frontiers | Frontiers for Young Minds

NEUROSCIENCE AND PSYCHOLOGY
Published: 17 April 2024
doi: 10.3389/frym.2024.1355260

TICK TOCK! IT IS TIME FOR BED!

Nicholas John Constantinesco *, ***Deylon Dianna Harkey and Lauren A. Fowler***

Translational Neuroscience, Wake Forest University School of Medicine, Winston-Salem, NC, United States

YOUNG REVIEWERS:

DELARA

AGE: 11

KING EDWARD VI GRAMMAR SCHOOL

AGES: 11–15

Getting a good night's sleep is essential for development during childhood, for health throughout adulthood, and a long life. Getting less than 8 h of uninterrupted sleep can lead to poor performance at school the next day. Today, most of us have easy access to technology in our daily lives, and young people often bring their devices to bed with them. While it might be a fun way to unwind after a long day of classes, nighttime electronics use can interfere with the ability to recover from the normal wear and tear on our bodies that builds up each day. Using technology close to bedtime interacts with the body's natural processes that help us fall asleep and help us recover so that we are prepared to take on the next day. As technology use continues to grow, it is important that our devices go to sleep at least an hour before we do.

CIRCADIAN RHYTHM

The body's clock, which is in a delicate balance and is aligned with daytime and nighttime.

THE SLEEP-WAKE CYCLE IS CRITICAL FOR HEALTH

Sleep is a part of the body's natural 24-h clock, which is called the **circadian rhythm**. The circadian rhythm regulates the body's sleep-wake cycle by using information from the environment to help

our bodies wake up in the morning and go to sleep at night. The cycle depends on messenger chemicals called hormones produced in the body, and it is in a delicate balance. When it is in proper balance, the circadian rhythm allows us to stay awake and alert during the day, and we have enough energy to complete our tasks. A balanced circadian rhythm also allows us to go to sleep on time at night, recover from tiredness, eliminate cellular waste products that have built up, and repair any minor damage to our muscles that we developed during our daytime activities—making us feel refreshed and ready to go again in the morning.

We depend on light in the morning and darkness at night to help the body's clock continue turning on schedule, regulating the body's processes. When it gets dark outside, the absence of light sends a signal to the brain that it is time to start the sleep cycle part of the 24-h clock. The brain interprets darkness as a message saying "there is no need to stay awake and alert", and a pea-sized gland in the brain called the pineal gland begins to release a hormone called **melatonin** into the bloodstream. Melatonin is essential for the sleep-wake cycle and it helps promote good-quality sleep so that your body recovers and feels rested in the morning.

The sleep cycle has four stages: N1, N2, N3, and rapid eye movement (REM) (Figure 1). All the stages are important. During N1–N3, growth occurs, the muscles and the immune system are repaired, and the body and mind recover from tiredness. In the REM stage, the brain is highly active just like when we are awake, and this stage is important for memory development, learning, and dreaming, as well as for decreasing the level of a type of cellular waste product called **free radicals** [1]. When free radicals are present in high concentrations, they can damage both the body and brain cells.

For healthy, restful sleep, we must go through several sleep cycles each night. Interruption or a decrease in the number of completed cycles can lead to poor-quality sleep, leading to poor **cognitive performance**, decreased recovery, and incomplete free radical elimination. Repeated interruption or decreased time sleeping can lead to a condition called **oxidative stress**, in which the level of free radicals gets dangerously high. This happens because bodily processes that normally slow down while we sleep keep running instead, like a car that never shuts off and keeps producing exhaust. Elevated levels of free radicals can decrease health and cognitive performance [1]. Interestingly, melatonin can help to neutralize excess free radicals in the body, so it is believed to have a strong protective effect against oxidative stress [2].

MELATONIN

A hormone produced and released by the pineal gland, to begin the sleep stages of the sleep-wake cycle. Levels of melatonin are increased in the absence of light.

FREE RADICALS

Cellular waste products that, when present at high levels, can damage cells and lead to oxidative stress.

COGNITIVE PERFORMANCE

The ability to think, reason, solve problems, pay attention, and remember things.

OXIDATIVE STRESS

A condition in which high levels of free radicals cause damage to the brain and body, which can lead to disease.

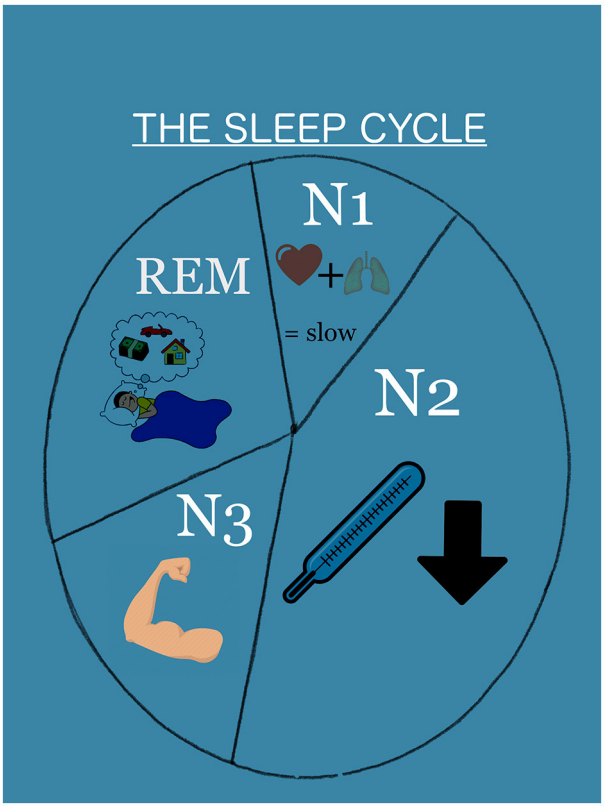


Figure 1

Figure 1

The sleep cycle has four stages. N1, which lasts a few minutes, the body is falling asleep but has not fully relaxed. The heart and breathing rates begin decreasing. N2 lasts about 25 min, during which the body relaxes and body temperature and brain activity decrease. N3, known as deep sleep, lasts 20–40 min. This is when the body is the most relaxed and when the most repair happens. During the REM stage, vivid dreaming happens and memory and creativity are boosted. REM stages begin after about 90 min of uninterrupted sleep, and they increase in length throughout the night.

HOW DO LIGHT AND DARKNESS REGULATE THE SLEEP-WAKE CYCLE?

All pathways that control essential functions in the body exist in balance with other pathways that produce the opposite effects. This way, the pathways can regulate each other. This is the case with the hormones melatonin and **cortisol** (Figure 2). Cortisol is a stress hormone released by the adrenal glands, which sit atop the kidneys, and it is responsible for creating the state of being awake and alert. In the morning, as the light from the sun enters our eyes, a signal is sent to the brain that acts like a wake-up alarm. The release of melatonin stops and the level of cortisol in the bloodstream rises, causing us to feel awake and alert. This process aligns the body's clock to the time of day.

CORTISOL

A stress hormone released from the adrenal glands, responsible for the wake stage of the sleep-wake cycle. Cortisol levels increase when light enters our eyes.

However, the same wake-up alarm effect happens when we use technology at night. The light from electronic devices enters our eyes, sending a signal to the brain that it should still be awake, alert, and on duty. One type of light produced by most devices, called blue light, is especially good at preventing melatonin release. The sun emits more blue light in the morning as it rises than at night when it sets—so our bodies are designed to respond to blue light by "waking up" [3].

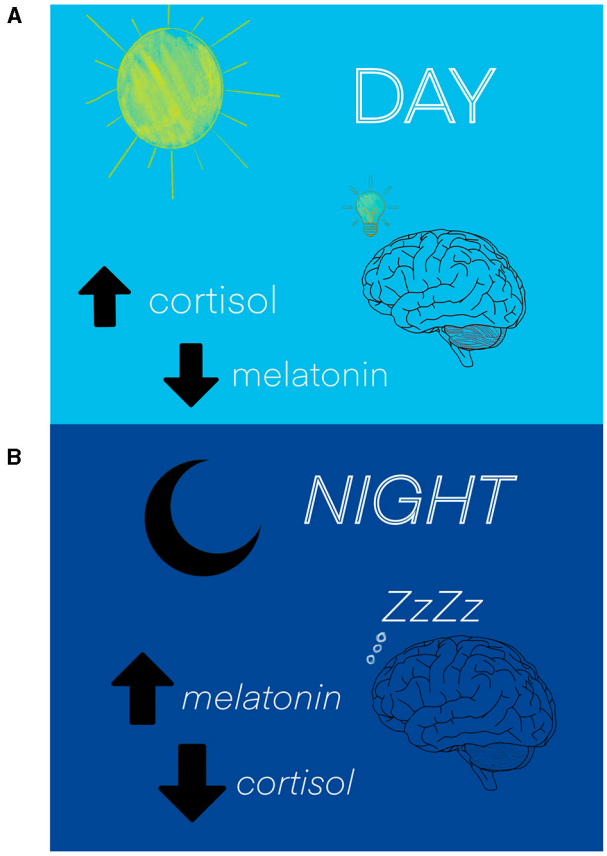


Figure 2

The circadian rhythm aligns the body with the 24-h day. Cortisol and melatonin regulate the sleep-wake cycle. **(A)** In the morning, sunlight enters the eyes and signals the brain to release cortisol to awaken the body, so that we can be alert and productive. During the day, cortisol remains elevated, and melatonin is decreased. **(B)** As the sky darkens, melatonin is released by the pineal gland to start sleep. Melatonin release depends on darkness sending a signal to the brain. Cortisol levels remain decreased while melatonin levels are elevated.

By preventing melatonin from being released when it should be, the brain is tricked into thinking it is still daytime even though it is dark outside. Therefore, we do not fall asleep when we should—a condition called **sleep latency**—because the brain is receiving the message that it should be awake, alert, and functioning. Sleep latency puts the circadian rhythm off balance, which can lead to a number of problems.

SLEEP LATENCY

The delay of the start of the sleep stages of the sleep-wake cycle, which can occur when we use devices at night.

TECH AT NIGHT AFFECTS MENTAL HEALTH

Just like our battery-powered devices, our bodies need to "recharge" to function at their highest capacity. If our bodies' "batteries" run down and we do not stop to recharge, our bodies will not run as efficiently nor function at their best (Figure 3A). Furthermore, the bodily systems for regulating mood depend on sleep. When sleep latency happens, other pathways that regulate cortisol levels will also be affected [4]. In this case, people can develop mood disorders related to elevated cortisol, including depression and other mental illnesses [3, 4]. Scientists have discovered that people who work night shift jobs are 40% more likely to develop depression [4], probably due to the interruption of the circadian rhythm and general lack of sleep.

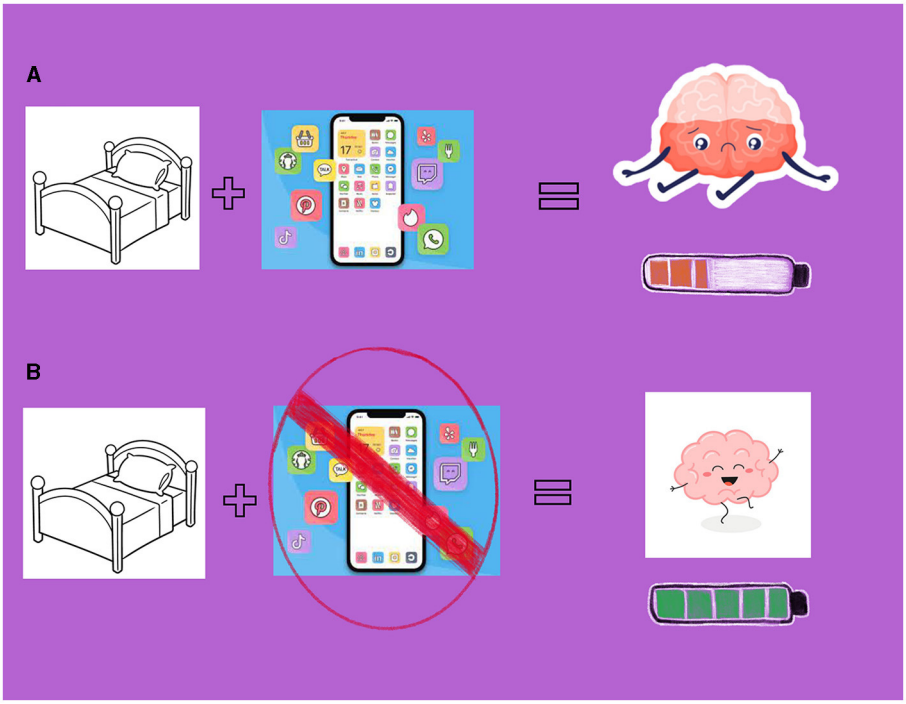


Figure 3

Figure 3

For the best sleep, it is important to put electronics away about an hour before going to bed. **(A)** Using electronics close to bedtime or while in bed prevents the normal release of melatonin and keeps cortisol levels high, leading to sleep latency, poor sleep quality, and increased oxidative stress. When this happens, the brain cannot fully "recharge", which leads to poor cognitive performance, tiredness, and poor recovery. **(B)** Shutting down electronics before sleep and decreasing blue light exposure at bedtime can help with melatonin production, which promotes quality sleep, restfulness, recovery, and good cognitive performance the next day.

PROTECTING YOURSELF FROM SLEEP PROBLEMS

Even if you currently use your devices at night and experience the negative effects lack of sleep can have, there are ways to help reverse the effects and fix any imbalance in your circadian rhythm. While scientists found that depriving rats of REM sleep for 96 h increased free radicals and oxidative stress in the rats' brains, these effects were reversed after the rats had some restorative sleep [1]. This means that, even if you feel unwell after a few nights of poor sleep, you can restore your circadian rhythm, reduce your levels of free radicals and oxidative stress, and get yourself back to functioning normally—simply by getting some good-quality sleep.

Furthermore, limiting or completely eliminating the use of electronic devices before bedtime can prevent interruption of the circadian rhythm, which will prevent sleep latency and help the natural sleep-wake cycle (Figure 3B). Switching the lights in your home to lower the amount of blue light you encounter leading up to bedtime can help, too. Red light has been shown to improve sleep quality, and yellow and orange lights have little to no effect on the circadian rhythm and may increase melatonin production.

Finally, if you must use technology at night, using a pair of blue light-blocking glasses and turning on "nighttime mode" in the evening can help to decrease the amount of blue light your devices give off. This will limit the signals to your brain that prevent melatonin release

and cause sleep latency, which can help you get a better night's sleep [3, 4].

Overall, sleep is one of the most important contributors to our mental and physical health and cognitive function. Taking care to place our devices aside about an hour before bedtime makes a world of difference in the sleep quality we have each night as well as our overall physical and mental health. As a result, our circadian rhythm will be in balance and we will be able to fall asleep and wake up around the same times every day. Through making these efforts, we can ensure we get regular, good-quality, and uninterrupted sleep to stay healthy and productive.

ACKNOWLEDGMENT

All figures were produced by DH and NC, 2023.

Image credits Figure 1: https://www.freepik.com/premium-vector/lungs-great-design-any-purposes-cartoon-illustration-simple-vector-illustration_28611922.htm, https://www.istockphoto.com/vector/red-heart-vector-gm842899542-137687935. https://www.iconfinder.com/icons/2329949/arm_bicep_cartoon_hand_muscle_muscular_sport_icon, https://www.vecteezy.com/vector-art/2889592-cartoon-man-dreams-of-money-house-and-luxury-car-while-sleeping-vector-illustration, https://www.vectorstock.com/royalty-free-vector/thermometer-cartoon-icon-on-white-background-vector-7571739. Image credit Figure 2: https://www.rawpixel.com/search/brain%20drawing?page=1&path=_topics&sort=curated. Image credits Figure 3: https://www.etsy.com/listing/885717259/75-bold-cartoon-style-ios-14-icons-cute, https://easydrawingguides.com/coloring-pages/cartoon-bed/, https://www.istockphoto.com/vector/funny-mischievous-cartoon-brain-character-gm1221591976-358143481, https://www.carstickers.com/products/stickers/anatomy-stickers/brain-stickers/marketplace/brain-depressive-cartoon-sad-tired-brain-sticker/.

REFERENCES

1. Mathangi, D. C., Shyamala, R., and Subhashini, A. S. 2012. Effect of REM sleep deprivation on the antioxidant status in the brain of Wistar rats. *Ann. Neurosci.* 19:161–4. doi: 10.5214/ans.0972.7531.190405
2. Korkmaz, A., Reiter, R. J., Topal, T., Manchester, L. C., Oter, S., and Tan, X. 2009. Melatonin: an established antioxidant worthy of use in clinical trials. *Mol. Med.* 15:43–50. doi: 10.2119/molmed.2008.00117
3. Bedrosian, T. A., and Nelson, R. J. 2017. Timing of light exposure affects mood and brain circuits. *Translat. Psychiat.* 7:e1017. doi: 10.1038/tp.2016.262
4. Walker, W. H., Walton, J. C., DeVries, A. C., and Nelson, R. J. 2020. Circadian rhythm disruption and mental health. *Translat. Psychiat.* 10:1–13. doi: 10.1038/s41398-020-0694-0

SUBMITTED: 13 December 2023; **ACCEPTED:** 05 April 2024;
PUBLISHED ONLINE: 17 April 2024.

EDITOR: Elizabeth Johnson, Northwestern University, United States

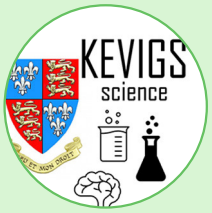
SCIENCE MENTORS: Charlotte Cartledge and Mohammad Dastjerdi

CITATION: Constantinesco NJ, Harkey DD and Fowler LA (2024) Tick Tock! It Is Time For Bed! Front. Young Minds 12:1355260. doi: 10.3389/frym.2024.1355260

CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

DELARA, AGE: 11
My name is Delara. I am 11 years old, and I am very excited to write this review from my point of view. Some facts about me are that I love reading, piano, soccer, and taekwondo. My favorite books are the Harry Potter series, Wonder, Pride and Predjust, and because of Winn Dixie. So far, I have learned much about the brain from my dad, and I can not wait to finish this interview.



KING EDWARD VI GRAMMAR SCHOOL, AGES: 11–15
Hello! We are a group of Year 7–10 students interested in science and psychology. We think that being Young Reviewers will expand our own horizons of knowledge and help researchers and scientists with their work!

AUTHORS

NICHOLAS JOHN CONSTANTINESCO
I am a current master's student at Wake Forest University School of Medicine, and previously earned my BS in Biology at the University of Pittsburgh. During undergrad and after graduating, I was involved in basic science research and published a manuscript in the realm of pulmonary immunology. I have a great research interest and am looking forward to my future in the field. After earning my master's, I plan to begin medical school and get involved in clinical research to move the needle forward in the world of medicine. Research is the foundation of clinical practice,

and I look forward to helping drive our knowledge of the body and medicine forward.
*njconsta@wakehealth.edu

DEYLON DIANNA HARKEY

My name is Deylon Harkey and I attended Wofford College in Spartanburg, SC, where I received my B.S. in biology. I continued my education at Wake Forest School of Medicine, where I am presently studying to receive a master's degree in biomedical science. I plan on attending medical school upon the completion of my master's degree. I hope to gain knowledge and experience that I will carry into becoming a skilled physician.

LAUREN A. FOWLER

My research focuses on how we change (physiologically, cognitively, behaviorally, and emotionally) in relation to our biological rhythms. As PI on several university, NSF, and NIH grants, and consultant for the Air Force Research Laboratories Human Effectiveness Directorate, I have established myself as a leader in the field of circadian desynchronization and fatigue, assessing how it affects our thoughts, our emotions, our perceptions, and our behavior. Much of my work has focused on physiological variables related to circadian desynchronization, however, my recent research has expanded to include how fatigue affects healthcare worker cognition, empathy, burnout, and perceptions, especially in emergency medical workers (ED physicians and EMTs).