Chapter #9

THE EFFECTS OF COGNITIVE TRAINING INTERVENTION ON QUALITY OF SLEEP IN OLDER ADULTS WITH INSOMNIA: A SYSTEMATIC REVIEW

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ABSTRACT
The risk of both — reduction in sleep quality and cognitive decline — increases with advanced age, raising the question of whether cognitive training intervention could improve sleep quality in older adults with insomnia. The current study aims to characterize existing literature on the possible effects of cognitive training intervention on sleep quality in older adults with insomnia. Evidence suggests that among older adults with insomnia cognitive training intervention (either personalized or in a group) improved sleep quality. The possibility of improving the sleep quality of these patients with a non-pharmacological treatment is an encouraging new concept that requires in-depth testing.

Keywords: older adults, sleep quality, insomnia, personalized cognitive training intervention, group cognitive training intervention.

1. INTRODUCTION

1.1. Insomnia in Older Adults: Understanding and Implications

Insomnia is the most common sleep disorder, affecting as many as 10% of European adults. Insomnia is defined by difficulty initiating or maintaining sleep that is associated with daytime consequences which occur at least 3 nights a week for at least 3 months despite adequate opportunity to sleep (Riemann et al., 2023; Van Someren, 2021).

Insomnia in elderly individuals is a complex problem rooted in physiological, psychological, and environmental elements (Ebben, 2021). The structure of sleep undergoes notable changes as people grow older, leading to modified sleep patterns that can trigger persistent insomnia. The aging process is linked to alterations in sleep structure. In contrast to younger adults, seniors experience shorter periods of Slow Wave Sleep (SWS) and Rapid Eye Movement (REM) sleep, which results in decreases in delta wave magnitude, REM sleep activity and density, and sleep spindle frequency (Espiritu, 2008; Feinsilver & Hernandez, 2017; Patel, Steinberg, & Patel, 2018). Thus, the sleep of older adults becomes fragmented, marked by frequent and prolonged awakenings (Espiritu, 2008; Patel et al., 2018). The ability to initiate and sustain sleep also diminishes and overall sleep duration decreases (Espiritu, 2008; Feinsilver & Hernandez, 2017; Patel et al., 2018).

Because sleep architecture changes with age, resulting in increased fragmentation, diminished Slow Wave Sleep (SWS), more stage 1 sleep (light sleep), and increased frequency of awakenings, the sleep patterns of elderly individuals exhibit greater susceptibility to disruption caused by medical and psychiatric disorders than in their younger counterparts (Espiritu, 2008; Feinsilver & Hernandez, 2017). Similarly, hormonal fluctuation in old age, particularly of melatonin (Haimov et al., 1994), and melatonin phase shift across the lifespan, especially between adolescents and older adults (Biggio et al., 2021), changes in gut microbiota composition, fluctuations in fecal short-chain fatty acids (Haimov et al., 2022; Magzal et al., 2021), and age-related health conditions, collectively contribute to the manifestation of insomnia in the elderly. Additionally, stress, anxiety, depression, and other psychological elements frequently intermingle with disturbances in sleep, culminating in an intricate nexus of causative factors (Ancoli-Israel & Ayalon, 2006; Foley et al., 1995; Morin & Benca, 2012). Late-life insomnia is a chronic sleep disorder that affects over 40% of older adults, according to epidemiological data, and therefore is a significant concern among the older adult population (Patel et al., 2018).

Late-life insomnia can significantly degrade both quality of life and psychological well-being. The ramifications of insomnia for older adults extend beyond mere disruption of sleep; its repercussions resonate widely throughout overall health and well-being (Palagini, Hertenstein, Riemann, & Nissen, 2022). The adverse influence on cognitive function, memory retention, and daytime vigilance has been broadly substantiated (Haimov, Hanuka, & Horowitz, 2008). Persistent insomnia also escalates the susceptibility to falls, accidents, and concurrent medical conditions such as cardiovascular disorders (Berkley., Carter., Yoder, Acton, & Holahan, 2020). Compounding this condition is the bidirectional interaction between insomnia and mental health concerns, such as depression and anxiety, accentuating the potential for a vicious circle (Espiritu, 2008; Palagini et al, 2022; Patel et al., 2018).

The first-line non-pharmacological treatment for chronic insomnia is Cognitive Behavioral Therapy for Insomnia (CBT-I), which has been shown to be more effective than medication alone, especially in the long term (Edinger et al., 2021). CBT-I combines sleep education, sleep restriction, stimulus control, cognitive restructuring, and relaxation techniques to improve sleep quality and duration. Treatment adherence rates are estimated to reach about 60% for in-person CBT-I (Morin, 2006) and for digital CBT-I approximately 50% (Horsch, Lancee, Beun, Neerincx, & Brinkman, 2015). Nevertheless, their level of efficacy in instances of late-life insomnia is only moderate (Altena, Ellis, Camart, Guichard, & Bastien, 2023; Baglioni et al., 2023; Espie & Henry, 2023; Epstein, Sidani, Bootzin, & Belyea, 2012).

The effect of insomnia on the physical and mental well-being of older adults underscores the imperative of providing a prompt answer to this condition. Hence, identifying the optimal approach for ameliorating the sleep quality of elderly individuals grappling with late-life insomnia is an urgent task.

1.2. Cognitive Performance of Older Adults: Understanding and Implications

Aging not only brings about changes in sleep quality but has also been found associated with cognitive impairments (Droby et al, 2022; Heckner et al., 2021; Lufi & Haimov, 2018; Lufi, Segev, Blum, Rosen, & Haimov, 2015). The aging process ushers in a plethora of changes across a spectrum of physiological, psychological, and cognitive realms. Of these, cognitive performance is markedly influenced by the passage of time, affecting several mental processes such as memory, attention, problem-solving, and language.

Aging exhibits a wide array of cognitive shifts. Whereas certain functions remain robust, others show marginal declines, and others yet are significantly degraded. Crystallized intelligence, including acquired knowledge and verbal ability, tends to maintain stability or even progress with time. Conversely, the aging process triggers declining performance in a range of cognitive tasks that are part of the executive function. These include processing speed, perceptual agility, concentration, attention, inhibitory capacity, and memory (Droby et al., 2022; Heckner et al., 2021).

Aging affects both implicit (nondeclarative) and explicit (declarative) memory. Explicit memory, which involves conscious recollection, declines with age, as shown by studies on recall and recognition tasks (Ward & Shanks, 2018). But the effect of aging on implicit memory, which is manifested in tasks that do not require conscious recollection, is less clear. Some studies suggest that implicit memory remains relatively stable over the adult lifespan (Lalla, Tarder-Stoll, Hasher, & Duncan, 2022) whereas others have reported age-related decline (Ward, Berry, Shanks, Moller, & Czsiser, 2020). Age effects on implicit memory can be influenced by factors such as attention and depth of processing (Almkvist, Bosnes, Bosnes, & Stordal, 2019).

Aging affects cognitive performance in a range of domains:

Everyday functioning. Aging leads to a gradual decline in cognitive performance that lowers everyday functioning. It takes approximately two decades for significant changes to manifest in elders. The decline is not affected considerably by gender or education level. Advanced age has a notable direct effect on everyday functioning, mediated by deficits in time-based and event-based prospective memory, executive functions, and retrospective memory. Likewise, diminished processing speed and working memory may render daily activities challenging for older adults, including financial management, navigation in unfamiliar environments, and multitasking (Hergert, Pulsipher, Haaland, & Sadek, 2020).

Quality of life. Declining cognitive performance in older adults significantly degrades their quality of life (QOL). As one ages, cognitive functions like memory tend to weaken, disrupting daily activities and decreasing QOL. Reductions in cognitive functioning correlate with lower satisfaction with aging, indicating the importance of sustained cognition for self-appraised wellbeing and QOL. Cognitive deficits in seniors are also associated with diminished QOL across domains, especially mental health. Cognitive decline can encroach on independence, curtail social involvement, and contribute to psychological distress, degrading the quality of life of older adults (Dolatabadi et al., 2019).

Healthcare. Declining cognitive performance in older adults significantly worsens their health outcomes and increases their medical care needs. Research indicates that cognitive impairment interacts with cardiovascular conditions like coronary heart disease and heart failure, heightening risks of adverse events and disrupting disease progression and self-management. Retired individuals with more pronounced cognitive deficits also exhibit higher medical expenditures resulting from poorer health (Zuo & Wu, 2022).

Studies have demonstrated that the cognitive deficits manifest in older adults grappling with insomnia surpass those evident in their insomnia-free counterparts (Haimov, 2006; Haimov, Hadad, & Shurkin, 2007; Haimov et al., 2008).

1.3. Cognitive Training

One effective tool for the prevention of cognitive decline in healthy aging individuals is cognitive training. This includes any intervention aimed to improve, maintain, or restore mental function in which the individual repeatedly practices mentally challenging tasks in a structured manner (Smid, Karbach, & Steinbeis, 2020). Numerous studies have demonstrated the beneficial effects of cognitive training on cognitive functions (e.g., memory, attention, processing speed, and executive functions) and on distal, untrained domains (e.g., reading and walking) among both aging populations (Shatil, 2013, Sprague, Phillips, & Ross, 2020) and populations with cognitive deficits (Shatil, Metzer, Horvitz, & Miller, 2010). Cognitive training can be implemented in two ways: in either a personalized setting or a group setting. Recently, personalized cognitive training exercises have been progressively integrated into computerized training: computers and game consoles as well as smartphones and tablets (Bonnechère, Langley, & Sahakian, 2020). Moreover, group programs of cognitive training have been developed alongside computerized personalized cognitive training (Srisuwan et al., 2019).

1.4 The Relationship between Sleep Quality and Cognitive Functioning

The interaction between sleep and cognitive functioning has been investigated extensively in the past two decades**.** A multitude of findings have demonstrated the central role of sleep in brain plasticity, memory consolidation, and optimal cognitive engagement (Diekelmann & Born, 2010; Walker & Stickgold, 2004). At the same time, learning may have positive effects on sleep architecture (de Almondes, Leonardo, & Moreira, 2017, Cerasuolo, Conte, Giganti, & Ficca, 2020; Diamond et al., 2015; Fogel & Smith, 2006; Huber, Ghilardi, Massimini, & Tononi, 2004; Peters, Ray, Smith, & Smith, 2008; Peters, Smith, & Smith, 2007; Schabus et al., 2004; Smith, Nixon, & Nader, 2004).

Research conducted in both youthful and elderly cohorts free from insomnia has revealed that young adults, after learning, displayed a rise in the proportion of REM sleep (De Koninck, Lorrain, Christ, Proulx, & Coulombe, 1989; Smith & Lapp, 1991; Smith et al., 2004). They also showed a rise in the count and density of REMs (Peters et al., 2007; Smith & Lapp, 1991; Smith et al., 2004), longer Stage 2 sleep, more sleep spindles, and higher spindle density (Fogel & Smith, 2006; Fogel, Smith, & Côté, 2007; Peters et al., 2008; Peters et al., 2007; Schabus et al., 2004). Finally, they showed evidence of enhanced slow-wave activity (SWA). By contrast, older adults showed a longer duration of slow-wave sleep (SWS) and an increase in its percentage (Fogel & Smith, 2006; Naylor et al., 2000; Peters et al., 2008).

As noted, with advanced age the risk of a decline in both sleep quality and cognitive function increases. This raises the question whether sleep quality in older adults with insomnia may be improved by cognitive training intervention. The present study reviewed the literature on this topic.

2. METHODS

This systematic review was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009).

2.1. Search Strategy

The literature search was conducted in November 2022 in PUBMED, CINAHL, SCOPUS, and Web of Science. No language restriction was imposed. To be eligible for this systematic review, the sample of the study needed to include adults aged 65 and above with the diagnosis of insomnia and objective or subjective measurement of the participants' sleep. Studies evaluating the effects of cognitive training intervention were included, irrespective of the form (e.g., group or individual) and duration of treatment. Only randomized controlled trials (RCTs) were included.

3. RESULTS

The literature review revealed that only two studies to date have investigated the beneficial effects of prolonged cognitive training (either personalized or in a group) on the sleep quality of older adults with insomnia (Haimov & Shatil, 2013; Keramtinejad, Azadi, Taghinejad, & Khorshidi, 2019). First, Haimov & Shatil (2013) demonstrated in a pioneering study the beneficial effects of personalized computerized cognitive training on sleep quality and cognitive function among older adults with insomnia. Their study revealed that, among this population, an improvement in sleep quality is predicted by an improvement in cognitive performance.

In their study (Haimov & Shatil, 2013), participants in the cognitive training group (n = 34) completed a home-based, personalized, computerized cognitive training program (using the CogniFit cognitive training program). Participants in the active control group completed a home-based program involving computerized tasks that do not engage high-level cognitive functioning (‘‘Word and Paint’’). Both programs were similar in time commitment of 20–30 minutes per session and both regimens were similarly structured - three sessions each week (with a no-training day between sessions), for a duration of 8 weeks (24 training sessions). At the beginning of the study, all participants completed a broad spectrum of questionnaires. In the two weeks immediately before the onset of the intervention and following the end of the intervention, baseline and post-training objective sleep quality data were collected i.e., during these two weeks participants' sleep was continuously monitored by actigraph and participants filled a daily sleep diary. In addition, before the onset of the intervention and following the end of the intervention participants' cognitive performance was evaluated using the CogniFit computerized neurocognitive evaluation program.

The results of this study revealed between-group improvements for the cognitive training group on both sleep quality (sleep onset latency and sleep efficiency) and cognitive performance (avoiding distractions, working memory, visual memory, general memory, and naming). Hierarchical linear regression analysis in the cognitive training group indicated that improved visual scanning was associated with the earlier advent of sleep, while improved naming was associated with the reduction in wake after sleep onset and with the reduction in the number of awakenings. Likewise, the results indicated that improved "avoiding distractions" was associated with an increase in the duration of sleep. Moreover, the results showed that in the active control group, cognitive decline observed in working memory was associated with an increase in the time required to fall asleep.

In the second study, Keramtinejad et al. (2019) examined the beneficial effects of prolonged group cognitive training intervention on subjective sleep quality and cognition performance in older adults suffering from both insomnia and mild cognitive reduction and revealed that group cognitive training promoted their cognitive function and sleep quality. The participants in the study comprised 108 older adults with mild cognitive reduction suffering from insomnia. Participants were randomly allocated to an experimental group (n=54) and a control group (n=54). The experimental group underwent group cognitive training intervention for two months. Data were collected using the Mini-Mental State Examination (MMSE) questionnaire, Pittsburgh Sleep Quality Index (PSQI), Insomnia Severity Index (ISI), and Clinical Dementia Rating Scale (CDR). Data were collected one month before and after the intervention. The results revealed that the group cognitive training intervention promoted cognitive function and improved subjective sleep quality in the intervention group compared to the control group.

4. CONCLUSIONS

Overall, the two studies included in the current review demonstrated that sleep quality in older adults with insomnia may be improved by cognitive training intervention. The mechanism by which cognitive training improve sleep quality is unknown. Possible mechanism that underlies the interplay between cognitive functioning and sleep assumes that both cognitive training interventions (either personalized or in a group) provided an intensive new learning experience that acts as a catalyst to enhance sleep-dependent processes such as memory encoding and consolidation. These processes yield learning-dependent changes in sleep architecture which may enhance sleep continuity, allowing sleep-related memory consolidation to proceed with less disruption and thereby leading to an improvement in sleep quality (Haimov & Shatil, 2013).

Insomnia is a common chronic condition in older adults. Therefore, the option of a non-pharmacological treatment that can improve their sleep quality is auspicious and should be further examined. Both personalized and group cognitive training should be investigated as promising non-pharmacological options that can benefit the initiation and maintenance of sleep. To further address the beneficial effect of cognitive training on sleep quality throughout the aging process, future studies should evaluate both methods of cognitive training in a broader elderly population. These studies may pave the way for the development of effective non-pharmacological interventions that may improve the sleep quality of older adults with insomnia.

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Short biographical sketch: Full Professor in the Department of Psychology at The Max Stern Yezreel Valley College, Israel, where she also serves as the Dean for Research & Development. In addition, she serves as the head of the Research Authority at the college. With a prolific academic career, Prof. Haimov has published over 50 papers in prestigious journals and actively contributes as an editorial board member for two journals. Prof. Haimov has secured grant funding from organizations including the Israel Science Foundation and serves as a frequent peer reviewer. Since 2014, she has been a member of the Clinic and Academic Committee of both the Asian Society of Sleep Medicine and the Israeli Association for Sleep Research. Her research focuses on the intricate relationship between sleep quality and cognition, exploring aspects such as the sleepiness curve, circadian rhythms, sleep deprivation, and insomnia. Her work has significantly advanced the understanding of sleep science and its impact on psychological well-being.