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Sleep hygiene: foundations, implications, and strategies for enhancing sleep health

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Abstract
Sleep hygiene is an array of behavioural and environmental practices that promote regular, sound and sufficient sleep. As sleep disorders such as insomnia, delayed sleep phase disorder and obstructive sleep apnea continue to rise in prevalence. The importance of sleep hygiene has even been recognized in non-clinical as well as clinical groups. This review discusses the biological need for sleep, defines components of adequate sleep hygiene, highlights evidence-based advantages of good sleep and examines compliance challenges. It also discusses sleep hygiene in certain populations such as adolescents, shift workers, and in those with mental health disorders. The review ends with a focus on public health and digital health interventions to enhance world sleep health.

Keywords Sleep behaviour, Circadian rhythm, Sleep health, Insomnia, Sleep-wake cycle, Sleep habits

Introduction

Sleep is an essential physiological process that is necessary for physical repair, cognitive functioning, emotion regulation, and metabolic homeostasis Baranwal et al. 2023. Sleep is a naturally reversible state of decreased self and environmental awareness and mental and physical inactivity Rutkowska et al. 2024. Sleep quality is required for memory formation, immune function, and emotional regulation Li et al. 2024. In our modern world, sleep deprivation and poor sleep quality are becoming more prevalent as a result of lifestyle changes, more screen time, and psychosocial stressors Nakshine et al. 2022. Sleep hygiene offers a non-pharmacological way to improve sleep quality using a daily plan and environmental changes. It can be used in the healthcare setting, but also among the general population Sella et al. 2023.

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Physiology and importance of sleep

Sleep architecture

Cycles of sleep include REM (rapid eye movement) and non-REM phases of sleep. Of non-REM sleep, there are three stages (N1, N2, and N3), the third being the deep sleep stage Le Bon 2021. In REM sleep, dreaming occurs and memory consolidation takes place. An average adult could have four to six complete sleep cycles per night. A sleep architect can map your sleep characteristics using sleep architecture, sleep depth, and sleep onset and offset Bloxham & Horton 2024. A hypnogram, a graph produced by electroencephalography (EEG), can show the cycle. In most situations, you should experience four or five distinct sleep cycles in an evening, with cycles lasting anywhere from about 90 min to two hours. Some of those cycles will contain all three NREM phases plus REM sleep, but not all cycles contain each phase Talukder et al. 2023. NREM stage 1 is a sleep phase where a

person is drifting into sleep and is accompanied by relaxing muscles, dropping body temperature, slow eye movements, and brain waves from an alpha state to mixed-frequency theta. This phase lasts approximately five to ten minutes, and it can occur several times overnight. The length of NREM 1 increases with age, which makes it more difficult to sleep, along with staying asleep Satapathy & Loganathan 2021. NREM stage 2 is a state of sleep where your brain is still monitoring and has K-complex wave and then rapid bursts of activity. This lasts between 10 min and 25 min; it is common for NREM stage 2 to last about half the night. This can alternate with REM sleep for much of the night, as long as there is no NREM stage 3. There are sleep spindles on the EEG, and those are thought to indicate the brain is organizing and consolidating memories after the brain has learned a lot of new information Spielman et al. 2021. NREM stage three sleep- deep sleeps or slow-wave sleep- is important for restorative sleep, memory, and creativity. During deep sleep, relaxation increases, pulse and breathing rate decrease, blood flow to the brain decreases, growth hormone is released for tissue repair, the immune system is more active, and brain waves are slow (delta waves) Marx-Dick C 2024. Deep sleep may last 40 min at the beginning of the night and will not necessarily occur with the later REM cycles. Typically, the transition from NREM 3 to REM is through NREM 2 and then REM Hauri PJ 2021.

Functions of sleep

Waste clearance & brain restoration Sleep is a critical element in the maintenance of physiological and metabolic homeostasis in the brain, via the influx of cellular waste and repair processes, through the lymphatic system Voumvourakis et al. 2023. Waste materials can be eliminated by the movement of interstitial fluid and CSF via the glymphatic system, a set of perivascular tunnels made by astrocytes. Cheng & Haorah 2019. Recent studies have shown that slow-wave sleep enhances CSF pulsations that improve the glymphatic system's ability to wash away waste materials Reddy & Werf 2020. Sleep deprivation may encourage the growth of tau and β-amyloid proteins which may accumulate in Alzheimer's disease. As well, sleep can help decrease ROS in neurons and restore mitochondrial functions Lv et al. 2022. While age and obesity may negatively affect CSF flow (and the efficiency of aquaporin-4 [AQP4] channels), there are other disrupting factors that impair clearance, such as sleep fragmentation or total sleep time (which can be altered in some degree by different sedations). Thus, it may be worth contemplating that establishing a regular sleep-wake schedule may act as a preventative form, considering long-term brain health Mader & Brimberg 2019. In summary, the extent of the glymphatic system to detoxify the brain functionally is dependent on sleep, especially deep slow-wave sleep (SWS). Overall, memory loss and cognitive decline related to aging, and neurodegenerative conditions exhibit disorder of this clearance route van Hattem et al. 2025.

Memory consolidation & neural reorganization The hippocampus may "replay" sequences of neural activity that emerge during prior learning. The hippocampal replay of activity aids in reactivating hippocampal cortical synapses with the slow oscillations of the cortex and spindles Pfeiffer 2020. An external stimulation to prefrontal cortex synapses that is precisely timed with medial temporal lobe slow waves improves oscillatory coupling in the cortex and improves the memory of a task Palacino et al. 2025. The use of closed loop stimulation improves memory performance by helping improve recognition memory and reduces false positives. Then, after being in states of NREM sleep, REM sleep decreases overall neural activity by reducing firing in the brain while also allowing for global downscaling of synaptic activity in a manner that optimizes what synapses are pruned on Ezzyat et al. 2018. fMRI research has shown that sleep enhances activation in the hippocampus and motor cortex following motor learning. TMS studies on motor learning have shown changes in prefrontal areas, ventral striatum, and cerebellum; mirroring the results seen with fMRI Lequerica et al. 2025. Finally, both NREM replay and REM aided spontaneous activity facilitate the reorganization of representations once the influence of contextual boundaries are relaxing, while allowing representations to remain stable but flexible among neural networks. Using cued targeted memory reactivation (TMR) during sleep, particularly cued slow oscillation and spindle activity in NREM sleep, led to improvements in outcomes during post-EMDR therapy, without disrupting the sleep opportunity Shuster et al. 2025.

Metabolic & mitochondrial homeostasis Studies found in Drosophila highlight that in daily flux of mitochondrial turnover in neurons and glia provides by sleep, with mitophagy peaking and decreasing in sleep deprivation. Sleep deprivation impacts mitochondrial gene and protein expressions, mitochondrial structure, and enzyme activity in both humans and animals Mauri et al. 2022. The Parkin pathway is still central in mitochondrial turnover; however, novel pathways have been discovered, most are already termed for sleep to clean up mitochondria Wu et al. 2021. Energy metabolism, including: AMPK, ketones, fasting, were considered associated with sleep and mitochondrial clean up Townsend & Steinberg 2023. Melatonin contributes to mitophagy initiation, and work on maintaining a balance in mitochondrial fission-fusion in models such as: sepsis, excitotoxicity, cardiovas-

cular injury, and neurotoxicity Rahmani et al. 2024. Lastly, other modalities to stimulate mitophagy, such as, metformin, ketone supplementation, and small molecules which target TFEB or SQSTM1, have led to the activation of mitophagy to enhance or preserve cell survival, and block aging or neuronal stress Qin et al. 2024.

Importantly, the circadian and sleep-wake cycles orchestrate organ-specific metabolic rhythms. In the liver, circadian genes regulate mitochondrial respiration, lipid metabolism, and detoxification processes, synchronizing with feeding-fasting cycles. The kidneys exhibit rhythmic expression of transporters and enzymes that govern electrolyte balance and filtration, both modulated by sleep-wake timing. Similarly, the heart's mitochondrial efficiency, redox state, and susceptibility to ischemic stress fluctuate with circadian signals and sleep quality. Disruption of these rhythms via sleep deprivation, shift work, or circadian misalignment has been linked to metabolic syndrome, renal dysfunction, and cardiovascular disease.

Together, these findings illustrate that sleep and circadian rhythms are not merely passive states but active regulators of mitochondrial quality control and metabolic stability across critical organ systems.

Immune function The immune function is reliant on sleep, which may regulate both adaptive immunity and innate immunity. Sleep, and in particular slow-wave sleep, enhances the communication and functional outcomes between T cells and antigen presenting cells, and provides a supportive background for antigen presentation and T cell proliferation Singh et al. 2024. Chronic sleep restriction or poor sleep quality has been associated with increased systemic inflammation, which appears to be a contributory factor to chronic inflammatory diseases. Furthermore, sleep supports immunological memory, which may increase the chances of adequate antibody responses to vaccination, especially for hepatitis and influenza Ditmer et al. 2021. Measures of sleep quality are associated with an increased risk of autoimmune disease such as lupus and rheumatoid arthritis Boeselt et al. 2019. Consider immune cells as conveyer belts, and if the coordination and functioning of the immune cells are misaligned there may be a higher risk of viral disease, as in the case of COVID-19. Investigations are on-going to develop ways to improve patient's quality of sleep in a manner that may improve the efficacy of the various cancer immunotherapy methods Poyen FB 2021. It has also been shown that the quality of sleep can predict the degree of severity of viral disease, even in the case of vaccine-mediated protection Jacob et al. 2020.

Emotional & psychological health Both sleep and sleep specifically in REM is important for regulating emotions and connecting the brain. Lack of sleep can exacerbate amygdala reactivity and disrupt the connection between the amygdala, which can control emotion, with the prefrontal cortex, relevant in impulse control and modulating negative emotions like anger or fear Lefter et al. 2022. Chronic sleep distress is at risk for depression and anxiety, and they are the most sleep-disturbed individuals; insomnia symptoms are likely to develop depression within 12 months (3 times more likely than those who did or do not have insomnia symptoms) Nguyen et al. 2022.

Treatment with CBT-I, Cognitive Behavioural Therapy, can provide better outcomes for improved sleep quality than pharmacotherapy for effecting anxiety and depressive symptomology Alimoradi Z VV et al. 2022. Sleep is important to coping with stress and resilience - sleep quality operates to moderate our HPA (hypothalamic-pituitary-adrenal) axis. The physiologic effects of sleep quality can make a difference in moderating whether and to what extent sleep does impact on (psychological) stress resilience Lo Martire et al. 2024.

REM sleep is important for emotional memory consolidation; painful memories can be kept and experience less intense (remotely-felt). Research suggests that sleep fragmentation, waking at night, can lead to increased suicidal ideation, as it has for some adolescents, or patients struggling with bipolar disorder Comsa et al. 2022.

Epigenetic regulation Because it impacts gene expression without impacting the DNA itself, sleep is crucial for epigenetic regulation. Studies have shown that various epigenetic processes, such as DNA methylation, histone modification, and non-coding RNAs, are affected by sleep duration, type, and architecture Gaine et al. 2018. The epigenetic regulation of DNA methylation patterns in genes associated with metabolism, stress response, and circadian rhythm can be altered by sleep deprivation. The lack of sleep creates long-term differences in immunity, where genes associated with inflammation are hypermethylated even in individuals that are otherwise healthy. The influence of sleep's impact on chromatin remodelling and histone modifications has received little attention Nilsson E et al. 2016. NREM sleep promotes histone acetylation in the prefrontal cortex and may play a role in memory consolidation and cognitive function, while lack of sleep decreased histone acetylation of BDNF – a critical neuroplasticity regulator. Sleep affects the expression of several mi-RNAs that are implicated in synaptic plasticity, metabolism and stress Wong et al. 2020. More recently, data suggest that sleep deprivation leads to an alteration in the expression of miR-132, miR-124, and miR-146a, which are all involved in neuro-inflammation or circadian control. Sleep strengthens memory not just functionally but epigenetically. REM sleep promotes epigenetic prim-

Table 1 Core components of sleep hygiene and their underlying concepts

Component	Conceptual Basis	Utility in Promoting Sleep	Reference
Consistent Sleep-Wake Schedule	Regulates circadian rhythms and aligns internal clock	Enhances sleep efficiency, reduces insomnia, improves mood and cognitive function	Lewis 2024; Dinis & Bragança 2018
Optimized Sleep Environment	Cool, dark, quiet settings promote melatonin secretion and sensory calm	Facilitates sleep onset and maintenance by minimizing environmental disruptions	Baranwal et al. 2023
Limiting Screen Time Before Bed	Screens emit blue light, which suppresses melatonin and delays circadian phase	Reduces sleep onset latency and improves REM sleep continuity	Dinis & Bragança 2018
Wind-Down Routine (e.g., reading, light stretching)	Prepares body and mind for rest by activating parasympathetic nervous system	Lowers physiological arousal, promotes relaxation, signals sleep readiness	Lewis 2024
Avoidance of Stimulants (e.g., caffeine, nicotine) and Heavy Meals Before Bed	Caffeine/nicotine stimulate CNS; heavy meals delay digestion and increase discomfort	Prevents delayed sleep onset, night awakenings, and disrupted sleep cycles	Baranwal et al. 2023
Moderate-Intensity Exercise (Habitual)	Improves sleep quality and increases sleep drive through energy expenditure	Facilitates deeper sleep stages (SWS), but timing is important to avoid overheating	Harding et al. 2019
Avoiding Late or Long Daytime Naps	Naps reduce sleep pressure; late naps can disrupt night time circadian alignment	Prevents fragmentation of night sleep and delayed bedtime	Harding et al. 2019

ing in genes associated with learning and synaptic plasticity Canoy et al. 2024.

Defining sleep hygiene

Sleep hygiene is a behavioural and environmental framework designed to promote better sleep quality. It is commonly used as part of cognitive-behavioural therapy for insomnia (CBT-I) but also serves as a preventive strategy for the general population McLaren et al. 2023.

Keeping a regular healthy sleep pattern includes good sleep hygiene. Good sleep hygiene includes keeping a consistent pattern, winding down prior to sleeping (about an hour before), creating a sleep enhancing sleep environment and avoiding stimulant consumption (such as alcohol and coffee) before sleeping Patel 2021. While irregular sleeping can interrupt the body's circadian rhythm, regular sleep is necessary for both the development and regulation of the body's natural sleep-wake cycle. Some ways to unwind before sleeping include reading, walking, taking a warm bath, and practicing relaxation techniques Pavlova 2017. To create a more dim, quiet, or cold environment, consider using blackout curtains, ear plugs, or a white noise machine Caddick et al. 2018. Generally speaking, maintaining a healthy lifestyle consuming the right foods, exercising, and scheduling fun or stress-reducing activities is the best way to enhance your sleep quality SANDUA D 2024.

Core principles of sleep hygiene

A collection of practices relating to both to environmental and behavioural matters, referred to as "sleep hygiene," effectively promotes good normal uninterrupted restorative sleep. These concepts are now being published and supported in newer literature that offers evidenced based interventions to avert insomnia and improve sleep quality for clinical and general populations Lewis 2024. A concise summary of each of the major sleep hygiene ideas are presented keeping sleep/wake schedules (Table 1); creating the right sleep environment; limiting screen time before sleeping; using a wind-down routine before bed; not consuming stimulants or large meals prior to sleeping; habitual moderate intensity exercise; avoiding daytime napping Baranwal et al. 2023.

Sleeping on a regular basis helps with sleep efficiency and strengthens circadian rhythms. Research indicates that inconsistent sleep schedules can contribute to depression and lower sleep quality among college students and working age adults. Because environments that promote sleep can enhance melatonin secretion and hygiene sensory environments; for adults and adolescents reducing screen time will postpone sleep onset and can reduce REM durations Dinis & Bragança 2018. Additionally, because naps longer than 30 min (especially when taken after 3PM) have been linked to poorer sleep quality and greater fragmentation at night, longer or late naps are a way to interfere with nocturnal sleep pressure Harding et al. 2019.

Methodology to assess sleep hygiene

Sleep hygiene was assessed using a combination of standardized self-report instruments and subjective behavioural evaluations. The Sleep Hygiene Index (SHI) developed by Mastin et al. 2006 was the primary tool employed, comprising 13 items that measure behaviours associated with poor sleep practices. Each item is rated on a Likert scale, with higher scores indicating poorer sleep hygiene. In addition to SHI, relevant components such as sleep duration, bedtime variability, screen time before sleep, caffeine/alcohol intake, and environmental conditions were evaluated through structured questionnaires and sleep diaries maintained over 1–2 weeks. Where applicable, Pittsburgh Sleep Quality Index (PSQI) was also used to assess overall sleep quality and disturbances, offering insight into how sleep hygiene practices

affect broader sleep outcomes. Quantitative data were statistically analyzed to identify associations between sleep hygiene practices and sleep quality indicators, while qualitative responses were coded thematically to identify behavioural patterns.

Evidence-based benefits of sleep hygiene

Sleep hygiene practices have been shown to have clear physiological, psychological and cognitive benefits, including cognitive performance, decreased anxiety, stress, and depression, better emotional regulation, and decreased risk of mood disorders Alimova et al. 2025. Studies have shown that individuals completing structured comprehensive sleep hygiene as a rehab program will demonstrate a decrease of 38% on anxiety and depressive scales. In addition, cognitive behavioural intervention (CBT-I) based on sleep hygiene practices showed a reduction in cortisol measures and stress levels, compared to text and mood self-monitoring, which improved in four weeks Barati & Amini 2022. Sleep hygiene and sleep hygiene practices have also shown great promise as both a preventative and treatment approach to insomnia, reducing sleep onset time, maximizing sleep duration, and sleep efficiency Chung et al. 2018. Research has indicated improved sleep onset and greater than 30% decreased total night awakenings of consistent sleep hygiene behaviours and bed times. Another beneficial aspect of good sleep hygiene is a stronger immune system, with improved antibody productions for hepatitis and influenza vaccinations. Following a 12 month study, the individuals that practiced good sleep hygiene had a 40% less risk for upper respiratory tract infections McAlpine et al. 2024. Good sleep hygiene can also enhance cardio metabolic health by decreasing the risk of obesity, type 2 diabetes, and hypertension Li et al. 2020. In one study, those with pre-diabetes had a significant association between sleep patterns and improvements in glucose regulation and a lower BMI. Consistent sleep wake cycles can also amplify melatonin production, and bring about normalization of core temperature cycles especially for shift workers Mostafa et al. 2022. Creating and maintaining good sleep hygiene is an effective, cost-effective, and accessible intervention that is well established with demonstrated health benefits across a wide range of health domains Billings et al. 2021.

Sleep hygiene in special populations

Diverse, distinct populations such as toddlers, adolescents, older adults, pregnant females and, anyone diagnosed with mental disorders or medical disorders (chronic pain, insufficiency) require tailored sleep hygiene recommendations Coleman et al. 2022. The current literature synthesizes and delineates the difficult situations that each population encounters and offers evidence-based suggestions to change. All children and babies have their own challenges with sleep such as the uncertainty of sleep, screen time, flexibility, and resistance to night time behaviours, etc. Various bedtime rituals, school based sleep education, and calming bedtime rituals can all be associated with sleep duration and sleep-onset latency Kitsaras 2019. Adolescents are subject to pressures that include many aspects of their lives not being regular. Irregular social schedules, excessive social media use, academic assignments, and delayed sleep phase are, arguably, all damaging to adolescents sleep patterns, health, and well-being. School based sleep education can help mitigate social jetlag and improve respiration metrics, as well as overall metrics. Older adults also have challenges, including but not limited to comorbidities, poly pharmacy, undesirable early morning awakenings, and sleeplessness Jiang et al. 2022. Cognitive-behavioural therapy (CBT) sleep hygiene interventions can lead to a reduction in the initiation of sedative medications and lead to a 30% improvement in sleep efficiency. Consistent activities and exposure to natural light may improve sleep duration and time for circadian alignment. Important challenges for pregnant women may include changes in hormonal function, being uncomfortable, anxiety, and nocturia. Mindfulness based sleep strategies should improve sleep satisfaction and should lower sleep latency (time to fall asleep) in their third trimester. Some challenges that people who have mental illness experience are circadian variation, hyperarousal and ruminating thoughts at night Kyle et al. 2023.

Barriers to good sleep hygiene

Sleep hygiene is something most important to our well-being; however, very few people are able to have good sleep hygiene practices because of psychological, social, technological, and environmental factors Leonidis et al. 2021. Psychological factors are defined as anxiety, rumination, or mental health issues that can result in hyperarousal due to a higher-than-average level of mental activity which also affects sleep initiation and maintenance. Some forms of technology use, whether excessive or from the perspectives of using screens (blue light exposure from devices, ease of access to social media) can now be identified as a barrier to healthy sleep Balter et al. 2025. Energy barriers refer to factors such as noise pollution, light pollution, or uncomfortable sleeping conditions that can disrupt sleep continuity. For example, shift workers and students with schedules that do not align with one's circadian rhythm can affect Melatonin cycles and ultimately decrease sleep duration. Similarly, there is a noticeable problem with sleep quality in a population of students that sleep at inconsistent times for various reasons Jackson & Gaston 2019. Socioeconomic and cultural barriers related to sleep hygiene may relate to the level

of sleep education, housing and structural safety, family responsibilities, and limited education on sleep practices. Some studies show low income families report poor sleep with inconsistent sleep timing and often report more than one person in the same bedroom that results in excessive noise and distractions. Furthermore, substance use, commonly, caffeine, alcohol, and nicotine might also impact sleep onset, fragmentation and sleep architecture Rottapel et al. 2020.

Integration with cognitive behavioural therapy for insomnia (CBT-I)

Cognitive Behavioural Therapy for Insomnia (CBT-I) is a non-pharmacological approach for chronic insomnia and sleep hygiene is a base level factor or foundational aspect of it. Recent research demonstrates that CBT-I that includes sleep hygiene improves success, accessibility, and sustainable outcomes. CBT-I includes five parts: sleep hygiene education, stimulus control therapy, sleep restriction therapy, cognitive therapy and relaxation training Park et al. 2024. Sleep hygiene education supports adherence with a number of the other CBT-I components. It also prepares individuals for engagement in a more intensive CBT-I components. CBT-I + sleep hygiene is efficient and effective for multiple populations, even when there are comorbid conditions. CBT-I + sleep hygiene shows improved sleep quality, and anticipated, with other mood symptoms compared to antidepressants alone Mellor et al. 2022. Technology-Enhanced CBT-I with sleep hygiene significantly enhances adherence to the program and gamified sleep hygiene recommendations resulted in a 40% reduction in insomnia severity index scores over 6 weeks El Rafihi et al. 2022. Improved sleep hygiene is associated with restoration of sleep architecture, as demonstrated by studies that involved behavioural sleep hygiene routines in conjunction and in collaboration with CBT-I Lah & Cao 2024.

Technological tools and sleep hygiene

Technology has a dual nature when it comes to sleep hygiene; digital overexposure via screens and devices, especially later in the evening, remains a barrier to sleep. However, well-constructed tools in the technology stratosphere can help monitor, manage, and regulate behaviours associated with sleep hygiene Premalatha 2024. Sleep tracking and wearable offers continued time measures in sleep, sleep efficiency, heart rate variability (HRV) and circadian rhythms respectively. In fact, wearable sleep trackers provide detection of sleep/wake cycles with an 80% accuracy rate in comparison to poly somnography, in which compared to overall sleep hygiene, capturing sleep or wake cycles would work as an indication for personalized recommendations for sleep hygiene De Zambotti et al. 2024. Mobile apps that target sleep hygiene, or include a full intervention of CBT-I, offer interactive sleep logs, guided relaxation, reminders for good sleep habits, as well as educational modules. Relaxation and mindfulness apps have shown promise in reducing pre-sleep arousal and improving stress-related insomnia. For example, in one study where college students used Calm application for 15 min nightly, they experienced less sleep onset latency and removed replaying thought patterns from the hour preceding going to sleep Erten Uyumaz et al. 2021. Smart lighting and natural environmental tools use natural light exposure patterns that are in synch with the body's natural circadian rhythms, with evening light exposure resulting in better alignment with recovery involving the melatonin circadian rhythm, and increased alertness during the daytime for shift workers. AI sleep coaching entails using machine-learning algorithms to provide users with feedback on sleep metrics, body temperature, and being behavioural Manfredini et al. 2023. Recently published research concluded AI sleep coaching with real time data improved overall sleep efficiency by 20% total and helped users build consistent sleep hygiene over a 30 day window, with a result of a modest decrease in night time wakefulness, delayed predicted nap compliance, delivered overall expected average bedtimes, and sleep quality improvement Liu et al. 2024.

Public health approaches and sleep hygiene promotion

Sleep hygiene is a priority for public health for a good reason: it has a direct impact on mental, physical and cognitive health. Poor sleep leads to chronic diseases, mental health disorders, accidents, and loss of economic productivity. The CDC and WHO now refer to sleep health as a public health determinant. As urbanized and shift-work societies continue to grow, sleep health is becoming even more important Chattu et al. 2018. School-based sleep education programs have been recommended to improve sleep health behaviours among children and adolescents. Sleep wellness programs carried out in the workplace have been recommended for shift workers, healthcare professionals and corporate staff, and have had a variety of presentations including sleep education workshops, the use of more optimal schedules, and fatigue management workshops Gaskin et al. 2024. There are ways for mass media or general community awareness campaigns to help people understand about sleep hygiene, particularly everything from radio or TV PSAs to social media campaigns, to infographics and SMS- based nudges. There are also community based-interventions using sleep hygiene workshops with community health workers and tailored outreach messages to those who are most under-resourced to promote sleeping equity Orozco-Olvera & Malhotra 2023.

Policy and environmental designs could also help reshape how environments support health-promoting sleep and could implementation tools such as better start times for school, controlling noise and light levels, and changing work hours. Recently, research findings show that delaying high school start times in three districts across the U.S. resulted in improved academic performance and a self-reported decrease in sleep disturbance by -18% Belmon et al. 2022.

Future directions and research gaps

Sleep hygiene has been recognized as an important concept in clinical and public health; however, its efficacy, customization, and implementation across populations have much to address. These issues include not taking into consideration individual differences that exists in circadian rhythms, chronotype, age or socio-cultural background in generic sleep hygiene recommendations Garbarino & Bragazzi 2024. Future directions should prioritize the development of "customized" sleep hygiene protocols with modernized use and technology including the use of wearable, AI models, and genome-based chronotyping to develop protocols for individuals who demonstrate atypical sleep behaviours. The biological basis for sleep hygiene's effects has not been fully elucidated, and, moving forward, future directions should consider neuroimaging and biomarkers to assess whether sleep promoting behaviours influence the microstructure of sleep and associated physiological stress response Saeed et al. 2025. Cultural and socioeconomic considerations are on-going, and the majority of sleep hygiene recommendations and guidelines have been developed from Western, educated, industrialized, rich, democratic (WEIRD) populations. There is also a dire need for technology infrastructure and advancement of integrated digital health technology, including smartphone or web-based applications, AI or machine learning, and gamification to help improve digital health adherence Bardhan 2022. Sleep hygiene recommendations have limited benefit alone, and subsequent future directions should direct randomized controlled trials to assess the independent versus combined effects of sleep hygiene embedded in multi-component interventions. Future directions should consider developmental age appropriateness for sleep hygiene strategies and whether they have beneficial impacts on mental, metabolic, and cognitive health at follow up Chandler et al. 2022.

Conclusion

Sleep hygiene is an essential element in developing and sustaining optimal sleep health for the remainder of our lives. Sleep hygiene consists of aspects related to maintaining a fixed sleep-wake pattern, limiting screen exposure, optimizing our sleep environments, and curtailing receptor stimulation. In this age of digital splendour, these aspects of sleep hygiene are undoubtedly critical. The evidence suggests that strong sleep hygiene practices lead to improved sleep duration and quality, lesser risk of chronic health conditions, and positive impacts on performance and mental toughness. Technology has unlocked new and innovative opportunities with wearable devices, sleep apps for smartphones, and artificial intelligence technologies that have the power of generating personalized sleep interventions. In terms of public health efforts, school-based education and workplace programs are vital in creating awareness of sleep hygiene; however, recent literature suggests the current mainly sleep hygiene interventions may only marginally help people chronic insomnia, along with/or co-morbid mental health problems. Future directions and studies would be enhanced with an inter-disciplinary approach planning that involved behavioural sciences, neurobiology, digital health, and public policy to create comprehensive, evidence-based public health initiatives. The enhancement of sleep hygiene is a shared responsibility extending to the health, education, technology, and public health sectors.

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