psychiatric comorbidities found that the mean effect size fell below 0.2, and that there was a significant publication bias [44]. The implementation of CBTi by primary healthcare providers or self-help methods is still limited by the difficulty of obtaining adequate feedback, coverage, and accessibility.

THE EMERGENCE OF INTERNET-DELIVERED dCBTi AS AN ALTERNATIVE TO CBTi

The limitations of CBTi, as discussed here, have led researchers to take on the challenge of delivering CBTi through the internet. Evolving internet-based communication methods are not limited to CBTi and online mental health services are increasingly available, potentially revolutionizing the provision of healthcare. Meta-analysis of randomized clinical trials show that online treatments are effective for depression, anxiety, and alcohol use disorder [45,46].

CBTi has many advantages that make it suitable for internet delivery. The greatest advantages of internet dCBTi are that it does not necessarily limit the audience and patients can be treated at the time and location of their choosing. In addition, dCBTi can improve access to insomnia treatment for people with limited transportation or poor hospital access. People with psychiatric and medical comorbidities that make it difficult to attend conventional CBTi may also consider dCBTi as a better option. Internet delivery can free patients from any fear of stigmatization associated with accessing a mental healthcare provider. There are already numerous books published for self-help CBTi, as well as manuals with treatment policies.

Swedish researchers evaluated the effects of dCBTi for the first time [7], reporting that 5 weeks of self-help dCBTi in 109 insomnia patients significantly improved total sleep time, total wake time in bed, and sleep efficiency. In another study from the United States, in which 45 insomnia patients were randomly assigned to the conventional CBTi waitlist or dCBTi, they observed a 16% increase in sleep efficiency and 55% decrease in wake time after sleep onset in the dCBTi group [47]. A study evaluating the durability of the dCBTi reported that 69.7% of participants maintained remission until 1 year after a 6-week dCBTi treatment. This result is comparable to the maintenance effect of classical face-to-face CBTi [48]. A meta-analysis of 15 randomized, controlled trials of dCBTi showed that dCBTi improves sleep efficiency, insomnia severity, total sleep time, sleep onset latency, wake time after sleep onset, and severity of depressive symptoms [49,50]. Of the 15 studies included in the analysis, eight were 6-week programs, two were 5-week, three were 8-week, and two were 9-week. This meta-analysis showed similar results to two other meta-analyses [51,52] and the calculated publication bias was non-significant.

dCBTi is reportedly convenient and effective for enhancing psychological well-being. In an assessment regarding dCBTi use, more than 90% of participants responded that dCBTi is convenient, understandable, effective, and useful [53]. In a survey of 1,711 participants that used dCBTi, researchers found that dCBTi improved insomnia symptoms, as well as daytime symptoms such as psychological well-being, sleep-related quality of life, mood, fatigue, and work productivity [54].

Recently, a patent for a dCBTi digital therapeutic was filed with the United States Food and Drug Administration (FDA) for use in treating chronic insomnia and depression [55]. The United Kingdom (UK), which provides national healthcare services, is already endorsing an internet-based mental health platform as part of a stepped-care approach [56]. The UK recommends dCBTi as an option for individuals with mild to moderate depression or subthreshold symptoms. In 2018, the U.S. FDA approved a mobile medical application for treating substance use disorder [57]. Thus, the utility of cognitive behavioral therapy via the internet has caught public attention. Multidimensional, multifaceted medical evaluation and treatment through the internet has many benefits, including increased convenience for patients, reduced cost, and increased access. However, there are still limitations, including the difficulty of individualized treatment, the liability of errors in care provision, and appropriateness of diagnosis and treatment selection [58].

It is possible for dCBTi to be a pioneer in the digital therapeutics market. However, there are clear limitations to the results so far. First, most randomization trials were conducted in North America and Europe, with few randomization studies in Asia [59]. Limited research in Asia, where smartphone and internet usage is prevalent, may be related to lack of policy support for telemedicine or a high level of regulation. Second, assessment of the effects and limitations of dCBTi have been mostly conducted in middle-aged adults. Additional randomized studies of adolescents, older people, and people of different cultures and races are essential. Third, most study participants had mild to moderate severity of insomnia symptoms, so future research on more severe cases is needed. Fourth, many studies did not follow up after dCBTi or followed up at variable times from 4 to 24 weeks [59-62]. Future studies should use more consistent follow-up periods to assess the efficacy of dCBTi.

Zachariae et al. [52] reported an average dropout rate of 24.7% in dCBTi studies across 11 randomized controlled trials, which is enough to influence results. Also, trials with higher dropout rates may show smaller effects and therefore, it is difficult to exclude publication bias [52]. Conventional face-to face CBTi has a dropout rate of 14−34%, and participants with a shorter baseline total sleep time tended to discontinue treatment early [63]. However, in a study of 207 dCBTi participants, the dropout rate increased for participants with less severe insomnia who had a total sleep time of >6 hours [64]. Future research should also be conducted regarding adverse effects and placebo effects. Although there is a sufficient lack of studies on conventional CBTi, some reports have shown that fatigue/exhaustion, extreme sleepiness, reduced motorization/energy, and headache/migraine [65] as possible adverse effects of CBTi.

Finally, the effectiveness of dCBTi compared to existing CBTi remains unclear. So far, most studies have compared dCBTi with wait-list or sham controls. One study comparing the effects of face-to-face group CBTi and dCBTi showed no difference between the two groups, not only in primary sleep-related outcomes, but also in secondary outcomes, such as adverse events, remission, re-

sponse rate, depression, and use of sleep medication [66]. However, Lancee et al. [67] found that dCBTi had better outcomes than a wait-list control group, but worse outcomes than a face-to-face CBTi group. Also, participants had a significantly higher preference for participating in the face-to-face CBTi group (78%) than in the dCBTi group (52%). Similarly, patient adherence was also significantly higher in the face-to-face intervention (70%) than in dCBTi (50%). Further research should determine where effort should be applied to improve dCBTi outcomes.

CONCLUSIONS

This review discusses the history of CBTi as a first-line treatment for insomnia, the current status and limitations of CBTi, the efficacy of dCBTi as an alternative therapy, and the future of dCBTi. The value of dCBTi extends beyond its usefulness in treating insomnia because it is a model for applying digital therapeutics to manage stress and improve the quality of life. The development of digital therapeutics is well underway, but the challenge will be to establish criteria for applying, standardizing, and assessing treatment.

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Conflicts of Interest

The author has no potential conflicts of interest to disclose.

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