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The Role of Exercise in Improving Sleep Quality Across Sleep Disorders: A Comprehensive Review

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Abstract

Introduction and Objective: Sleep disturbances are increasingly common in the general population, posing significant public health challenges and economic burdens. Traditional treatments frequently fall short, leading to increased interest in physical activity as an alternative approach. This review aims to evaluate the efficacy of exercise in improving sleep quality across various conditions, including obstructive sleep apnea (OSA), insomnia, Parkinson's Disease (PD), depression and the perimenopausal period.

Review and Methods: The review draws from studies, including randomized controlled trials and meta-analyses, sourced via Google Scholar and PubMed.

State of Knowledge: Research highlights the significant public health impact of sleep disturbances. Studies suggest that regular exercise can improve sleep quality across conditions like OSA, PD, depression, and menopause. Traditional treatments, such as CPAP, psychotherapy, and medications, often have limitations. As a result, there is growing interest in using physical activity as alternative therapy or a complementary approach to enhance these existing options.

Conclusions: Exercise shows promise as a non-pharmacological intervention for sleep disorders, offering potential benefits for various conditions. Further research is needed to refine exercise protocols and understand its mechanisms. Integrating physical activity into treatment plans could enhance sleep quality and health outcomes alongside existing therapies.

Keywords: exercise, sleep, insomnia, obstructive sleep apnea, depression, physical activity

Introduction

Sleep disturbances are increasingly prevalent in the general population. These conditions include common issues like insomnia and obstructive sleep apnea (OSA), as well as rarer ones such as narcolepsy, central sleep apnea, and circadian rhythm sleep disorders. Approximately 10% of the European population experiences insomnia disorder, with prevalence rates ranging from 5.7% to 23.1% across different countries [1-3]. This widespread issue underscores the urgent need to address sleep-related problems that not only diminish quality of life but also contribute to increased morbidity, cognitive impairment, cardiovascular disease, and a higher risk of accidents. Additionally, sleep disturbances impose significant economic burdens on society due to increased healthcare costs, reduced productivity, and absenteeism from work.

Traditional treatment methods for sleep disturbances, such as pharmacological interventions and continuous positive airway pressure (CPAP) therapy, often face limitations for instance side effects and accessibility challenges. Consequently, there is growing interest in alternative, non-pharmacological approaches, particularly exercise, as a potential method for enhancing sleep quality. Research suggests that regular physical activity may have beneficial effects on sleep architecture, making it an attractive complement to conventional therapies.

This review aims to explore the impact of exercise on sleep quality across various conditions, including OSA, insomnia, Parkinson's Disease (PD), depression and menopause-related sleep disturbances. It also explores the potential of physical activity as a cost-efficient, low-risk strategy for managing sleep-related disorders.

The impact of exercise on normal sleep

Meta-analysis has convincingly shown that individuals who engage in regular exercise experience improved sleep architecture compared to those who are inactive [51]. Earlier research suggested that exercising close to bedtime could negatively impact sleep quality but more recent studies indicate that it does not harm and may even enhance its architecture [52 - 54]. In a cross-sectional survey of healthy adults, participants reported better subjective sleep quality on days they exercised compared to days without physical activity. Additionally, those who exercised in the morning were more likely to rate their sleep quality higher than individuals who engaged in physical activity in the evening [55]. Recent meta-analyses have shown that brief evening exercise does not negatively impact sleep parameters; however, intense physical activity within an hour of bedtime may disrupt sleep architecture [56,57].

Several possible mechanisms may explain how exercise can either enhance or diminish sleep quality. A decrease in body temperature improves sleep, whereas an increase delays sleep onset [58]. Since physical activity elevates body temperature, exercising right before bed may postpone the time it takes to fall asleep. This could account for the negative impact of high-intensity physical activity within an hour of bedtime on sleep quality.

Research on how exercise affects endocrine function during sleep is outdated and inconsistent. During sleep, levels of growth hormone, prolactin, and melatonin increase, while cortisol levels decrease [59]. One study found that physical activity significantly boosted growth hormone levels in healthy participants [60], but another one with a small group of ten persons showed no increase in growth hormone following a graded daytime exercise regimen [61]. This discrepancy might be attributed to differences in intensity of physical activity.

A separate small study indicated that in individuals engaging in moderate exercise, growth hormone levels initially decreased but then increased during the second half of the night [62]. The precise impact of pre-sleep physical activity on endocrine physiology remains unclear. Further research is needed to clarify how these mechanisms interact before drawing definitive conclusions.

Effects of Exercise on Obstructive Sleep Apnea and Associated Factors

Obstructive sleep apnea (OSA) is the most prevalent condition causing sleep-disordered breathing and is often associated with overweight individuals. Exercise training, as a method of weight reduction, has garnered significant interest in the scientific world. Besides its potential for weight loss, physical activity may also alleviate sleep-related symptoms.

Numerous studies found that sedentary behavior elevates the risk of OSA [25-28]. Prolonged inactivity can impair proper venous return, leading to fluid accumulation in the lower extremities' blood vessels and tissues [29]. When lying down at night, this fluid shifts toward the neck, increasing upper airway resistance and contributing to OSA development [30]. Additionally, a meta-analysis has shown that sedentary habits promote obesity [31], which leads to increased fat deposits around the maxilla, pharynx, and upper airways. These accumulations can block the upper respiratory tract during sleep, triggering OSA [32].

A 12-week case-control study of breathing and aerobic exercise demonstrated improvements in apnoea-hypopnoea index (AHI) and subjective sleep quality, independent of changes in body measurements [4]. While randomized studies have reported mixed results, several have noted positive outcomes. For example, one research found that a supervised cycle ergometry program improved AHI, arousal index, and desaturation index compared to controls [20]. Another study comparing a 12-week aerobic exercise class to a stretching control group saw significant improvements in AHI and overnight desaturation. However, there were no meaningful changes in sleep time and efficiency [21]. Analogously, a randomized study involving a community walking group found improved AHI in participants under 60 but did not observe sleep quality modifications [22].

Research comparing exercise therapy to continuous positive airway pressure (CPAP) therapy did not consistently show additional benefits of physical movement. One randomized trial found no differences in sleep parameters between patients receiving CPAP alone and those receiving both CPAP and exercise [23]. A different study comparing CPAP, exercise therapy, and oral devices found that although CPAP therapy led to improvements in AHI, exercise therapy did not have the same effect [24]. None of this research was designed to assess sleep quality as a primary outcome, and it remains unclear whether the benefits of exercise are solely attributable to weight loss or if they provide additional sleep-related advantages. Systematic reviews and meta-analyses have compiled several studies and determined that, although the evidence quality is not strong and the number of studies is small, supervised exercise therapy in OSA shows positive effects on disease severity (AHI) and daytime sleepiness, beyond its influence on BMI, with its impact on sleep quality still unclear. More robust research powered to investigate sleep outcomes are needed to validate this low-cost intervention.

Exercise is considered the second most effective treatment for OSA after CPAP. Although the exact mechanisms by which physical activity benefits OSA remain unclear, several potential pathways have been proposed. These include reducing fluid buildup in the neck [33,34], increasing the tension of upper airway dilator muscles [36], enhancing sleep quality [35] and redistributing fat [37]. Tian et al. study suggests that vigorous physical activity (VPA) offers protection against OSA, while moderate-to-vigorous physical activity (MVPA) does not significantly reduce the risk [28]. This implies that lighter exercises, such as slow cycling or light weight-bearing activities, may not be as effective in preventing OSA. This analysis confirmed a causal relationship between VPA and reduced risk of this condition, likely due to several factors. First, VPA improves the quality of slow-wave sleep by increasing its stability, which can alleviate OSA [38]. Second, intensive physical activity helps redistribute body fat which helps to reduce its accumulation around the neck and improve airway function [39]. Though both high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) are effective at reducing body fat [40], the first one is particularly beneficial in promoting fat redistribution, especially in specific groups like postmenopausal women [41]. By reducing neck circumference, HIIT may enhance airway patency, which may explain why VPA specifically protects against OSA. Moreover, intensive physical activity strengthens lower limb muscles and reduces fluid retention in the legs, thereby decreasing its transfer to the airway during sleep, helping to keep the upper airway open. This aligns with findings that HIIT, but not MICT, improves muscle function in sedentary individuals [42].

Exercise as an Alternative Therapy for Insomnia

Insomnia, a prevalent sleep disorder, severely impairs daytime functioning [43]. This condition is also linked to significant economic burdens and workplace-efficacy problems [44]. While cognitive behavioral therapy and pharmacological treatments are the primary approaches, their limitations, such as cost, accessibility, and potential side effects, have led to interest in alternative therapy [45]. Small randomized trials have shown that moderate aerobic exercise can improve both objective measures (such as increased total sleep time, reduced sleep onset latency, enhanced sleep efficiency and decreased wakefulness after sleep onset) and subjective assessments (e.g., Pittsburgh Sleep Quality Index) [46,47]. Resistance training and stretching exercises have also been found to enhance polysomnographic indicators compared to control groups, with no significant difference between the effects of these two types of physical activity [48]. Wu et al. [49] reported a moderate improvement in subjective sleep parameters among the elderly through interventions such as Yoga, Tai Chi, or Qigong. In contrast, Rubio-Arias et al. [50] found no significant impact from low or moderate-intensity physical activity on insomnia symptoms in middle-aged women, although aerobic training did show a meaningful enhancement in subjective sleep quality. Although exercise timing does not seem to influence its benefits in people with normal sleep, determining its impact on those with insomnia could be important.

Parkinson’s Disease

Parkinson's Disease (PD) is a progressive neurodegenerative disorder that is primarily driven by the loss of dopaminergic neurons in the substantia nigra, leading to a decrease in dopamine levels [4]. Sleep disturbances are common in PD, affecting up to 90% of patients [5]. These issues include conditions such as insomnia, obstructive sleep apnea, and restless leg syndrome, which not only diminish quality of life but also exacerbate the progression of the disease. A key factor in this progression is the neuronal protein α-synuclein, which plays an essential role in synaptic function. Sleep disturbances contribute to the aggregation of α-synuclein, which can accumulate and lead to neurodegeneration [6]. Research indicates that a single night of sleep deprivation can elevate α-synuclein levels by up to 36% [7]. Improving sleep quality in PD patients can reduce the aggregation of α-synuclein, potentially alleviating symptoms associated with the disease.

A study revealed that patients undergoing an intensive rehabilitation program, which included different exercises, showed significant improvements in their total Parkinson's Disease Sleep Scale scores [8]. Additionally, a recent randomized controlled trial demonstrated that individuals with PD who participated in resistance training three times per week for sixteen weeks experienced notable enhancements in sleep efficiency, total sleep duration, time spent in slow-wave sleep, and overall sleep architecture. These improvements were more significant compared to those in a control group receiving only sleep hygiene advice [9].

Another study demonstrated that even low-intensity exercises, such as Qigong, can significantly enhance sleep quality in individuals with Parkinson's Disease [10]. Moreover, Tai Chi training, conducted three times per week, has been shown to reduce sleep disturbances and enhance sleep quality in patients with PD [11]. These findings are particularly noteworthy because such gentle exercises can be especially beneficial for individuals with limited mobility, a common challenge in PD. Incorporating low-impact activities like Qigong into treatment plans can provide a practical and accessible means to improve sleep and overall well-being in this population. Overall, exercise has been shown to enhance sleep quality and duration, reduce insomnia, and alleviate daytime sleepiness in individuals with Parkinson's Disease. Moreover, physical activity not only improves sleep patterns but also positively impacts α-synuclein levels, which are linked to the disease's progression [4]. This dual benefit underscores the importance of incorporating regular exercise into the management of PD, as it can contribute to both better sleep and overall neurological health.

Depression

Three meta-analyses of prospective cohort studies have found that experiencing insomnia symptoms more than doubles the likelihood of developing depression [12]. These symptoms not only forecast the initial onset of depression but also impact the progression and recurrence of depressive episodes. Additionally, even after a depressive episode has subsided, sleep disturbances often remain, increasing the chances of relapse and frequently acting as early indicators of depression’s return [13]. When insomnia coexists with depression, it notably raises the risk of suicide, underscoring the importance of addressing sleep disturbances in the overall treatment and management of depression [14].

Current guidelines for treating depression recommend a combination of psychotherapy and pharmacotherapy [15]. However, despite these treatments, insomnia symptoms persist in nearly half of the patients who initially respond to therapy [16]. While meta-analyses indicate that psychotherapy can improve subjective perceptions of sleep quality [18], it does not significantly enhance objective sleep measures as defined by polysomnography [17]. This underscores the need for alternative approaches to effectively address sleep disturbances in patients with depression. Several studies have examined the impact of exercise on sleep in patients with depression. Seventeen trials specifically compared the effects of aerobic, resistance, and mind-body exercises on sleep quality. None of these studies used objective sleep measurements, relying instead on participants' self-reported sleep quality. The findings indicated that all exercise interventions, except for moderate aerobic exercise alone and meditation, were more effective than the control group. Combining mind-body exercises with standard treatment provided additional benefits. Notably, vigorous strength training and mind-body exercises combined with standard treatment were the only interventions that significantly outperformed standard treatment alone [12]. These studies suggest that exercise, particularly when combined with standard treatment, can improve sleep quality in patients with depression. However, it is important to note that the confidence in these findings is moderate to very low due to factors such as small sample sizes [12]. Future research should incorporate objective measures of sleep quality, such as polysomnography, to enhance the reliability of results. Despite these limitations, aerobic, strength, and mind-body exercises remain cost-effective, non-invasive, and non-pharmacological options that should be considered as part of a comprehensive approach for alleviating insomnia symptoms in patients with depression [12].

Menopause

Sleep disturbances affect 39% - 47% [65] of perimenopausal women, making it crucial to support their transition through this period with appropriate health care, medical treatment, exercise and diet. Some evidence suggests that estrogen changes, neurotransmitter imbalances, and psychological factors produced during perimenopause contribute to a decrease in sleep quality, which in turn results in sleep disturbance [63]. Sleep disorders can severely affect their life quality. Furthermore, poor sleep quality and insomnia in postmenopausal women are linked to increased morbidity and mortality [64]. Despite the significant impact, insomnia and sleep disorders often go underrecognized and undertreated. While chronic insomnia medications can be effective, they come with side effects and cognitive impairments.. As a non-pharmacological alternative, exercise has been proposed to enhance sleep quality without these associated risks. Twelve studies published between 2007 and 2022 explored the link between physical activity and insomnia in perimenopausal women [63]. These studies included various forms of exercise, such as aerobic exercise, yoga, walking, and fitness Qigong. Overall, exercise interventions significantly improved participants' sleep issues, with the effect on sleep quality being slightly more pronounced than on insomnia symptoms. Among the exercises studied, fitness Qigong proved to be the most effective in enhancing sleep [63]. The research also identified the most beneficial regimen: practicing Qigong for 10–12 weeks, at least three times per week, with each session lasting 30–60 minutes [63]. This approach is recommended to achieve optimal improvements in sleep quality during the perimenopausal period.

Data from four randomized controlled trials evaluating the impact of 12 - 16 weeks of exercise on sleep quality and insomnia demonstrated that low to moderate levels of physical activity significantly improved sleep quality compared to controls [64]. Specifically, moderate intensity exercises like aerobic workouts showed notable enhancements in sleep quality, while low intensity activities such as yoga did not yield significant effects. Although these structured exercise programs effectively improved sleep quality in middle-aged women, they did not lead to a notable reduction in insomnia severity [64].

Research has consistently demonstrated that exercise significantly enhances sleep quality in perimenopausal women. While the impact on insomnia symptoms appears less pronounced, the overall benefits of incorporating physical activity are clear. Given the absence of adverse effects and the holistic improvements to well-being, regular exercise is strongly recommended as a valuable component of managing sleep disturbances during the perimenopausal period.

Conclusions

This article highlights the significant potential of exercise as an effective, affordable, and non-pharmacological approach to improving sleep quality across various conditions, including obstructive sleep apnea (OSA), insomnia, Parkinson's Disease (PD), depression, and menopause-related sleep disturbances. Although its efficacy varies depending on the condition and intensity of the exercise, it generally contributes to improving sleep architecture, reducing symptoms, and mending overall health outcomes. Despite these encouraging findings, the current research is limited by factors such as small sample sizes, a lack of objective sleep measurements, and varying study designs. These restrictions underscore the need for more rigorous and larger trials to better understand and quantify the impact of exercise on sleep quality. Nonetheless, many positive outcomes suggest that exercise should be considered a component of comprehensive treatment plans for managing sleep disturbances. Integrating regular physical activity into therapeutic regimens offers a holistic approach that not only addresses sleep issues but also promotes overall physical and mental well-being.

As the prevalence of sleep disturbances rises, promoting exercise emerges as a promising and accessible strategy for enhancing sleep health. Continued research and clinical attention in this area are essential to fully realize the potential of physical activity in mitigating the negative impact of sleep disorders.

Disclosure

Author's contribution

Conceptualization, Michalina Dubińska, and Wiktoria Paduch-Jakubczyk; methodology, Anna Dobosz and Wiktoria Zduńczyk; software, Urszula Ciułek; check, Michalina Dubińska, Anna Dobosz and Ada Żydek; formal analysis, Wiktoria Bilska; investigation, Ada Żydek; resources, Anna Dobosz and Ada Żydek; data curation, Urszula Ciułek; writing - rough preparation, Wiktoria Paduch-Jakubczyk, Wiktoria Zduńczyk and Anna Dobosz; writing - review and editing, Michalina Dubińska, Wiktoria Zduńczyk and Wiktoria Bilska; visualization, Wiktoria Bilska; supervision, Wiktoria Paduch-Jakubczyk and Urszula Ciułek; project administration, Wiktoria Paduch-Jakubczyk and Michalina Dubińska; receiving funding, no specific funding.
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