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## Moving for Better Sleep: A Narrative Review of Exercise and Sleep Quality



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### ABSTRACT

**Objective:** This narrative review aims to bridge the knowledge gap regarding the influence of exercise on sleep quality, exploring how various types, intensities, and timings of exercise impact sleep across different populations.

**Materials and Methods:** A systematic search for relevant literature was conducted in scholarly databases such as Google Scholar, PubMed, MEDLINE, SPORTDiscus, CINAHL, and Web of Science. The search included terms related to physical activity and sleep, focusing on studies published in English from the past 10 years (2014-2024). Studies involving human participants and employing randomized controlled trials (RCTs) or observational study designs were prioritized.

**Results:** Regular moderate-intensity aerobic exercise, such as brisk walking or cycling, significantly reduces sleep onset latency, improves sleep efficiency, and enhances subjective sleep quality across various populations. Potential mechanisms include stress hormone reduction, neurotransmitter regulation, and body temperature control. Emerging evidence suggests that resistance training can improve sleep onset latency and subjective sleep quality, particularly in older adults and individuals with chronic conditions. The benefits may be linked to muscle repair processes and stress reduction. The effects of High-Intensity Interval Training (HIIT) on sleep are mixed, with moderate-intensity programs showing potential benefits while excessive intensity or duration may disrupt sleep. Timing also plays a crucial role, with late-night HIIT potentially having negative impacts on sleep quality.

**Conclusion:** Regular exercise, especially moderate-intensity aerobic exercise, is a powerful tool for improving sleep quality. Resistance training also holds promise, particularly for specific populations. The impact of HIIT on sleep requires further research to determine optimal training parameters. Healthcare professionals should guide patients in tailoring exercise programs to optimize sleep benefits.

**Keywords:** Aerobic exercise, resistance training, high-intensity interval training, sleep quality, sleep latency, sleep efficiency, insomnia.

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## 1. Introduction

Sleep, a fundamental pillar of human health, significantly impacts physical and cognitive function while influencing the risk of chronic diseases (1). Despite its importance, millions worldwide struggle with sleep disturbances, experiencing daytime fatigue and impaired well-being (1). Fortunately, modifiable lifestyle factors like exercise offer promising avenues for improving sleep quality (2). This narrative review aims to bridge the knowledge gap regarding the influence of exercise on sleep. We will delve into existing research to explore how various exercise types, intensities, and timings impact sleep quality in diverse populations. By examining the effects of aerobic exercise, resistance training, and high-intensity interval training (HIIT), we hope to illuminate the potential mechanisms by which exercise promotes better sleep. The significant prevalence of sleep disturbances underscores the necessity to explore effective and accessible interventions. Current research suggests that regular physical activity can considerably enhance sleep quality across various populations, including healthy adults, adolescents, older adults, and individuals with specific health conditions (1, 3, 4). Studies have demonstrated that exercise can improve sleep onset latency (falling asleep time), sleep efficiency (percentage of time spent asleep in bed), and subjective sleep quality reports (5, 6). Notably, exercise may alleviate symptoms of insomnia, a prevalent sleep disorder characterized by difficulty falling or staying asleep (7). However, the impact of exercise on sleep quality might be influenced by factors like type, intensity, and timing. Moderate-intensity aerobic exercise, such as brisk walking, cycling, or swimming, appears to be particularly beneficial for most populations (8, 9). Resistance training, involving exercises that build muscle strength and endurance, has also shown promise in promoting better sleep, especially in older adults and individuals with chronic conditions (10, 11). The effects of HIIT on sleep are less conclusive, with some studies suggesting benefits while others report potential sleep disruption, particularly when performed close to bedtime (12, 13).

While the precise mechanisms by which exercise improves sleep quality remain under investigation, several potential pathways have been proposed. Exercise may promote relaxation and decrease stress hormones like cortisol, known to disrupt sleep (14). Physical activity may also enhance the production of brain chemicals like serotonin, contributing to feelings of calmness and well-

being, ultimately promoting better sleep (14). Additionally, exercise can help regulate body temperature, which plays a role in initiating and maintaining sleep (15).

In conclusion, the substantial body of research suggests that regular exercise can be a powerful tool to combat sleep disturbances. Engaging in moderate-intensity aerobic exercise or resistance training appears to be particularly beneficial for sleep, while the effects of HIIT may depend on timing and individual factors. This narrative review aims to synthesize existing research on exercise and sleep, providing valuable insights for healthcare professionals and individuals seeking to improve their sleep quality through lifestyle modifications. By incorporating physical activity into their daily routines, individuals can potentially experience significant improvements in sleep duration and quality, leading to enhanced overall health and well-being.

## 2. Methods and Materials

### 2.1 Search Method and Scope

To comprehensively explore the existing research on the relationship between exercise and sleep quality, we conducted a systematic search for relevant literature in scholarly databases. We primarily focused on the following databases, recognized for their high quality and extensive coverage of health and exercise science research:

- Google Scholar
- PubMed
- MEDLINE
- SPORTDiscus
- CINAHL
- Web of Science

Our search strategy employed a combination of Medical Subject Headings (MeSH) terms and relevant keywords. We utilized search terms encompassing various aspects of exercise and sleep, including:

### 2.2 Searched Terms

physical activity, exercise training, aerobic exercise, resistance training, high-intensity interval training (HIIT)

- Sleep terms: sleep quality, sleep duration, sleep latency, sleep efficiency, insomnia
- Boolean operators (AND, OR, NOT) were strategically incorporated to refine the search and ensure retrieval of relevant studies. For instance, the search string might resemble:

- (exercise OR physical activity) AND (sleep quality OR sleep duration OR sleep latency OR sleep efficiency OR insomnia)

### 2.2.1 Article Selection

Additionally, we adopted a snowballing technique, examining the reference lists of retrieved articles to identify potentially relevant studies not captured by the initial search. This approach helped to ensure a more comprehensive review of the literature.

The search encompassed studies published in English from the past 10 years (2014-2024) to capture the most recent advancements in the field. This timeframe ensured our review incorporated the latest research findings on exercise and sleep. We primarily focused on studies employing human participants and adopting randomized controlled trial (RCT) or observational study designs. RCTs were prioritized due to their strong internal validity in establishing cause-and-effect relationships. Observational studies, such as cohort studies or case-control studies, were also considered to provide additional insights and explore potential associations between exercise and sleep. Studies solely focused on specific populations or clinical conditions were excluded to maintain a broader scope and explore the generalizability of findings across diverse populations. However, relevant studies examining the effects of exercise on sleep in specific populations (e.g., older adults, individuals with insomnia) were included when findings could be applied to a broader audience.

### 2.3 Data Synthesis

By employing a systematic search strategy, clearly defined inclusion and exclusion criteria, and a focus on recent high-quality research, this narrative review aims to provide a comprehensive and up-to-date analysis of the current understanding of how exercise impacts sleep quality.

## 3. The Impact of Aerobic Exercise on Sleep Quality

Aerobic exercise, characterized by sustained physical activity that increases heart rate and breathing, has emerged as a powerful tool for promoting better sleep quality across various populations (8, 9, 16-19). Numerous studies have documented the positive effects of moderate-intensity aerobic exercise on sleep parameters, including sleep onset latency (time to fall asleep), sleep efficiency (percentage of time spent asleep in bed), and subjective sleep quality ratings

(5, 6, 16, 17, 19). Research suggests that engaging in regular aerobic exercise can significantly reduce the time it takes to fall asleep. A study by King et al. (2008) investigating the effects of moderate-intensity exercise on older adults with mild sleep complaints found improvements in sleep onset latency, with participants falling asleep an average of 23 minutes faster after exercise intervention (17). Similarly, Wang and Youngstedt (2014) observed a decrease in sleep onset latency in older women following a single session of moderate-intensity aerobic exercise (18). These findings highlight the potential of aerobic exercise for individuals struggling to fall asleep quickly. Aerobic exercise also appears to improve sleep efficiency, the percentage of time spent asleep in bed. Reid et al. (2010) conducted a study on older adults with insomnia, demonstrating that participants who engaged in regular aerobic exercise experienced significant increases in sleep efficiency compared to the control group (18). Likewise, Ezati et al. (2020) observed improvements in sleep efficiency among female student dormitory residents following participation in a regular aerobic exercise program (16). These studies suggest that aerobic exercise can promote a more consolidated sleep pattern, reducing nighttime awakenings and improving overall sleep quality. Subjective sleep quality reports, which rely on individuals' self-reported perceptions of their sleep, further support the beneficial effects of aerobic exercise. Studies by Singh et al. (1997) and Driver and Taylor (2000) reported significant improvements in subjective sleep quality among participants engaging in regular aerobic exercise programs (2, 10). These findings suggest that individuals engaging in aerobic exercise perceive their sleep to be deeper, more restorative, and more satisfying. The mechanisms underlying the positive impact of aerobic exercise on sleep quality are not fully understood, but several potential pathways have been proposed. Exercise can promote relaxation and reduce stress hormones like cortisol, which can interfere with sleep initiation and maintenance (14). Additionally, aerobic activity may enhance the production of brain chemicals like serotonin, contributing to feelings of calmness and well-being, ultimately leading to better sleep (14). Furthermore, exercise can help regulate body temperature, a crucial factor for sleep initiation. As body temperature decreases after exercise, it can signal the body to prepare for sleep (15).

In conclusion, a compelling body of evidence supports the positive impact of aerobic exercise on sleep quality. Engaging in regular moderate-intensity aerobic exercise appears to reduce sleep onset latency, improve sleep

efficiency, and enhance subjective sleep quality across various populations. While the precise mechanisms remain under investigation, potential pathways involve stress reduction, neurotransmitter production, and body temperature regulation. Given the significant public health burden of sleep disturbances, incorporating moderate-intensity aerobic exercise into daily routines offers a safe, effective, and accessible strategy for promoting better sleep and overall well-being.

#### 4. Exploring the Effects of Resistance Training on Sleep

Resistance training, a form of exercise that builds muscle strength and endurance, is emerging as a potential tool for improving sleep quality, particularly for older adults and individuals with chronic conditions (11, 20). While aerobic exercise has traditionally received more attention in this area, research on resistance training's impact on sleep is growing. A key strength of resistance training for sleep appears to be its ability to improve sleep onset latency, the time it takes to fall asleep. Kovacevic et al. (2018) conducted a systematic review of randomized controlled trials and found evidence suggesting that resistance training can reduce sleep onset latency (20). This aligns with the findings of a pilot study by Ferris et al. (2005) which demonstrated improved sleep onset latency in older adults following resistance training (21). These findings suggest that resistance training may be beneficial for individuals struggling to fall asleep quickly. The impact of resistance training on sleep efficiency, the percentage of time spent asleep in bed, is less clear. While some studies, like those by Faria et al. (2009), observed positive changes in sleep efficiency with resistance training (22), further research is needed to confirm these findings across diverse populations (20). Subjective sleep quality reports offer additional insights. Studies by Silva-Batista et al. (2017) on Parkinson's disease patients and Ferris et al. (2005) on older adults reported significant improvements in subjective sleep quality following resistance training interventions (11). These findings suggest that resistance training may be particularly beneficial for populations struggling with sleep disturbances. The exact mechanisms by which resistance training might improve sleep remain under investigation. One possibility is that the muscle repair and growth processes stimulated by resistance training may promote fatigue and a greater need for sleep (20). Additionally, resistance training may enhance sleep quality by reducing stress and anxiety, similar to aerobic exercise (20). It's

important to note that some studies, such as the one by Alley et al. (2015), suggest that the timing of resistance training may influence sleep outcomes (23). However, more research is needed to draw definitive conclusions (20). In conclusion, evidence suggests that resistance training has the potential to improve sleep quality, particularly for specific populations. It may improve sleep onset latency and subjective sleep quality, potentially through mechanisms involving muscle repair processes and stress reduction. Although the research base is not as extensive as for aerobic exercise, and the optimal timing of resistance training sessions remains to be fully elucidated, resistance training appears to be a promising tool for promoting better sleep and overall well-being. Further research is needed to fully understand the mechanisms at play and explore the generalizability of these findings across diverse populations.

#### 5. High-Intensity Interval Training (HIIT) and Sleep: A Balancing Act

High-Intensity Interval Training (HIIT), characterized by intense bursts of activity followed by short rest periods, has become a popular fitness trend. While its effectiveness in boosting cardiovascular health and fitness is well-established, the influence of HIIT on sleep remains a topic of ongoing research with mixed findings (24, 25). Some studies suggest that HIIT can be beneficial for sleep. For instance, a review by Min et al. (2021) found that HIIT interventions were associated with improvements in overall sleep quality (23). Similarly, Jahrami et al. (2022) observed positive changes in sleep quality among patients with depressive disorders following eight weeks of HIIT (26). These findings suggest that HIIT may be a valuable tool for promoting better sleep in certain populations. However, the intensity and duration of HIIT workouts appear to be crucial factors. Studies like the one by Bullock et al. (2020) suggest that exceeding recommended intensity levels or durations during HIIT sessions might have negative consequences for sleep quality in older adults (25). This aligns with concerns raised in fitness communities regarding excessive HIIT leading to overexertion and sleep disturbances (12).

There's also evidence that HIIT can be beneficial for specific sleep disorders. Karlsen et al. (2017) observed improvements in obstructive sleep apnea (OSA) symptoms following HIIT intervention (12). This finding highlights the potential of HIIT as a complementary therapy for managing certain sleep conditions. Overall, the relationship between HIIT and sleep appears to be dose-dependent. Moderate intensity and duration HIIT programs may promote better

sleep, particularly for specific populations. However, exceeding recommended training parameters or engaging in HIIT too close to bedtime could have negative impacts. Further research is needed to definitively establish the optimal HIIT training protocols for sleep benefits across diverse populations. In the meantime, consulting with a healthcare professional or certified trainer can help individuals determine the most appropriate HIIT program to incorporate into their routines without compromising sleep quality.

## 6. The Science Behind Exercise-Induced Sleep Improvement: A Multifaceted Approach

Exercise is a powerful tool for promoting overall health and well-being, and its positive influence on sleep quality is well-documented by research (2, 5, 6). But how exactly does exercise promote better sleep? The answer lies in a complex interplay of physiological and psychological mechanisms.

Stress hormones and neurotransmitters play a key role. Regular exercise has been shown to reduce stress hormones like cortisol, which can interfere with sleep (3, 14). Conversely, exercise promotes the release of mood-boosting neurotransmitters like serotonin, which can contribute to feelings of calmness and relaxation, facilitating sleep onset (14). Studies by Lederman et al. (2019) and Singh et al. (1997) support this connection between exercise-induced reductions in stress hormones and improved sleep quality, particularly in individuals with mental health conditions (2, 3). Body temperature regulation also appears to be a crucial factor. Exercise elevates core body temperature, and as our body temperature drops afterward, it can signal sleepiness and prepare the body for sleep (15, 16). Research by Horne and Staff (1983) suggests that this post-exercise core temperature decrease may play a significant role in promoting sleep (15). The type, intensity, and timing of exercise can also influence sleep outcomes. Moderate-intensity aerobic exercise seems to be most beneficial for sleep across various populations (5, 16-19). Studies by King et al. (2008), Reid et al. (2010), and Wang et al. (2014) all observed improvements in sleep quality following moderate-intensity aerobic exercise interventions (17-19). However, the timing of exercise is important. Engaging in vigorous exercise too close to bedtime may have disruptive effects due to the elevated body temperature it causes (8, 13). Myllymäki et al. (2011) observed negative impacts on sleep quality when vigorous exercise was performed late at night (8). While research on the effects of resistance training on sleep is less extensive, some studies suggest potential

benefits. Resistance training may improve sleep quality by promoting muscle repair and growth processes, leading to greater fatigue and a need for sleep (20). Ferris et al. (2005) observed positive changes in sleep quality among older adults following resistance training (11). However, the optimal timing and intensity of resistance training for sleep benefits remain areas of ongoing investigation (23). The research on HIIT offers a more nuanced picture. HIIT can be beneficial for sleep, particularly moderate-intensity programs, as suggested by Min et al. (2021) (24). However, exceeding recommended intensity or duration levels may disrupt sleep due to the physiological stress it can cause (25). Jahrami et al. (2022) observed improvements in sleep quality with HIIT in individuals with depression, but it's important to note that this population may have different sleep characteristics compared to healthy adults (26).

In conclusion, exercise promotes better sleep through a combination of factors, including stress hormone reduction, neurotransmitter release, and body temperature regulation. Moderate-intensity aerobic exercise appears to be most consistently beneficial, with timing being a crucial factor. While resistance training and HIIT may also offer sleep benefits, more research is needed to determine the optimal training parameters for different populations. Consulting with a healthcare professional or certified trainer can help individuals design an exercise program that promotes both physical and sleep health.

## 7. Exercise as a Sleep Remedy for Diverse Populations

Exercise is a powerful and non-pharmaceutical intervention for promoting better sleep across various populations (2, 5, 6). Research suggests that the benefits of exercise on sleep extend to adults, older adults, adolescents, and even individuals with specific health conditions (3, 11, 16, 17).

**Older Adults:** For older adults experiencing sleep disturbances, moderate-intensity aerobic exercise seems to be particularly effective (16-19). Studies by King et al. (2008) and Reid et al. (2010) observed significant improvements in sleep quality among older adults with insomnia following moderate-aerobic exercise programs (17, 18). Resistance training may also be beneficial for older adults, with some evidence suggesting improved sleep quality (Ferris et al., 2005) (11). However, more research is needed to determine the optimal types and timing of resistance training for sleep benefits in this population (23).

**Adolescents:** Similar to adults, adolescents can experience sleep problems due to academic stress, social pressures, and changes in biological rhythms (1). Desjardins and Tanguay-Labonté (2018) highlight the potential of physical activity to improve sleep quality in adolescents, although the specific mechanisms need further investigation (1).

**Individuals with Health Conditions:** For individuals with mental health conditions like depression, exercise offers a promising non-pharmacological approach to improve sleep. Lederman et al. (2019) found that exercise interventions were associated with better sleep quality in individuals with mental illness (3). Similarly, Jahrami et al. (2022) observed improvements in sleep quality among patients with depression following HIIT (26). It's important to note that the sleep characteristics of individuals with depression may differ from healthy adults, and further research is needed to understand the optimal exercise strategies for this population.

**Exercise as a General Treatment for Insomnia:** Across diverse populations, exercise has emerged as a first-line treatment for insomnia. Research by Xie et al. (2021) suggests that exercise interventions are effective in improving sleep quality and reducing insomnia symptoms in adults (5). Similarly, Singh et al. (1997) observed positive changes in sleep patterns among adults with insomnia following an exercise program (2).

**Optimizing Exercise for Sleep:** While most studies support the benefits of exercise for sleep, the type, intensity, and timing of exercise can influence outcomes. Moderate-intensity aerobic exercise appears to be most consistently beneficial (16-19). Engaging in vigorous exercise too close to bedtime may disrupt sleep due to its effects on body temperature (8, 13). Resistance training may also offer benefits, but more research is needed to determine optimal parameters (20, 23). HIIT may be a viable option for some populations, but exceeding recommended intensity levels can have negative consequences for sleep (24, 25).

In conclusion, exercise is a safe and effective non-pharmacological intervention for promoting better sleep across diverse populations. Consulting with a healthcare professional or certified trainer can help individuals design an exercise program that addresses their specific needs and promotes both physical and sleep health.

## 8. Optimizing Exercise for Sleep: A Tailored Approach

Exercise is a powerful tool for promoting better sleep, but for maximum benefit, tailoring the type, intensity, and timing of exercise to individual needs is crucial (4, 9, 10). Healthcare professionals can play a key role in guiding patients towards an exercise routine that optimizes sleep quality.

## 9. Type of Exercise

**Moderate-Intensity Aerobic Exercise:** Research consistently shows that moderate-intensity aerobic exercise is the most effective type for improving sleep quality across various populations (16-19). Activities like brisk walking, swimming, or cycling for 30 minutes most days of the week are excellent options (16).

**Resistance Training:** While evidence is less extensive, resistance training may also benefit sleep by promoting muscle repair and growth, leading to greater fatigue and a need for sleep (20). Studies by Ferris et al. (2005) suggest potential improvements in sleep quality among older adults following resistance training programs (11).

**High-Intensity Interval Training (HIIT):** HIIT can be a viable option for some individuals, particularly moderate-intensity programs as suggested by Min et al. (2021) (24). However, exceeding recommended intensity or duration can disrupt sleep due to the physiological stress response (25). More research is needed to determine the optimal role of HIIT in sleep improvement for different populations.

## 10. Intensity of Exercise

The intensity of exercise significantly impacts sleep outcomes. Moderate-intensity exercise, where you can comfortably hold a conversation, seems to be the sweet spot for promoting sleep (4, 10). Very vigorous exercise too close to bedtime can elevate core body temperature and disrupt sleep onset, as observed in Myllymäki et al. (2011) (8).

## 11. Timing of Exercise

When you exercise can significantly influence its impact on sleep. Ideally, schedule exercise sessions earlier in the day to allow for your core body temperature to return to baseline before bedtime (15). However, some studies suggest that even evening workouts may not disrupt sleep in certain populations, like endurance athletes (Thomas et al., 2020) (13). Consulting with a healthcare professional can

help individuals determine the optimal timing of exercise based on their fitness level and sleep patterns.

## 12. Recommendations for Healthcare Professionals

Healthcare professionals can effectively utilize exercise as a non-pharmacological intervention for sleep problems by:

**Assessing individual needs:** Considering factors like age, health conditions, current activity level, and sleep disturbances is crucial for tailoring an exercise program (3, 11).

**Providing education:** Educating patients on the connection between exercise and sleep, along with the different types, intensity, and timing considerations, empowers them to make informed choices (9, 10).

**Developing a personalized plan:** Collaborate with patients to design an exercise program that is safe, enjoyable, and fits their lifestyle and sleep schedule (4).

**Monitoring progress:** Regularly monitor sleep patterns and adjust the exercise program as needed to ensure continued benefits (5, 6).

By incorporating these considerations, healthcare professionals can leverage the power of exercise to help individuals achieve better sleep and improve overall health and well-being.

## 13. Future Research Directions

Scientific evidence shows exercise improves sleep, but there's room for improvement when it comes to tailoring exercise routines for different people. Here's how future research might help us get the best sleep possible through exercise. One area of focus will be figuring out the ideal exercise mix. Researchers might explore how combining aerobic exercise, weight training, and high-intensity training benefits different groups of people and addresses specific sleep issues. For example, they could see how these combinations impact different sleep stages or help people who struggle with insomnia or frequent awakenings.

Current research often looks at the short-term effects of exercise on sleep. To get a clearer picture, scientists will explore how exercise continues to improve sleep quality over extended periods. This long-term research will help us understand the lasting impact of exercise on sleep. Another key area of investigation is the "dosage" of exercise for optimal sleep. Researchers will delve into how factors like exercise frequency, duration, and intensity influence sleep

outcomes in various populations. This will help us determine the ideal amount of exercise for different people to get the best sleep benefit.

While some research exists on exercise and sleep for older adults and people with mental health conditions, there's a gap in knowledge for other groups. Future studies could examine the best exercise strategies for children, teenagers, pregnant women, and individuals with specific chronic health problems. Understanding the "why" behind exercise and sleep is also important. Research will explore the biological and psychological mechanisms at play. This could involve studying how exercise affects stress hormones, brain chemicals, body temperature regulation, and other factors that influence sleep. The future might involve personalized exercise plans based on your unique sleep profile. Researchers could explore creating exercise routines tailored to your individual sleep patterns, natural sleep-wake tendencies (chronotype), and even genetics. This would allow for highly targeted exercise programs to maximize sleep improvement. Finally, wearable technology and sleep trackers hold promise for optimizing sleep through exercise. By monitoring your sleep and providing feedback on how your exercise choices affect your sleep quality, this technology could become a valuable tool in your sleep health journey.

By addressing these areas of future research, we can refine our understanding of how exercise improves sleep and develop more effective and personalized exercise strategies to help everyone achieve better sleep.

## 14. Conclusion

Exercise is a powerful and safe non-pharmacological intervention for promoting better sleep across diverse populations. Research suggests that moderate-intensity aerobic exercise is most consistently beneficial, with resistance training and potentially HIIT offering additional possibilities depending on the individual. Optimizing the type, intensity, and timing of exercise based on individual needs and sleep patterns is crucial for maximizing benefits. Healthcare professionals can play a vital role by guiding patients towards personalized exercise programs that promote sound sleep and improve overall health.

Future research should delve deeper into refining exercise recommendations for specific populations, understanding the long-term effects of exercise on sleep, and exploring the underlying mechanisms at play. The development of personalized exercise prescriptions and the integration of

wearable technology hold promise for further optimizing sleep health through exercise interventions. By harnessing the power of exercise, we can empower individuals to achieve better sleep and unlock a multitude of health benefits.

### Authors' Contributions

P. G. conceptualized and conducted a systematic search across scholarly databases to explore the influence of exercise on sleep quality, synthesizing findings from studies published over the past decade. P. I. supervised the review process, provided critical insights into interpreting the results, and contributed to drafting and revising the manuscript. Both authors critically reviewed and approved the final version of the manuscript for publication.

### Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

### Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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### Declaration of Interest

The authors report no conflict of interest.

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### References

- Desjardins S, Tanguay-Labonté M. The Effects of Physical Activity on Sleep among Adolescents and Adults: A Narrative Review. *Journal of Sleep and Sleep Disorder Research*. 2018;1(2):42-59. [DOI]
- Singh NA, Clements KM, Fiatarone MA. A Randomized Controlled Trial of the Effect of Exercise on Sleep. *Sleep*. 1997;20(2):95-101. [PMID: 9143068] [DOI]
- Lederman O, Ward PB, Firth J, Maloney C, Carney R, Vancampfort D, et al. Does exercise improve sleep quality in individuals with mental illness? A systematic review and meta-analysis. *Journal of Psychiatric Research*. 2019;109:96-106. [PMID: 30513490] [DOI]
- Taylor SR. The influence of exercise on sleep quality. *International SportMed Journal*. 2001;2(3):1-10.
- Xie Y, Liu S, Chen X-J, Yu H-H, Yang Y, Wang W. Effects of Exercise on Sleep Quality and Insomnia in Adults: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Frontiers in Psychiatry*. 2021;12. [PMID: 34163383] [PMCID: PMC8215288] [DOI]
- Banno M, Harada Y, Taniguchi M, Tobita R, Tsujimoto H, Tsujimoto Y, et al. Exercise can improve sleep quality: a systematic review and meta-analysis. *PeerJ*. 2018;6:e5172. [PMID: 30018855] [PMCID: PMC6045928] [DOI]
- Youngstedt SD. Effects of Exercise on Sleep. *Clinics in Sports Medicine*. 2005;24(2):355-65. [PMID: 15892929] [DOI]
- Myllymaki T, KYRÖLÄINEN H, SAVOLAINEN K, HOKKA L, JAKONEN R, JUUTI T, et al. Effects of vigorous late-night exercise on sleep quality and cardiac autonomic activity. *Journal of Sleep Research*. 2011;20(1pt2):146-53. [PMID: 20673290] [DOI]
- Uchida S, Shioda K, Morita Y, Kubota C, Ganeko M, Takeda N. Exercise Effects on Sleep Physiology. *Frontiers in Neurology*. 2012;3. [PMID: 22485106] [PMCID: PMC3317043] [DOI]
- Driver HS, Taylor SR. Exercise and sleep. *Sleep Medicine Reviews*. 2000;4(4):387-402. [PMID: 12531177] [DOI]
- Ferris LT, Williams JS, Shen CL, O'Keefe KA, Hale KB. Resistance training improves sleep quality in older adults a pilot study. *Journal of sports science & medicine*. 2005;4(3):354.
- Alarcón-Gómez J, Chulvi-Medrano I, Martín-Rivera F, Calatayud J. Effect of High-Intensity Interval Training on Quality of Life, Sleep Quality, Exercise Motivation and Enjoyment in Sedentary People with Type 1 Diabetes Mellitus. *International Journal of Environmental Research and Public Health*. 2021;18(23):12612. [PMID: 34886337] [PMCID: PMC8656786] [DOI]
- Thomas C, Jones H, Whitworth-Turner C, Louis J. High-intensity exercise in the evening does not disrupt sleep in endurance runners. *European Journal of Applied Physiology*. 2020;120(2):359-68. [PMID: 31813044] [PMCID: PMC6989626] [DOI]
- Irandoust K, Taheri M. Effect of a high intensity interval training (HIIT) on serotonin and cortisol levels in obese women with sleep disorders. *Women's Health Bulletin*. 2019;6(1):1-5. [DOI]
- Horne JA, Staff LHE. Exercise and Sleep: Body-Heating Effects. *Sleep*. 1983;6(1):36-46. [PMID: 6844796] [DOI]
- Ezati M, Keshavarz M, Barandouzi ZA, Montazeri A. The effect of regular aerobic exercise on sleep quality and fatigue among female student dormitory residents. *BMC Sports Science, Medicine and Rehabilitation*. 2020;12(1):44. [PMID: 32774864] [PMCID: PMC7405354] [DOI]
- King AC, Pruitt LA, Woo S, Castro CM, Ahn DK, Vitiello MV, et al. Effects of Moderate-Intensity Exercise on Polysomnographic and Subjective Sleep Quality in Older Adults With Mild to Moderate Sleep Complaints. *The Journals of Gerontology: Series A*. 2008;63(9):997-1004. [PMID: 18840807] [PMCID: PMC7182081] [DOI]
- Reid KJ, Baron KG, Lu B, Naylor E, Wolfe L, Zee PC. Aerobic exercise improves self-reported sleep and quality of life in older adults with insomnia. *Sleep Medicine*. 2010;11(9):934-40. [PMID: 20813580] [PMCID: PMC2992829] [DOI]



19. Wang X, Youngstedt SD. Sleep quality improved following a single session of moderate-intensity aerobic exercise in older women: Results from a pilot study. *Journal of Sport and Health Science*. 2014;3(4):338-42. [PMID: 25685605] [PMCID: PMC4326238] [DOI]
20. Kovacevic A, Mavros Y, Heisz JJ, Fiatarone Singh MA. The effect of resistance exercise on sleep: A systematic review of randomized controlled trials. *Sleep Medicine Reviews*. 2018;39:52-68. [PMID: 28919335] [DOI]
21. Silva-Batista C, de Brito LC, Corcos DM, Roschel H, de Mello MT, Piemonte MEP, et al. Resistance Training Improves Sleep Quality in Subjects With Moderate Parkinson's Disease. *The Journal of Strength & Conditioning Research*. 2017;31(8):2270-7. [PMID: 27787472] [DOI]
22. Faria APd, Cavagnoli DA, Ferreira SE, Bittencourt LRA, Tufik S, Mello MTd. Effects of resistance exercise on the sleep patterns of sedentary individuals. *Sleep science*. 2009;2(3):141-6.
23. Alley JR, Mazzochi JW, Smith CJ, Morris DM, Collier SR. Effects of Resistance Exercise Timing on Sleep Architecture and Nocturnal Blood Pressure. *The Journal of Strength & Conditioning Research*. 2015;29(5):1378-85. [PMID: 25426516] [DOI]
24. Min L, Wang D, You Y, Fu Y, Ma X. Effects of High-Intensity Interval Training on Sleep: A Systematic Review and Meta-Analysis. *International Journal of Environmental Research and Public Health*. 2021;18(20):10973. [PMID: 34682718] [PMCID: PMC8535574] [DOI]
25. Bullock A, Kovacevic A, Kuhn T, Heisz JJ. Optimizing Sleep in Older Adults: Where Does High-Intensity Interval Training Fit? *Frontiers in Psychology*. 2020;11. [PMID: 33192886] [PMCID: PMC7609693] [DOI]
26. Jahrami H, BaHamam AS, Stubbs B, Sabah A, Saif Z, Bragazzi NL, et al. Eight-week high-intensity interval training is associated with improved sleep quality and cardiorespiratory fitness in patients with depressive disorders. *Sleep and Breathing*. 2022;26(1):397-406. [PMID: 34046817] [DOI]