Sleep & Medical Training

"If sleep doesn't serve an absolutely vital function, it is the greatest mistake evolution ever made."—Allan Rechschaffen, University of Chicago

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The Mystery of Sleep

A period of daily physiologic quiescence is a predictable and seemingly inescapable phenomenon in nearly all organisms from yeast to primates. Humans have long pondered the purpose of this seemingly disadvantageous state. Fortunately, recent discoveries have shed light on the evolution of sleep, its nature, and its function.

Sleep serves different purposes at different developmental stages and varies depending upon sleep state (rapid-eye-movement [REM] sleep vs non-REM [NREM] sleep). An energetic and fascinating debate regarding sleep function has emerged over the last decade. Contesting theories include adaptive inactivity,[1] synaptic homeostasis,[2] clearance of CNS toxins,[3] processing of novel stimuli,[4] and reactivation of memory traces (Table 1).[5]

Sleep in Medical Training

Physicians and, in particular, neurology residents find themselves in a uniquely challenging position. During training, they learn about the importance of sleep in brain health and the consequences of sleep deprivation yet must curtail their own sleep. One week they discover that poor sleep may contribute to the aggregation of insoluble β-amyloid, and the next, they are learning about the role of sleep in emotional regulation with consequences for substance abuse and suicidality.[6,7] This unique combination of insight and sleep disruption primes a neurologist for burnout.

The challenges start early. Beginning in medical school, usually with clinical training—historically during the third year—a culture of sleeplessness is established. The shift from foundational learning to clinical training is often jarring on sleep and circadian rhythms as the student shifts from relatively consistent wake-sleep patterns to early starts, late evenings, disrupted meals, and inconsistent exercise routines. Later, as neurologists enter residency, they experience more sleep fragmentation when they begin taking overnight on-call duties.

The initiation of an 80-hour work week by the Accreditation Council for Graduate Medical Education (ACGME) in July 2003 was based upon the assumption that limiting hours would better address trainee fatigue and decrease medical errors.[8] These changes, however, created new challenges, as they often led to more more overnight shift work and more disruption of circadian rhythms because of intermittent "night float" schedules. Recently a report from 4 medical teaching centers confirmed that the greatest pre-

TABLE 1. THEORIES OF SLEEP FUNCTION

Theory[a]	Sleep state	Mechanism	Function and evolutionary advantage
Adaptive inactivity[1]	NREM and REM	Limit wakeful activities to maximize efficiency in food acquisition, reproduction, and safety	Reduce nonvital energy expenditures
Synaptic homeostasis[2]	NREM	Slow-wave activity depotentiates or prunes brain synapses	Promote synaptic plasticity and optimize CNS energy expenditures
Clearance of CNS toxins[3]	NREM	Constriction of neuronal cell bodies expands extracellular space and increases CSF flow through glymphatic system	Increased clearance of insoluble β-amyloid and other metabolic toxins
Novel stimuli processing[4]	REM	Motor twitches promote nervous system processing of novel stimuli	Establish high-fidelity sensorimotor cortical circuits in the perinatal period
Hippocampal replay[5]	REM	Repotentiation of limbo-hippocampal circuits	Encode and enhance emotionally salient memories

Abbreviations: CFS, cerebrospinal fluid; CNS, central nervous system; NREM, non-rapid eye movement; REM, rapid eye movement.
[a] References given are representative of only some work of only some of the pioneers advancing this particular theory.

dictor for burnout among residents was not a loss of professional satisfaction, call burden, or malignant faculty, but instead the presence of a sleep problem.[9]

Of course, once physicians enter practice, duty hour regulations are lifted, and many neurologists begin having more than 80 hours of work per week plus all of the sleep disruption that comes with a busy clinical practice. Even if they work less than 80 hours per week, many neurologists suffer from sleep and circadian rhythm disorders affecting their mood, cognition, and cardiovascular health. Concerningly, poor sleep puts us at risk not only for metabolic disturbances, cognitive dysfunction, and sleepiness, but also fatal motor vehicle accidents. Ultimately these consequences are felt by our patients when our ability to practice medicine is impaired. Fortunately, there is good reason for us to be hopeful because sleep and circadian rhythm disturbances are easily managed—even as call and overnight shift work must go on.

Neurologist, Sleep Thyself

The first step toward sleeping better requires that we identify the nature and phase of our circadian rhythms. It would be difficult to overstate how important circadian rhythms are in medicine and how frequently these physiologic processes are overlooked by clinicians and patients alike. Circadian rhythms help coordinate not only sleep and wakefulness but also align the biorhythms of all organs, from the skin to the cardiovascular system. Hospitals, which should be conducive to healing, notoriously disrupt the body's 24-hour clock with evening light from computer screens, patient devices, and medical equipment and a paucity of bright morning sunlight exposure. Not surprisingly, many patients develop evening confusion, or "sundowning," and medications may lose efficacy when administered in a manner that is out of sync with an individual's internal clock.[10]

Just like height or eye color, all of us have our own unique circadian rhythm to understand and explore (Box). Day in and day out, your suprachiasmatic nucleus (SCN) is trying to find a consistent rhythm. Our environment, however, with changing work and social schedules, varying meal times, and artificial light exposure are constantly pushing the SCN in one direction or the other. For most of us, a simple thought experiment can bring critical insight by asking: What would your natural sleep time be, if you were given the opportunity to sleep ad lib? In particular, what would your sleep schedule look like, if you did not have any professional, educational, familial, or social constraints on your schedule? Specifically if:

- you did not need to wake up in the morning for any obligation
- you did not need to go to bed at any particular time
- you did not have any social pressure, nor guilt about falling asleep or sleeping in until a certain time of the day
- you did not take any exogenous sedating or stimulating substances (ie, no alcohol and no caffeine as well as no sedating or activating medications or supplements)

When would you naturally fall asleep? How late could you sleep in? When would you wake up without an alarm?

For most individuals, this thought experiment will bring to mind a certain sleep schedule. More often than not, this sleep schedule is misaligned with our work, educational, and social obligations. For most young physicians (ie, residents) who struggle with sleep, the most common scenario is that they have a circadian rhythm delay, meaning that under a genuine ad lib schedule they would naturally go to bed later at night and sleep in later in the morning. Circadian rhythms are typically delayed in adolescents and young adulthood and then progressively advance over a lifetime.[11,12] Sometimes a circadian rhythm advances to the point where a person would naturally fall asleep and wake up earlier than desired. This is called an *advanced circadian rhythm* and manifests with an individual who is excessively tired in the evening but can't sleep through the night.

It is critical for each individual struggling with sleep to define their circadian phase because most sleep disorders are, at least in part, circadian disorders. Further, unless the circadian rhythm is properly aligned, individuals' sleep symptoms are unlikely to be resolved.

Box. Questions for Physicians to Explore Their Own Circadian Rhythms

- →When do I naturally get sleepy?
- →When do I best wake up for the day?
- →When is the best time for me to exercise?
- →When is it natural and comfortable to go to the bathroom?
- →When do I best retain new information such as continuing medical education (CME) content?

Establish a Healthy Circadian Foundation

Once a circadian rhythm is identified, steps can be taken to shift it toward the direction of more restful healthy sleep. For example, take the common situation of a circadian rhythm delay in neurology residents. They struggle to fall asleep early enough in order to wake up refreshed in the morning. If given the opportunity, they would naturally fall asleep later and wake up later in the morning.

Circadian delays are, in large part, a modern consequence of excessive evening light exposure. Light from lamps, smart phones, tablet computers, and other sources activate the SCN, through a pathway that starts in the retinal ganglion cell (RGC) layer, incorrectly signaling the brain that the sun is still out late into the evening. This results in a permanent state of

"social jet lag," because an individual's body clock is often several hours later than their environment. Not surprisingly, with such circadian misalignment, it is not only a struggle to fall asleep at night but also a struggle to wake up in the morning.[10]

The solution to this problem is to decrease the hypothalamic signal from evening light exposure, while increasing the intentional delivery of bright light in the morning. Everyone who struggles with a circadian delay should focus on getting a consistent sunrise (or the equivalent with a 10,000-lux light source). This light should be used at the same time every day for at least 30 minutes per day, 7 days per week. The most robust effect is seen when the light is used for more than 1 hour. Comparatively, in the evening, light bulbs and the glow from hand-held devices should progressively dim in the hours leading up to bedtime. Blue-light–blocking software (eg, night shift or night light programs on cell phones and tablets) are helpful to limit RGC activation because the circadian-cuing melanopsin receptors are most sensitive to this color of light. For individuals who still need help advancing a circadian rhythm, low doses of melatonin (0.5 mg) taken orally 4 hours before bedtime is a strategy with substantial clinical evidence. Conversely, individuals who struggle with an advanced circadian rhythm may benefit from evening light therapy and avoidance of morning light (through wearing dark sunglasses).[10] For more details on managing these and other circadian rhythm disorders, see the excellent review by Zee et al.[1]

Address Sleep Fragmentation

Although the sleep-fragmenting effects of being on call are outside of physicians' control, it is important to screen for and manage common sleep disorders that can impair the quality of the little sleep physicians often get. In particular, sleep-disordered breathing and sleep-related movement disorders such as obstructive sleep apnea (OSA) or restless legs syndrome (RLS) are highly prevalent in the general population.[13]

The collapse of the upper airway during sleep, OSA causes frequent sleep disruption that leads to feeling unrefreshed even when getting full nights of sleep. The combination of hypoxemia and hyperadrenergia increases cardiovascular and cerebrovascular risks.[13]

Characterized by lower extremity discomfort that worsens in the evening, during motor quiescence, RLS interferes with sleep onset and restoration. The discomfort of RLS is relieved by movement, although only momentarily.

Other sleep disorders that can affect young physicians include narcolepsy and psychophysiologic insomnia. Importantly, the disabling symptoms of these and other sleep conditions are often effectively resolved once they are properly diagnosed and treatment is initiated.[13]

Surviving—or Even Thriving—During Overnight Shift Work

For physicians in training, adjusting to overnight shift work is challenging. Although each individual responds uniquely to sleep restriction and circadian disruption, there are a few evidence-based strategies that can help (Table 2). In particular, in the days leading up to the first night of overnight work, start adjusting the circadian rhythm later with bright light therapy (eg, use a 10,000-lux light box) in the evening and, if practical, sleep as late in the morning as possible. Once work has begun, use bright light therapy for the first half of your shift and wear sunglasses on the way home from work in the morning. If needed, take a small dose of melatonin (1-3 mg) at your desired bedtime. Work to achieve consistency in timing your meals and exercise, which—along with bedtime melatonin and wake time sunlight—are important *zeitgebers* (literally "time givers"), reminding and reinforcing your circadian physiology.

TABLE 2. STRATEGIES[a] FOR SHIFTING INTO AND MAINTAINING CONSISTENT OVERNIGHT SHIFT WORK (9:00 PM TO 7:00 AM)

Days	Days prior to shift	Days during shift	Days after shift
Bright light therapy	Evening until bedtime Avoid upon waking	Evening until 2:00 AM Avoid upon waking	Evening until at least midnight
Bedtime	Delay typical bedtime by 2-3 hours	1-2 hours after getting home (for example 8:00 AM)	No more than 2 hours earlier than work bedtime (for example 6:00 AM)
Melatonin	None or a small (0.3-0.5 mg) dose upon awakening	Bedtime	None
Meal times	Delay by 2-3 hours from typical meal times	3:00 PM, 9:00 PM, 3:00 AM	No more than 2 hours earlier than work meal times (1:00 PM, 7:00 PM, 1:00 AM)
Exercise	Delay by 2-3 hours from typical exercise times	Same consistent time during awake period	Same consistent time during wake period

[a]These strategies are based on the assumption that an individual will be shifting to overnight shift work for a sustained period of time. They are not meant for doing 1 night of overnight shift work and then switching back to days, or some other similar rotation.

On weekends, try to maintain schedule consistency, even when not working, because people do best if they do not shift their schedules forward or back by more than 2 hours on a weekend. Shifting more than 2 hours makes it substantially more difficult to switch back to overnight work schedules, resulting in "social jet lag" upon returning to shift work. Because overnight shift work is often socially isolating, support from family, roommates, and friends is critical.

Be careful driving. If you feel tired or sleepy, don't hesitate to call a friend, family member, or coworker, or catch a ride home with a ride share, bus, or taxi.

Conclusion

It is clear that sleep is critically important for the health of our 100 billion neurons and their trillions of synapses. New insights shed light on the neurologic functions of sleep and have implications for the development of novel CNS therapies.

For physicians in training, the opportunity to practice medicine and care for others is an honor that requires many sacrifices, including sleep. Fortunately, there are strategies that can help you deal with the 24-hour challenges of practicing modern medicine. Work first to optimize your circadian rhythm and manage any underlying sleep disorder so the sleep you do obtain is as refreshing as possible.

Sleep well. ■

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Disclosure

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