Everything about Sleep and How to Improve It

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Abstract

Sleep is an important biological process that plays a role in maintaining both mental and physical health. However, people are often not aware of this and neglect a healthy sleep routine. This review talks about the importance of sleep, its benefits, and physiology. It also focuses on the most common sleep disorders and sleep deprivation. At the end, we also provide some tips for improving sleep hygiene. The goal of this review is to educate the public and eventually support our readers in improving their sleep hygiene.

Introduction

How long can the human body go without sleep? “Nearly 264 hours! But extreme symptoms such as hallucinations, speech impairment, and an inability to think begin after 36 hours.” (Vandergriendt, C. (2018). How Long Can You Go Without Sleep? Function, Hallucination, More. Healthline. https://www.healthline.com/health/healthy-sleep/how-long-can-you-go-without-sleep) That is why sleep is so important, it is the body's daily rest. Sleep is defined as a naturally recurring and reversible state of reduced consciousness and sensory activity. Basically, sleep makes your brain and body slow down, making you less responsive to the world around you.

We spend around one-third of our lives asleep, and even then, our brains are still busy. They clear and strengthen our memories and store only the important information. That's why we remember so much more in the morning after studying for a test right before going to bed.

Getting enough sleep is crucial for normal functioning during the day. If we don't sleep enough, it causes sleep deprivation, which leads to tiredness and concentration problems and keeps us from performing well. Nowadays, as life keeps moving fast, many people don't

sleep enough, and “about 50 million Americans suffer from some kind of sleep disorder” (Cleveland Clinic. “Sleep Disorders: Conditions That Prevent You from Getting Restful Sleep.” Cleveland Clinic, 19 June 2023, my.clevelandclinic.org/health/diseases/11429-sleep-disorders.). Understanding sleep is very important for our well-being. In this paper, we will describe all the stages of sleep, focus on dreams and sleep disorders, and explain what happens when people don't get enough rest. At the end, we will suggest a few tips on how to improve it and make your life better.

Physiology of sleep

Sleep is a very complicated process. In this chapter, I will introduce the topic of sleep physiology, mostly focusing on the mechanisms that take part in sleep regulation.

Mechanisms Influencing Sleep

Circadian rhythms are natural, circa 24-hour-long cycles that our bodies follow. They regulate lots of important functions. For example metabolism, body temperature, hormone release, and sleep. Unlike sleep homeostasis, which I will talk about further in the text, circadian rhythms are also influenced by external forces like light or darkness.

During the day, our retinas perceive light via specialized photoreceptors. They send a signal about light exposure to the SCN (suprachiasmatic nucleus), the master clock that regulates the sleep and wake cycles in animals. The SCN then stimulates the wake-promoting regions that are mostly located in the hypothalamus, or the brainstem. These regions then inhibit the VLPO, our sleep centre and the main sleep-promoting region, keeping us awake and functioning. The SCN also inhibits the PVN (paraventricular nucleus). This structure acts as a relay station that transmits signals from the SCN to the pineal gland, and when it gets inhibited, it does not stimulate the pineal gland. If not stimulated, the pineal gland does not secrete much melatonin, which is a sleep-promoting hormone.

But when the receptors don’t perceive light, the SCN becomes less active and stimulates the wake-promoting regions with a weaker force. In response, these regions become less active and their influence on the sleep-promoting regions weakens. This results in increased activity of the VLPO. Lower SCN activity also means that the inhibition of the PVN will be weaker,

which then allows the pineal gland to activate. The pineal gland then releases a higher amount of melatonin that overall prepares the body for sleep.

Simply said, the sleep and wake cycles are based on mutual inhibition of the wake and sleep-promoting regions. They kind of play tug-of-war. During the day the wake-promoting regions are more active and act with a stronger force, “tiring down” the sleep-promoting ones. But when the sun sets, the sleep-promoting regions become more excited and overpower them, wearing them down by inhibition. It is important to note that they never actually stop inhibiting each other, and that neither the sleep nor the wake-promoting regions are completely silenced.

All of this is regulated by the SCN, which I mentioned before. Based on light exposure it sends signals to various parts of the brain, which then secrete chemicals that either promote sleep or wakefulness. Those chemicals usually act both ways, suppressing one and exciting the other sleep or wake promoting region. One example might be the pineal gland with its melatonin production. Melatonin helps with sleep induction, so it stimulates the sleep-promoting regions and inhibits the wake-promoting regions.

Funny thing is that both sleep and wake-promoting regions use the same chemical to inhibit the other one. That is why I chose the tug-of-war metaphor. The chemical is called gamma-aminobutyric acid and is the most common inhibitory neurotransmitter of the central nervous system.

Besides circadian rhythms, **homeostasis** also takes part in sleep regulation. It is a kind of balance that our bodies try to keep. When we do not sleep, the need for sleep gets stronger, forcing us to rest in order to get the desired balance back.

During wakefulness, our bodies use ATP to function. Phosphate groups are broken away, which releases energy. But if we break away all three of the phosphate groups, only adenosine remains. It is a neuromodulator which accumulates in extracellular spaces. The longer we stay awake, the more adenosine we have. Adenosine then causes sleepiness by reducing the excitation of the wake-promoting regions and increasing activity of the sleep-promoting regions. This allows the VLPO to “activate” and initiate sleep.

Sleep Stages and Sleep Cycles

Sleep Cycles

In one night, an average person goes through four to six sleep cycles. One whole cycle lasts about 90 minutes, but its length changes during the night. The first one is the shortest and the last one is the longest. The cycles have four stages, and the time we spend in each stage changes throughout the night. One cycle consists of three NREM (non-rapid eye movement) stages and one REM (rapid eye movement) stage. The main difference between them is that during NREM sleep, our eyes do not move, but in REM stage eyes begin to shift rapidly.

Brain Waves

Brain waves, also known as neural oscillations, are rhythmic patterns of neural activity in the CNS. In individual neurons, changes from resting to action potentials happen. When a large number of neurons sync up, the changes in potential become macroscopic and can be recorded by EEG. In other words, brain waves tell us how active the brain is at the moment. During NREM sleep, brain activity lowers with each stage. It is at its minimum during stage 3. But as we move into REM sleep, it spikes up to the point where it resembles the activity of a brain that is wide awake.

Stage 1

Stage 1 occurs when a person falls asleep. It is the lightest and the shortest one and lasts around 1 to 7 minutes. The body is still not fully relaxed, but the muscles begin to ease up, and the heartbeat with breathing slows down. Some people might experience twitches as the tension in muscles starts to lower. The brain activity is also slowly decreasing. The person can be easily woken up, but if not disturbed, continues to stage 2.

Stage 2

During this stage, which usually lasts about 20 minutes, the temperature begins to decrease and eye movement stops. Breathing and heartbeat continue to slow down, and muscles become less tense. For this stage, slower brain waves are characteristic, but we can also observe repeating bursts of higher brain activity, known as sleep spindles. Sleep spindles are believed to block external stimuli which could disturb and awaken us.

Stage 3

The third one is the deepest phase of sleep, which lasts around 20 to 40 minutes. The heartbeat and breathing are now completely slowed down, the temperature is at its lowest, and muscles are completely relaxed. Brain activity is also lowered, giving this stage the name slow-wave sleep. Scientists believe that this is the most important part of the sleep cycle because, during this stage, cells regenerate, tissues get repaired, and our bodies grow because of growth hormone release. Overall, these are some of the greatest benefits of sleep. Stage 3 is also linked to memory and creativity.

In the third stage, sleepwalking and night terrors can happen. Both occur more frequently in children than in adults. The main difference between those two is the level of consciousness. During a night terror, a person partially wakes up. The person then proceeds to scream and kick around in fear and panic. But sleepwalkers are fully unconscious when they perform activities that humans usually do when they are awake.

Stage 4

The last stage is slightly different from the other ones. During it, a temporary paralysis that does not affect the smooth muscles and the muscles involved in eye movement happens. Eyes begin to move rapidly, and brain activity becomes similar to the one in the state of wakefulness. Blood pressure and heartbeat increase, and breathing becomes irregular. REM sleep usually takes place 90 minutes after falling asleep. In adults, it lasts about 10 minutes during the first cycle. The younger the person is, the more REM sleep they get in one night. During REM sleep, information from temporary memory is moved to permanent memory, and vivid dreams occur.

Dreams

Dreams are basically stories our brain makes up when we sleep. We can dream in any stage of sleep, but the most memorable dreams happen during REM sleep. Some believe that dreams do not have any specific purpose, however, evidence from research suggests otherwise. Neuroimaging machines that record brain activity significantly helped us to uncover what happens in the brain during dreaming. Despite that, scientists are still not entirely sure about their purpose but some studies show that they help us cope with difficult situations, find solutions to problems, or process emotions.

When dreams happen, our brain activity spikes up. Many brain regions become active. The limbic system, which includes the amygdala and hippocampus, is in charge of the emotional side of dreams. It makes sure to include recent emotional experiences in them. The imagery is processed by the visual cortex, which is highly active during REM sleep.

But why are dreams often so bizarre? Well, because the prefrontal cortex is less active and does not engage in logical thinking. Serotonin also plays a role in this. Its levels drop during REM sleep and free the brain from the logic of everyday life, which allows dreams to become more unreal. Another neurotransmitter whose levels decrease during dreaming is norepinephrine, which is linked to stress responses. The drop creates a stress-free dreaming environment. An increase can be observed in acetylcholine levels. This chemical contributes to the activation of the amygdala and hippocampus.

Benefits and Functions of Sleep

Sleep is very important for all living organisms. It influences many processes and systems. During the daytime, these systems are active and sustain many fundamental functions, which naturally consumes energy. At night, they get to “recharge” thanks to sleep. Their activity decreases, allowing them to restore energy supplies. And since their activity is lowered, less energy is consumed, so the remaining energy can be used elsewhere. For example, to heal injuries or deal with infections. This is why doctors often tell us to rest when we are sick or injured.

Enough sleep helps us to process and retain information. NREM sleep prepares the brain for learning by consolidating memories of facts and events. It also filters out unnecessary information and strengthens important memories. Emotional memory processing happens during REM sleep, helping us cope with stress and emotional baggage, often through dreams. REM sleep can also help us solve complex problems. That is why people sometimes recommend to “sleep on it” when facing a complex problem.

As I mentioned before, sleep takes part in healing processes and has restorative effects. It allows the body to remove waste (especially from the brain), which boosts the immune system. During sleep, a large number of hormones gets released. For example, growth hormone (HGH - human growth hormone), which supports tissue growth, and leptin, which regulates appetite

and reduces hunger. High leptin levels are partially the reason why we don't feel the need to eat right after waking up. Sleep is also involved in stress reduction. Levels of cortisol, a stress hormone, naturally drop during the evening to prepare for rest.

A healthy sleep schedule can also count as a prevention against many diseases. For example, respiratory illnesses, infections, and cardiovascular diseases. Sleep deprivation can reduce glucose tolerance and impair insulin production. This can increase the risk of type 2 diabetes.

Many people know that sleep is somehow related to mental health. Poor sleep quality can worsen mental disorders, and those disorders can cause poor sleep hygiene. One leads to another.

All stages of sleep are important. However, REM sleep appears to be the most significant one of them all. It influences both mental and physical health, but the mental benefits are more substantial. During this stage, our brains process emotions and store memories. Sleep is especially important when it comes to storing emotional memories, which lack of sleep can impair. It can also be responsible for mood throughout the day and emotional reactivity.

Sleep has many benefits that cannot be overlooked. Everybody who tries to live a healthy lifestyle should not forget that sleep and rest are just as important as regular exercise or a healthy diet.

Sleep disorders

Sleep disorders affect the quality and amount of sleep you're able to get at night. About one third of the whole population suffers from sleep disorders and there are over 80 different types of sleep disorders. Here are the four most common ones, along with their symptoms, causes and treatments:

Insomnia:

> Insomnia is when you aren't sleeping as you should. You aren't getting enough sleep have trouble staying asleep for extended period of time. There is either acute (short-term) insomnia that lasts less than three months or chronic (long-term) that lasts three months or longer. You might have already heard about chronic insomnia because

when people talk about insomnia, they mostly mean this one. “One-third of adults experience symptoms at some point in their lives and 10 % of those people meet the criteria for insomnia disorder” Cleveland Clinic. “Insomnia.” (Cleveland Clinic, Cleveland Clinic, 13 Feb. 2023, https://my.clevelandclinic.org/health/diseases/12119-insomnia.).
The most common symptoms include difficulty falling asleep, waking up in the middle of the night, waking up too early in the morning, feeling tired and sleepy all day, slowed thought processes and reactions, and trouble concentrating.

Scientists don’t really know why insomnia happens or what is the exact cause behind it, but it can involve many factors, such as genetics, stress and anxiety, medical conditions, and poor sleep hygiene.

Fortunately, there are many ways to treat insomnia by improving your sleep habits. Your doctor can also recommend therapy because mental health has a huge impact on your brain. And if nothing works you can get medication that helps you fall and stay asleep, for example, Benzodiazepines (a class of medication that slows down brain and nervous system activity).

Parasomnias:

Even though it sounds very similar to insomnia, parasomnias are a different type of sleep disorder that causes unusual behaviors that occur during sleep, while falling asleep, or right before you wake up. By unusual behaviors, I mean sleepwalking, having nightmares, sleep-talking, and acting out dreams. When this happens people might think you're awake, but in reality, you're asleep and in most cases don’t even remember anything you did duringtge time you were asleep.

There are three main groups of parasomnias based on the stage of sleep they take place in. Non-REM sleep parasomnias involve physical and verbal activity such as sleepwalking and sleep terrors (when you suddenly wake up scared in the middle of the night). Especially kids suffer from these night terrors, but they mostly fade away when kids grow up and start school. In REM sleep parasomnias occurs vivid dreaming like nightmares and sleep paralysis (when you wake up and can't move your

body). And lastly, there are parasomnia types that don't fit neither into non-REM or REM sleep. That category involves for example bedwetting or sleep-related hallucinations.

Since there are so many types of parasomnias, there is no estimated number of people who suffer from them, we can say that "4%-67% of adults have experienced symptoms of parasomnia at least once in their lifetime" (Cleveland Clinic. "Parasomnias & Disruptive Sleep Disorders | Cleveland Clinic." Cleveland Clinic, 2017, my.clevelandclinic.org/health/diseases/12133-parasomnias--disruptive-sleep-disorders.).

There are many causes of parasomnias such as an irregular sleep-wake schedule, genetics, or side effects of some kind of medication. There is treatment available that helps you manage symptoms throughout your life. Same as with insomnia, sleep hygiene is very important. What also helps is maintaining a consistent bedtime and wake-up time, limiting alcohol and drug intake, and locking away sharp and dangerous objects for safety reasons. And of course, sedative medication is an optional treatment too.

Sleep apnea:

Sleep apnea causes you to repeatedly stop breathing while sleeping. The lack of oxygen activates a survival reflex in your brain, that results in you having to wake up to be able to breathe again. This prevents restful and healthy sleep. Sometimes this condition can even be life threatening.

Why does it happen? There are multiple answers to that. Currently we know about three different types of sleep apnea. Obstructive sleep apnea (OSA) is the most common one and around 1 billion people have it. When you have OSA the muscles in your throat relax while you are asleep and the surrounding tissue starts to press on the windpipe blocking all the air that comes in. The less common type, central sleep apnea (CSA), happens when your brain stops sending signals to keep you breathing. Some people can have complex sleep apnea which is a combination of both types, but it is extremely rare.

The key symptoms are loud snoring mixed with choking and gasping sounds during the night, followed by morning headaches and daytime fatigue. Anyone can develop this condition at any age and the risks increase as you get older. Another risk factor is obesity because the extra throat tissue blocks the trachea more easily.

If you suspect that you or your loved one might have sleep apnea you can do a sleep study (an overnight diagnostic test that monitors your heart rate, breathing, blood oxygen, and brain waves). Then a healthcare provider will recommend different treatment options based on the severity. These may include using a breathing device, losing weight, taking medication, or even undergoing surgery on your nose, mouth, and throat that helps improve your breathing during sleep.

Narcolepsy:

Narcolepsy is a condition where it is hard to stay awake plus you often fall asleep in the middle of the day. It affects approximately 3 million people and it is most likely to be diagnosed in young adults in their early 20s.

There are four main symptoms of narcolepsy, excessive daytime sleepiness, cataplexy, sleep-related hallucinations, and sleep paralysis. Most people don't have all four symptoms and can have "just" the daytime sleep attacks, which are typical for everyone with narcolepsy.

I've already mentioned the term cataplexy. It is sudden muscle weakness while still awake and conscious. Narcolepsy is then divided into whether or not you have cataplexy. Narcolepsy type 1 is less common (about 20% of people with narcolepsy) and involves cataplexy. Then there is narcolepsy type 2, which doesn't involve cataplexy, about 80% of people have this type.

Narcolepsy is often caused by genetics or a lack of the brain chemical hypcretin, that normally keeps us awake. Therefore it is treatable but not curable. Scheduled naps or medication such as antidepressants, sodium oxybate, or amphetamine-like stimulants, help deal with the symptoms.

Sleep Deprivation and Its Effects

What happens to people who don't get enough sleep? They become sleep-deprived. This can be only a short-term issue (a few nights), or it can be a chronic problem that lasts weeks and even months and can happen either voluntarily (staying up late to study or finish homework) or involuntarily (sleep disorders, being sick).

During a typical night, an individual cycles through the three stages of NREM sleep, followed by a period of REM sleep every 90 to 120 minutes several times. Both the brain and body experience distinct changes during these cycles. During each part of the process, different chemicals become activated or deactivated to let the brain rest and recover.

Teenagers and students suffer from sleep deprivation the most, because of waking up early to go to school, homework, and social activities. Around 60-70% of adolescents don't get enough sleep and since important brain development happens exactly at this age, being sleep-deprived can have serious consequences.

Short-term lack of sleep makes people drowsy and less alert. One night of poor sleep can cause microsleep (short involuntary dozing), which can happen during class or even while driving, making it more dangerous. Sleep deprivation has a huge impact on memory and creativity. It reduces attention, slows reaction time, makes learning new information harder, and weakens problem-solving skills. For students, this means difficulty focusing in class, remembering homework, or performing well on tests and exams.

Long-term lack of sleep can harm not only the brain but also the body. In the brain, it can increase the amount of beta-amyloid. This protein is a waste product of brain activity and gets cleared during sleep. When sleep is constantly low the protein accumulates in the brain which leads to Alzheimer's disease. For the body, it raises the risk of heart disease, diabetes, and obesity. Sleep is also known for supporting the immune system so sleep-deprived people are more likely to catch colds or flu.

Lastly, sleep deprivation has a huge effect on mood and emotions. People tend to feel more irritated and anxious and overall, it becomes harder for them to deal with stress. It is like a cycle. Person doesn't sleep enough, they start to experience sadness or depression, which leads to anxiety, which then turns into having problems with falling asleep. And then it repeats all over again.

Improving Sleep Hygiene

The healthy amount of sleep you need per night changes with your age. As you can see in Table 1 below, newborns need more sleep than adults, because both their mind and body are still developing and need their brains to rest often.

Table 1 "Daily sleep recommendations based on age groups"

(Vandergriendt, C. (2018). How Long Can You Go Without Sleep? Function, Hallucination, More. Healthline. https://www.healthline.com/health/healthy-sleep/how-long-can-you-go-without-sleep)

Age	Sleep recommendations per night
Newborns (0-2 months)	14-17 hours
Infants (2 months – 1 year)	12-16 hours
Toddlers (2-3 years)	11-14 hours
Preschool (4-6 years)	10-13 hours
School (7-12 years)	9-12 hours
Teens (13-18 years)	8-10 hours
Adults (18+ years)	7-9 hours

Fortunately, there are several ways to prevent sleeping problems through good "sleep hygiene" (Suni, Eric. "Mastering Sleep Hygiene: Your Path to Quality Sleep." *Sleep Foundation*, 4 Mar. 2024, www.sleepfoundation.org/sleep-hygiene.) – healthy habits and behaviours that help us to get good sleep.

Here are some tips:

1. *Keep consistent sleep and wake times:* By setting a standard bedtime and wake time, you are training your circadian rhythm (which controls your body's sleep-

wake cycle). When your body goes to bed and wakes up every day at the same time, it will get used to it and will fall asleep faster and wake up feeling less tired.

2. *Start winding down an hour before bedtime:* You know that you need 7 to 9 hours of sleep, and you have to wake up at 7 a.m. So, this means you should be in bed by 11 p.m. And therefore, at 10 p.m., you should start getting ready (showering, brushing your teeth, etc.).
3. *Set boundaries for screen time:* Limit using your phone or any other electronic device 1 hour before bedtime. The blue light that comes from the screens interferes with the production of melatonin and keeps the brain awake, which makes it harder to fall asleep.
4. *Make your room comfortable:* Your bedroom should be a safe space where you feel comfortable and encouraged to sleep (comfortable mattress, minimal lighting, cooler room temperature).
5. *Cut out bedtime drinking and snacking:* As your body winds down for sleep, so does your digestive system. So, try to avoid eating three hours before bedtime. Also avoid drinking anything with caffeine as it has stimulating effects.
6. *Calm your mind* (for example with meditation or yoga)
7. *Avoid exercise before bed:* It is not good to exercise two hours before bedtime, because it activates the release of stimulating hormones, which can cause insomnia or difficulty falling asleep.
8. *See an expert if you need more help:* If you have tried all the tips above and still cannot get a good night's sleep, and especially if your sleep problems last for three months, you should consider seeing a doctor and seek diagnosis, you are probably suffering from a sleep disorder.

Conclusion

In conclusion, sleep is crucial for our well-being. It affects both mental and physical health and provides us with a number of benefits. Despite them, sleep is often undervalued, leading to sleep deprivation. This review highlighted the benefits and importance of sleep, focusing on the sleep mechanisms and common sleep disorders. By offering tips for improving sleep hygiene, we hope to encourage our readers to sleep better.

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