# A World of Daytime

## Analyzing Environmental Effects on Sleep

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## Abstract

There is less habituation of physiological responses to environmental stimuli during sleep than previously understood. According to the World Health Organization, every industrialized nation in the world is in a state of sleep epidemic (Walker, 2018). The National Sleep Foundation recommends seven to nine hours of sleep for adults. The average American gets less than six hours of sleep, according to many sources. This lack of sleep volume doubles the risk of death from heart disease and cancer, which coincidentally are the top two causes of death in the United States. Mental health and emotional intelligence are severely hindered with every lost hour of sleep. To make matters worse, sleepers are often unaware of the deficiency.

Inadequate, ineffective, or inappropriate sleep causes impaired cognitive function, debilitated memory formation, reduced brain function related to reward processing, diminished empathetic abilities and hampered emotional intelligence. During sleep, critical bodily functions occur, like cell repair, waste removal and muscle regeneration. Dreams assist in negotiating cognitive dissonance from waking experiences, maintaining a healthy psyche and a sane mind. The environment surrounding the sleep domicile greatly impacts the ability of the sleeper to achieve restorative sleep. Environmental factors may trigger the senses but can also subconsciously affect the brain through neural pathways. External stimuli set the sleep-wake rhythm and can have a profound affect an individual's ability to sleep effectively. To what extent light, sound and temperature affect sleep are examined in this paper.


*Keywords*: sleep, circadian rhythms, suprachiasmatic nucleus, light, temperature, sound

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**How does sleep work?**

"Circadian Rhythms are endogenous rhythms with a periodicity of approximately 24 h (24 +- 4 h). They are widespread and regulate most, if not all, of the major physiological systems in mammals. Circadian rhythms are unquestionably the most studied in the literature through other periods exist that range from milliseconds (i.e. ultradian rhythms, for which the period extends from milliseconds to 20 h) to a year (i.e. infradian rhythms, for which the period extends from 28 h to a year). Circadian rhythms are dependent on an internal clock located in the suprachiasmatic nucleus (SCN) of the anterior hypothalamus. Each of the paired suprachiasmatic nuclei is composed of a heterogeneous group of about 10,000 interconnected neurons that give rise to circadian rhythms through specific neuronal gene expression patterns and by the rate at which they fire action potentials" (Touitou, Reinberg, Touitou, 2016).

Human circadian rhythms are different with each person. The endogenous human sleep-wake circadian rhythm is usually longer than a day. It can vary from 20 to 28 hours, but, the average is 24.5. Circadian rhythms control everything in the body down to the cell. The Curtis Lab at the Royal College of Surgeons in Ireland focuses how the molecular clock controls the immune system (Curtis Lab, 2018). According to Curtis Lab, the body clock controls cells of the innate immune system, which is the first line of defense against infection. Just a year ago, three men won the Nobel prize for discovering how the human molecular biological rhythm is affected by the earth's revolutions. "Jeffrey C. Hall and Michael Rosbash, both then at Brandeis University in Massachusetts, and Michael W. Young of Rockefeller University did research that found an elaborate internal clock of genes and the cellular functions that DNA controls working together in much the same way the gears and springs in an old-fashioned timepiece do, with interconnected functions controlling one another" (NBC, 2017). Because human circadian rhythms are usually not 24 hours, they need to be reset to stay in synchronization with the 24 hour cycle of the earth. Every day, circadian rhythms will reset based on environmental, behavioral and social cues. The most reliable cue in the world is the sun. As the sun goes down each day, light and temperature reduction are detected by the human brain through neural pathways. At the end of each night, the sun rises; bringing with it more light and more heat.

Astronomical dawn is the point at which it becomes possible to detect light in the sky, when the sun is 18° below the horizon. Nautical dawn occurs at 12° below the horizon, when it becomes possible to see the horizon properly and distinguish some objects. Civil dawn occurs when the sun is 6° below the horizon and there is enough light for activities to take place without artificial lighting. These phases of dawn control the volume and rate of natural light available to the human eye in the morning. The total volume and timing of sunlight varies depending on which season of the year and what geographic location. Alaska, for example, can have less than four hours of daylight each day in December and more than 19 hours each day in June. When daytime and nighttime are not balanced, it is common for sleep efficiency to be affected.

Humans have many different hormones and chemicals that influence the body's physical responses. Throughout the day, humans build up the sleepiness neuromodulator, adenosine. As this chemical buildup increases, so does the desire to sleep. This buildup is often referred to as sleep pressure. If sleep pressure is too high, humans will uncontrollably experience micro-sleeps. This can happen at any time; for example: driving. Caffeine can block the receptors for five to six hours, but eventually the adenosine buildup returns with an increased level of influence. Once sleep is achieved, adenosine can begin dissipation. This is why afternoon naps can sometimes make sleep onset in the evening challenging. As environmental cues and adenosine direct the brain to begin the nightly sleep routine, the pineal gland releases melatonin. Melatonin signals the body to begin the incredible process of sleep where physiological repair and cognitive resolution occur. As sleep cycles progress, melatonin production reduces, and adenosine buildup dissipates causing shallower sleep. The eb and flow of adenosine is known as the sleep drive. Figure 1 shows how sleep drive, from adenosine, builds and dissipates in relationship to the circadian rhythm.

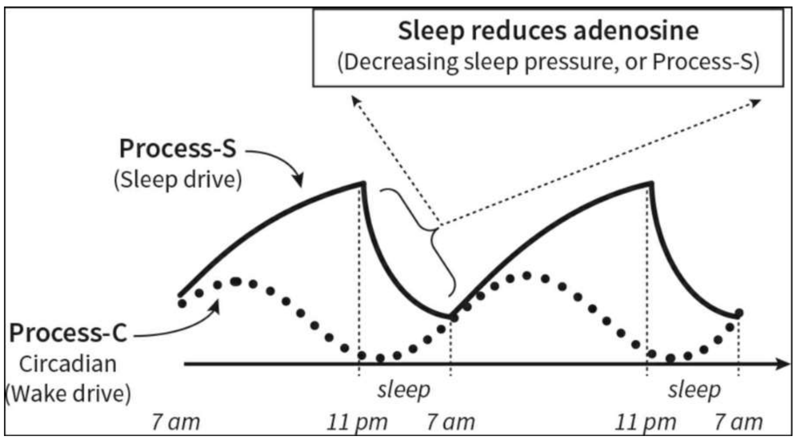



*Figure 1.* Adenosine levels in relationship to the circadian rhythm. Adapted from "Why we sleep: Unlocking the power of sleep and dreams" by Matthew Walker, PhD, 2018, p. 31 Copyright 2017 by Scribner.

Sleep occurs in cycles. Typically, a human will experience 4-5 cycles before awaking. A cycle can be measured by brain wave activity. Following sleep onset, the brain wave activity will drop immediately into NREM stage 4 sleep as pictured in figure 2. This is known as deep sleep or slow wave sleep (SWS). Deep sleep is also referred to as non-rapid eye movement (NREM) simply because it lacks eye movement. NREM stage 4 represents brainwave activity of less than 4 Hz. This activity is slow in comparison to the 20 Hz experienced while awake. Activity levels above 9 Hz usually mean consciousness. At around 90 minutes into the sleep cycle, brain activity increases dramatically. It will reach the Rapid-Eye-Movement (REM) stage rapid where flickering eye movement becomes visible. This increased brain activity can be correlated to dream activity. After approximately half an hour of REM, a new cycle will begin. This cyclic pattern will continue, becoming more and more shallow each time. Every sleep cycle is important, even the final and most shallow.

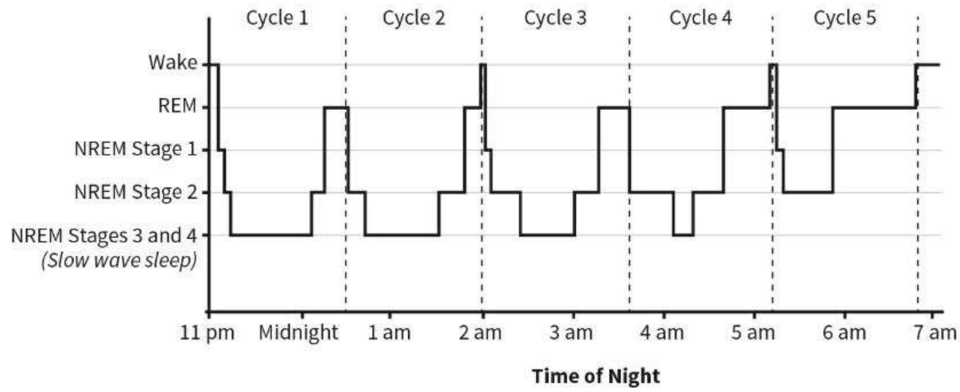



*Figure 2.* Normal sleep period containing five cycles. Adapted from "Why we sleep: Unlocking the power of sleep and dreams," by Matthew Walker, PhD, 2018, p. 43 Copyright 2017 by Scribner.

The diagram shown in figure 2 is called a hypnogram; achieved with polysomnography. Most notably, electroencephalography (EEG) measures the brainwave activity in Hz. Figure 3 compares different brainwave frequencies by Hz. EEG works like an oscilloscope recording the post-synaptic currents from cortical pyramidal cells. A complete EEG uses 256 electrode sensors placed in specific points along the scalp. New EEG technology has been able to retrieve accurate results with as few as four electrodes. Neuroverse Inc. has developed a novel EEG device the size of a credit card (Neuroverse, 2018). The Neuroverse device is placed on the forehead to passively monitor brainwave activity using the accompanying cell phone application.

As the sleeper moves through a sleep cycle, EEG can measure the frequency of the brain waves. After a baseline is established, an event related potential (ERP) test can show the response within the brain to certain stimuli. For example, the effectiveness of a vibrating bed can be measured using ERP. Sleep cycles can then be correlated to body temperature, melatonin and cortisol levels. The circadian rhythm of core body temperature is measured by the lowest point in a 24 hour period. Usually melatonin reaches its peak while body temperature is lowest. When the sleep period ends, melatonin has sharply decreased and is replaced by an increase in cortisol and body temperature.

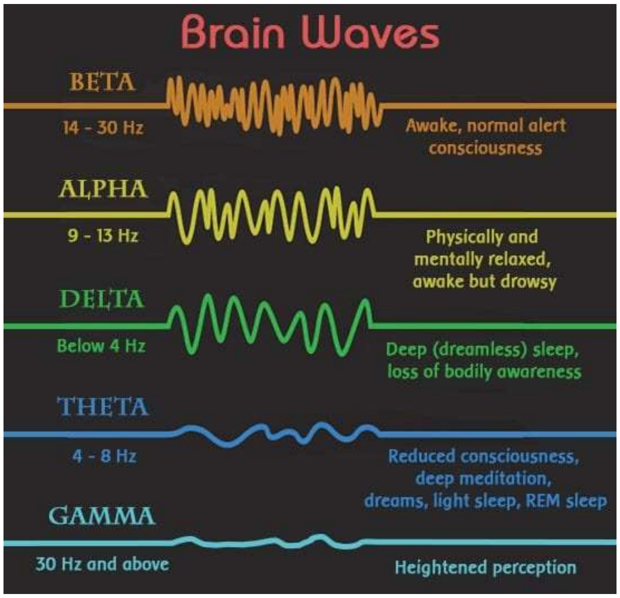



*Figure 3*. Brainwave activity measured in Hertz. Adapted from "What are brainwaves?," by The Meta-Center Chicago, 2018, Copyright 2018 by The Meta-Center.

**Sleep Health Statistics**

The United States is experiencing a sleep epidemic. For decades, shift workers have been exposed to unhealthy sleep cycles. Business people willingly force themselves into sleep deprivation to increase sales or profit margins. American culture carelessly associates a great deal of pride with sleep deprivation. The truth is, people who sleep deprive are shortening their life, dramatically. Quality of life begins to diminish, mentally and physically, with less than six hours of sleep consistently each night. Stress intolerance and depression can set in. To compound, humans cannot properly self-identify the symptoms of sleep deprivation. General feelings of fatigue are common, but measurements of degraded mental and physical performance can only be identified in a laboratory setting. To make matters worse, lost sleep throughout the week cannot be recovered by oversleeping on the weekend. The effects of one missed night of sleep can be measured months later.

Each year, more people are getting less sleep in the United States. According to the Centers for Disease Control and Prevention (CDC), one third of the population is getting less than seven hours of sleep. In a census report from the CDC, age cohort 45-54 had the highest number of reported short sleepers while Native Hawaiian/Pacific Islanders topped the charts. Almost a quarter of the short sleepers reported depression, which physicians know to be a contributor to bad sleep; a vicious cycle. The worst region in the US for sleep is the Appalachian Mountains, where in some areas nearly half of the people report less than seven hours sleep (CDC, 2014).

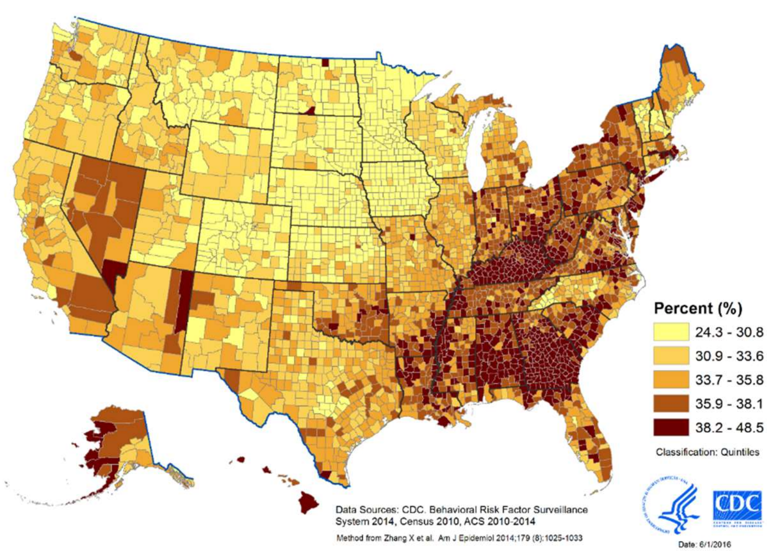


*Figure 4*. The prevalence of Short Sleep Duration for adults ≥ 18 Years, by County, US, 2014. Adapted from "Behavioral Risk Factor Surveillance System 2014," by Centers for Disease Control and Prevention, 2014, Copyright 2014 by CDC.

Sleep Score Max recently released data from its new sleep measurement device. The device, marketed by Dr. Oz and RESMED, has already recorded millions of nights of sleep. According to data from the Sleep Score Max and the Sleep Score App, 79% of people are getting less than seven hours of sleep in the United States. Women are getting an average of six hours and a nine minutes of sleep per night, while men are achieving five and three quarters (Sleep Score Labs, 2017). The device uses sonar, temperature and light to measure sleep within the bedroom of the user. This level of measurement is far more accurate than self-reported survey results conducted by government agencies, such as the CDC and the ASA. For this reason, sleep in the United States appears to be far worse than previously understood.

**Sleep Disorder Types**

According to the American Sleep Association, 50-70 million US adults have a sleeping disorder. That is roughly 30% of the 200 million Adults (of the nearly 330 million people) living in the United States. Over a third reported falling asleep during the day. Nearly 5% admitted this happened while driving, which accounts for 1,550 deaths per year in the United States. Another 40,000 are injured annually from drowsy driving. Over a third of all adults report getting short sleep every night. Short sleep durations are defined as less than seven hours of sleep. Thirty-seven percent of 20-39 year-olds report short sleep durations, while that number rises to 40% between ages 40-59 (ASA, 2018).

There are several types of sleep disorders, all resulting in reduced sleep efficiency. Sleep disorders can arise from a physiological problem or develop from a mental health challenge. In the case of mental health disorders, if sleep health improves, the mental disorder will usually also improve. The same is true for physical issues, like pain from inflammation. This cycle can often leave a sleeper confused as to the causality and solution of a sleep disorder. While there are sleep disorders that cannot be cured, many can be significantly improved. Often sleep challenges are treated with medications, which can further exacerbate the problem.

There are five main categories for sleep disorders: Insomnias, Sleep Related Breathing disorders, Hypersomnias, Parasomnias and Sleep Movement Disorders. Thirty percent of Americans suffer from insomnia, while 10% complain of chronic insomnia (ASA, 2018). Insomnia is when there is an inability to fall asleep or stay asleep as long as desired. Insomnia will cause all mental and physical faculties to degrade. Insomnia can be caused by allergies, gastrointestinal problems, endocrine problems, arthritis, asthma, neurological conditions, and chronic pain, but as this paper will illustrate, environmental factors have a large influence.

The next large category is Obstructive Sleep Apnea (OSA). About 15% of women have OSA and the statistic doubles for men. OSA is when the airway becomes blocked, usually in the throat, leading to hypoxia. The minimum number of obstruction events for an OSA diagnoses is five per hour during a sleep period. Snoring is often an early detection of the sleep breathing issues but does not always preclude the disorder. Often times, weight gain can contribute. Interestingly, military members that have been forward deployed show double the rate of sleep apnea indicating a possible link to psychological triggers causing the breathing disorder. Kushida, et al. suggests the existence of a complex OSA-neurocognitive relationship in a study of long term CPAP use (2012). If there is psychological causation behind OSA, it is plausible that a calming environment could improve the disorder.

Hypersomnias are generally related to narcolepsy, head injuries or drug abuse. Parasomnias are disruptive sleep disorders that can occur during arousals from rapid eye movement (REM) sleep or arousals from non-rapid eye movement (NREM) sleep. Examples of sleep movement disorders are restless leg syndrome and bruxism. This paper examines how environmental factors affect sleep, therefore the primary focus within sleep disorders is insomnia.

To measure sleep and sleep disorders, technological measurement devices can be used. Dr. Kang of UC San Diego School of Medicine states that sleep disorders can be diagnosed by an overnight polysomnogram (PSG). PSG is widely known in the medical community as the "gold standard" in sleep measurement. It utilizes multiple sensing modalities to measure biophysiological signals, including electroencephalography (EEG), electrooculography (EOG), electrocardiography (ECG), and electromyography (EMG). Additionally, respiratory rate, temperature and acceleration can be monitored. These methods can accurately measure the state of the mind and body during sleep.

## Sleep and Environmental Factors

Environmental factors greatly affect sleep latency, sleep efficiency and sleep duration. World travelers, military and shift workers experience some of the greatest environmental strains. The top three environmental factors are light, sound and temperature. Latitude, longitude and altitude alter the light, sound and temperature in any given location. Seasonal changes within a given location can also vary these factors dramatically. The perfect sleep opportunity occurs when sunlight phases out naturally, the temperature reduces to a comfortable level, there are no disturbing noises, and at least eight hours of darkness are available followed by a reverse increase in light and temperature.

In our modern world, the perfect sleep opportunity is challenging to find. Televisions, tablets and smart phones emit artificial light resulting in mixed signals received by the optic nerves. The sounds of the city, modern home technology devices, and crime are all pollution that can keep sleepers awake all night. Extremely hot temperatures can cause increased sleep latency while electronic thermostats can overregulate temperature. Without diurnal temperature variation, the brain cannot use temperature as a gauge for sleep modulation. Add to this the growing number of sleep disorders and the statistics begin to compound.

**Light Affects Sleep**

Light, especially blue, strongly influences the circadian rhythm by entering the brain through neural pathways. It is the greatest factor in resetting the human body clock. The volume and consistency of light in a human's day strongly influences the natural sleep wake rhythm. Without light, humans are left to their own natural clock which has been found to run slightly longer than 24 hours. If there were no light and a human experienced a 25 hour day, there would only be 246 days in that person's year. To keep the circadian rhythm in healthy balance, consistent environmental factors are required.

Light enters the eye through the pupil activating melanopsin. Melanopsin is a retinal photopigment crucial for conveying nonvisual light information to the brain. The Superchiasmatic Nuclei (SCN) is located within the hypothalamus of the brain. It is believed that the SCN entrains circadian rhythms via chemical cues. In the evening, when light fades, the eyes sense the reduction in light and the SCN tells the body to start producing melatonin. In the morning, when light is sensed, the SCN tells the body to warm up and produce cortisol. In all mammals, sleep-wake cycles, heartbeat frequency, blood pressure, body temperature, renal activity, liver metabolism, and the secretion of many hormones are controlled by the SCN.

“The circadian system in human beings is a complex entity that starts in the eye and that terminates in the pineal gland, which produces melatonin, a neurohormone essential for functioning of the clock. In humans, melatonin is secreted during the dark phase of the light-dark cycle. While light is a key factor that controls the secretion of melatonin, it differentially affects the secretion of this hormone as a function of the time of day of the exposure, the intensity, the light spectrum, and the duration of the exposure” (Touitou, Reinberg, Touitou, 2016). Touitou et al. infers that light is the primary factor in setting the circadian rhythm.

Light has become a major disruptor of sleep efficiency in every industrialized nation. The proliferation of televisions, laptops, tablets and cellphones has made the abundance of artificial light a critical factor. Exposure to artificial light at night (ALAN) will disrupt the circadian rhythm, especially when blue light is not filtered. This can cause suppression of melatonin release and sleep deprivation. According to Touitou et al., “this desynchronization is detrimental to health, as underscored by a large number of epidemiological studies that have uncovered elevated rates of several diseases, including cancer, diabetes, cardiovascular risks, obesity, mood disorders and age-related macular degeneration.”

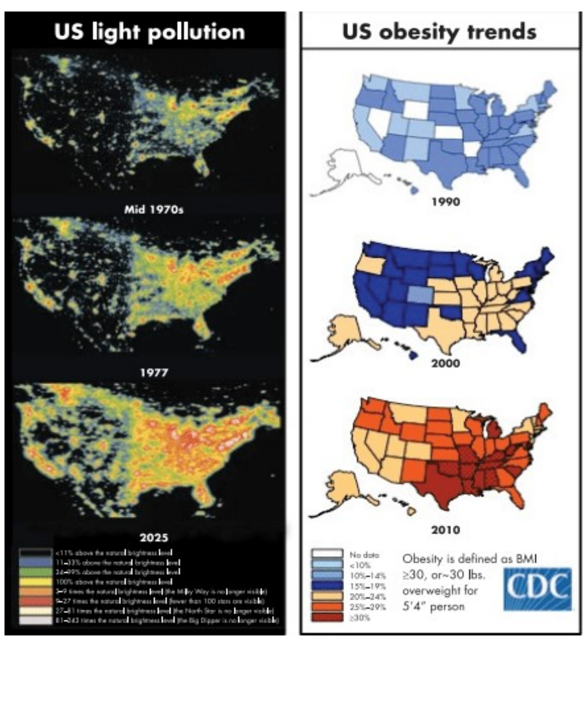
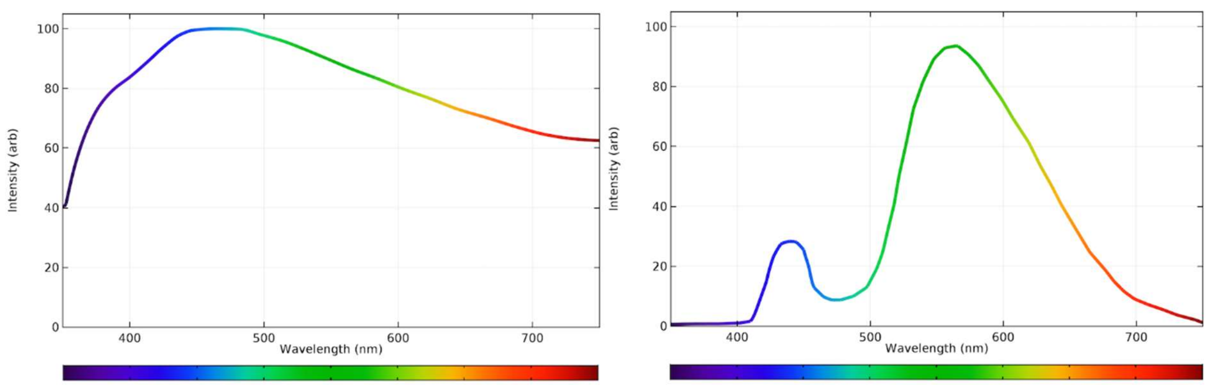


*Figure 5.* The correlation between light pollution and Obesity. Adapted from “Blue Light at Night Can Cause Weight Gain,” by Cohen, J., 2018, Copyright 2010 by CDC.

In 1981 Charles Czeisler demonstrated that bright light must exceed 2500 lux to suppress dim light melatonin onset (DLMO), which occurs as humans prepare for bed. This is also the time when the circadian cycle is the most sensitive to phase-delay shifting. “In a laboratory study, the output of the circadian pacemaker of an elderly woman was monitored before and after exposure to 4 hours of bright light for seven consecutive evenings, and before and after a control study in ordinary room light while her sleep-wake schedule and social contacts remained unchanged. The exposure to bright light in the evening induced a 6-hour delay shift of her circadian pacemaker, as indicated by recordings of body temperature and cortisol secretion” (Czeisler, et al., 1986). This means that a person’s natural circadian rhythm can be shifted by remaining in a brightly lit environment before sleep. ALAN has a greater impact on the sleep-wake circadian rhythm than social or behavioral influences. People that have varying work schedules, like shift workers or military may be the most affected due to sunlight exposure immediately preceding sleep.

Sunlight is segmented into spectrums. The visual spectrum of light is also known as electromagnetic radiation. This spectrum is further broken into colors by wavelength. The wavelengths range from 380 nanometers (nm) to 750 nm with a frequency between 484 Terahertz (THz) and 789 THz. For example, the color of blue is approximately 475 nm with a wavelength of 650 THz. Currently, there is no way to exactly reproduce the light emitted from the sun, however, it can be simulated through modern Light Emitting Diodes (LEDs). LEDs can produce millions of different colors of varying brightness. One company in Italy, coeLux, is attempting to replicate sunlight with LEDs. The company developed a thin coating of nanoparticles to simulate the Rayleigh scattering that occurs in the earth's atmosphere.

Some light, like ultraviolet, can damage the human eye. Therefore, the cornea filters the very short (below 360 nm) ultraviolet wavelengths. In this way, the rods and cones located in the retina are protected from it. The primary properties of visible light are intensity, propagation direction, frequency or wavelength spectrum, and polarization. Figure 6 shows the wavelength and intensity of normal sunlight. Figure 7 shows the same chart for a normal LED. Light between zero and 500 nm is significantly lower when comparing LEDs to natural sunlight.



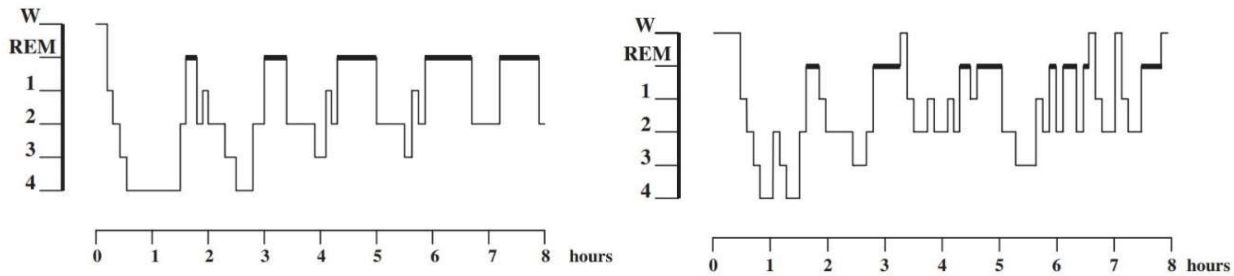

*Figures 6 & 7*. Sun light spectrum and LED light spectrum. Adapted from "Calculating the Emission Spectra from Common Light Sources," by Smith, D., 2016, Copyright 2018 by Comsol Inc.

**Sound Affects Sleep**

"Sound is produced by any mechanical movement and is propagated as a motion wave through the air or any other material. Therefore, sound is defined by its mechanical energy and is measured in energy-related units. Sound pressure proportional to the square of sound intensity (W/m2) is expressed in Pascal units (Pa), whereas sound pressure level is expressed in decibel units (dB) on a logarithmic scale, owing to the wide range covered. Sound evokes physiological signals in the auditory system constituted by the ear and the auditory pathways. However, some sounds do not evoke those signals as they are out of the auditory perception range in humans, which theoretically ranges from 20 to 20,000 Hz. Sleep is a physiological state that needs its integrity to allow the living organism to recuperate normally. It seems to be sensitive to environmental factors that can interrupt it or reduce its amount. Ambient noise, for example, is external stimuli that are still processed by the sleeper sensory functions, despite a non-conscious perception of their presence. After 4-5 hours, noise events can more easily wake the sleeper leading to less sleep time" (Muzet, 2007).

The effects of noise can be detrimental to sleep efficiency. Noises levels of 45 dB and higher can increase sleep latency, fragment sleep cycles and interrupt the sleep period prematurely. As the sleep cycle advances and sleep pressure is reduced, it is more likely that noise can end sleep abruptly. "Each noise stress on the human body is associated with a cardiovascular response that is composed of a vasoconstriction of peripheral circulatory system and an increase of blood pressure even if the sleep itself is not affected. There is no habituation of the cardiovascular responses to noise (WHO, 2004)." This statement may be troubling for people living in a busy city as cardiovascular health can be affected by environmental noise while sleeping.

Muzet (2007) recorded a young adults brainwave activity to see what stages of sleep were achieved with and without noise. "Hypnograms of a young adult during non-disturbed sleep in Figure 8. Sleep onset occurs within 10 min after lights out. Sleep begins by NREM sleep stages and the first REM episode occurs some 90 min after sleep onset. SWS (stages 3 and 4) occurs mainly during the first 3 h of the night. REM sleep episodes appear at very regular intervals. No awakening is seen during the entire night. Figure 9 shows during a noise-disturbed night. Sleep onset is slightly delayed. The first episode of stage 4 is partly interrupted. A significant amount of SWS does occur during the fifth hour (possibly as a compensatory mechanism of the disturbed first episode). REM sleep still shows clear rhythmic occurrence but some of the episodes are fragmented. Significant awakenings occur throughout the sleep process. Sleep efficiency is reduced."




*Figures 8 & 9*. Baseline hypnogram versus with environmental noise. Adapted from "Environmental noise, sleep and health," by Muzet, A., 2007, Copyright 2007 by Muzet.

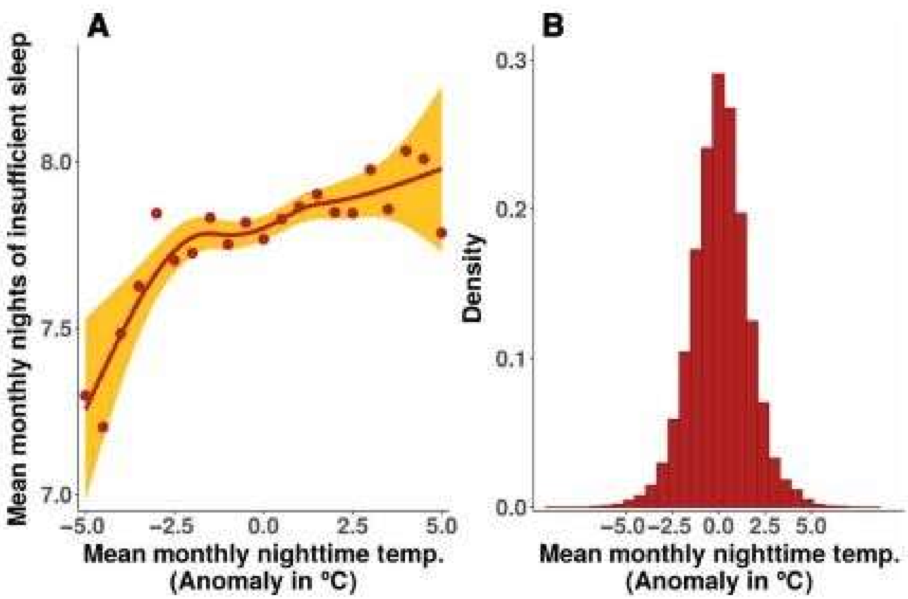
"Environmental noise, especially that caused by transportation means, is viewed as a significant cause of sleep disturbances. Poor sleep causes endocrine and metabolic measurable perturbations and is associated with a number of cardiometabolic, psychiatric and social negative outcomes both in adults and children. Nocturnal environmental noise also provokes measurable biological changes in the form of a stress response, and clearly affects sleep architecture, as well as subjective sleep quality" (Halperin, 2014). The World Health Organization (2004) has documented seven categories of adverse health and social effects resulting from noise pollution, whether occupational, social or environmental. The fifth noise pollution category outlines how it is considered a major cause of exogenous sleep disturbances.

**Temperature Affects Sleep**

Human beings are endotherms and therefore have the ability to thermoregulate. Within the hypothalamus is a thin temperature sensitive membrane. Humans feel ready for bed when this membrane senses a two–three degree Fahrenheit drop. This is the science behind the old household remedy of drinking a glass of warm milk. Homeostasis decreases the core body temperature to offset the warm milk, causing sleep onset. Minimum core body temperature is the marker for measuring changes in the timing of this circadian rhythm. The rhythm for body temperature goes up during activity in the day and down as the body relaxes at night. Typically, the body will be the warmest in the early evening (before bed) and reach a low in the early morning. In a healthy adult, the lowest core body temperature will occur about six hours into a normal eight-hour sleep routine. In an optimal environment, the external temperature will reduce before bedtime. When diurnal temperature variation exceeds 15 degrees, the core body temperature can adequately reduce, giving the hypothalamus permission to signal the pineal gland to increase melatonin production.

"Of the factors affecting sleep, temperature plays an integral role. As the body prepares for sleep, dilation of blood vessels in the skin facilitates heat loss, producing an important signal for sleep onset: a decrease in core body temperature. This core temperature decrease is preceded by amplification of temperature at distal sites (for example, the hands and feet). The ratio of distal to proximal skin temperature is highly predictive of sleep onset, suggesting that heat loss from distal skin temperature regions helps to cool the core in the evening and early morning. Once core body temperature drops to produce sleep onset, it remains low throughout the night and rises again shortly before awakening. By affecting circadian thermoregulation, ambient temperatures can interrupt the normal physiology of sleep. Previous laboratory-based studies have found that exposure to elevated temperatures can prevent core body heat shedding and that poor sleep is associated with elevated core body temperature" (Obradovich, N., et al, 2017).

The Centers for Disease Control and Prevention conducted a survey between 2002 and 2011 on the self-reported sleep inadequacies of 765,000 people. The results from that study were correlated to data from National Centers for Environmental Information Global Historical Climatology Network–Daily, in a georectified manner. “As can be seen in Figures 10 A and B, as temperature anomalies become more positive, the incidence of nights with insufficient sleep increases.” (Obradovich, N., et al, 2017). In other words, an increase in average monthly nighttime temperature resulted in more nights per month of inadequate sleep.




*Figures 10 A & B*. Temperature fluctuations in relationship to short sleep. Adapted from “Nighttime temperature and human sleep loss in a changing climate,” by Obradovich, N., Migliorini, R., Mednick, S., & Fowler, J., 2017, Copyright 2017 Obradovich et al.

The human body is sensitive to the ambient temperature before and during sleep. The ability of the skin to release body heat equates to the change of core body temperature. This would account for the effect that different types of bedding have on temperature regulation. The phenomenon of sleep onset is accompanied by vasodilation. A study by Kräuchi (1999) showed the degree of dilation of blood vessels in the skin of the hands and feet, which increases heat loss at these extremities, is the best physiological predictor for the rapid onset of sleep.

## Conclusion

Humans originally went to bed when the sun went down. When the sun arose, they woke, and the day began. In our modern age with the prevalence of light pollution, highly regulated temperatures and noisy environments, it is harder than ever to get a good night sleep. To make matters worse, there is a misunderstanding of sleep and its importance. Many people in the United States and other countries view sleep as subordinate health priority. Studies show that sleep is in fact, one of the three pillars of health, if the other two are diet and exercise. Achieving perfect sleep can be a very difficult task in 2018. The solution would then be to return to nature and leave the electronic devices behind. All of the environmental factors required for perfect sleep are present in nature. These factors contribute to the thousands of years of core programming humans operate on. Re-entering nature, for small vacations or retirement, may work temporarily but is unsustainable for the average working adult. The solution then must be to use technology to support the need for a natural environment.

Perfect sleep can be defined as an ample sleep opportunity followed by rapid sleep onset, uninterrupted rich sleep and the gradual awakening by sunlight and temperature. To replicate these factors with technology would be challenging but can be done. The volume and frequency of light can be replicated with modern organic light emitting diode (OLED) displays to simulate what the eyes experience in nature. Climate controlled environments can simulate the temperature changes of the earth from day to night. Sound dampening material and noise cancelling technology can be applied to reduce the effects of sleep disturbing noise. If a virtual sleep environment with all of the aforementioned features were to be constructed, it is possible that natural sleep could be achieved. This virtual sleep platform could be ubiquitously used in every possible scenario to support the required physiological signals that the human body so desperately needs to sleep in the modern world.

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