“Nodding Off” The Radiologist and the Implications of Poor Sleep Hygiene

Authors and Disclosures

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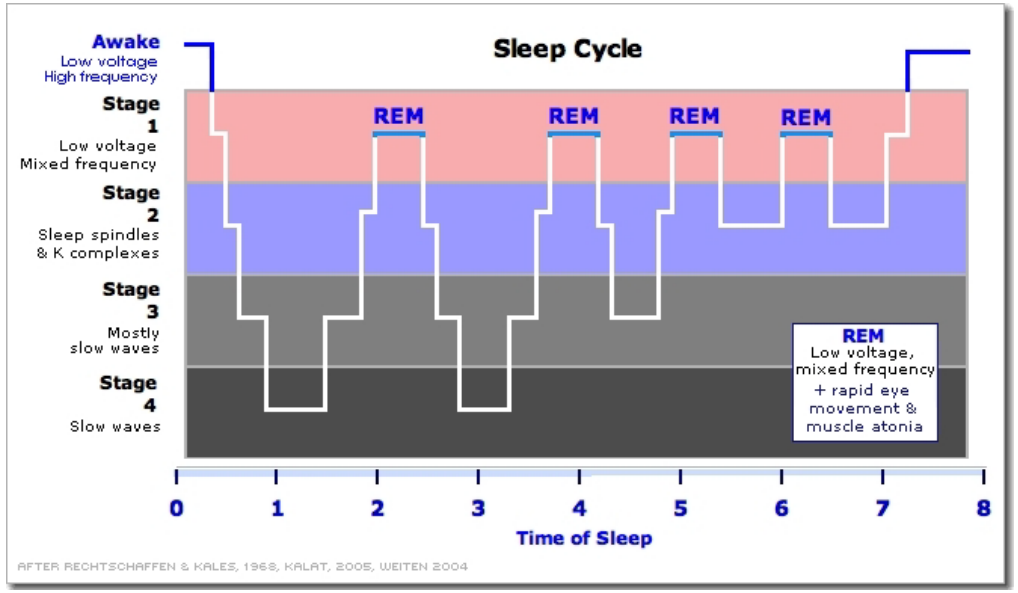
Sleep Cycle Overview

- A comprehensive definition of sleep remains elusive
- Sleep is “an easily reversible and self-regulating… natural state characterized by a reduction in voluntary motor activity, a decreased response to stimulation and stereotypic posture” (Fuller et al 2006)
- Although the reasons and evolutionary origins of sleep are still debated, its physical and cognitive importance has been clear intuitively for millennia and scientifically for decades.

Sleep Cycle Overview

- The "Sleep Cycle" is better viewed as the "Sleep-Wake Cycle", divided broadly into:
  - Wakefulness: Ascending arousal system from upper brainstem to diffuse cerebral cortex activation
  - Non-REM sleep: Stages 1-4; Decreasing brainwave frequency; ~ 75-80% by time
  - REM sleep: Low voltage; mixed frequency brainwaves with muscle atonia and rapid eye movements; ~20-25%.



Sleep Hygiene

- Interestingly, research thus far has demonstrated sleep hygiene education as an ineffective monotherapy for insomnia, however it may still have a role in public health efforts
- Research tools such as the Sleep Hygiene Index attempt to standardize the factors contributing to an individuals sleep health

Sleep Hygiene Index (Mastin, Bryson and Corwyn, 2006)	
1. I take daytime naps lasting two or more hours.	8.I go to bed feeling stressed, angry, upset, or nervous.
2. I go to bed at different times from day to day.	9.I use my bed for things other than sleeping or sex (for example: watch television, read, eat, or study).
3.I get out of bed at different times from day to day.	10.I sleep on an uncomfortable bed (for example: poor mattress or pillow, too much or not enough blankets).
4.I exercise to the point of sweating within 1 h of going to bed.	11.I sleep in an uncomfortable bedroom (for example: too bright, too stuffy, too hot, too cold, or too noisy).
5.I stay in bed longer than I should two or three times a week.	12.I do important work before bedtime (for example: pay bills, schedule, or study).
6.I use alcohol, tobacco, or caffeine within 4 h of going to bed or after going to bed.	13.I think, plan, or worry when I am in bed.
7.I do something that may wake me up before bedtime (for example: play video games, use the internet, or clean).	

Evidence Behind Sleep Hygiene Factors (Irish et al, 2015)

- **Caffeine and alcohol**:
  - Do cause sleep disruptions if used close to bedtime. Response is dose-dependent, but tolerance can be developed within days.
- **Exercise**:
  - Regular exercise produces moderate improvements in sleep
- **Schedule Regularity**:
  - Studies support benefit in regularity of wake time
- **Napping**:
  - Most research suggests daytime naps do not have a substantial impact on nocturnal sleep
- **Stress management techniques:**
  - Have been shown effective to reduce pre-sleep arousal and improve sleep
- **Bedroom noise**:
  - Increases arousals. Habituation occurs but EEG arousals persist.
  - Noise reduction strategies have been shown effective

Importance of Sleep: Short-Term, Severe Deprivation

- Controlled experimental data has been highly effective in demonstrating the cognitive effects of severe sleep deprivation (24-72 hours) (Jackson 2013)
- Decreased function during working memory tasks, slower reaction time, increased driving errors
- While these findings certainly confirm the dangers in severe sleep deprivation, these conditions likely should not be able to be applied to radiology practice outside of the most extreme conditions

Importance of Sleep in Cognitive Performance

- Cross sectional population based study. Assessed cognitive performance for reasoning, reaction time, numeric memory, visual memory and prospective memory.
- Sleep medication use as well as long (>9h) or short (<7h) sleep durations were associated with impaired performance.
- Surprisingly, frequent insomnia symptoms were correlated with higher cognitive performance
- Cognitive performance was inferior for those with propensity to “morningness” rather than “eveningness” (Kyle et al, 2017)

Importance of Sleep in Cognitive Performance

- Dose-response chronic sleep restriction experiment (Van Dongen et al, 2013)
- Restricted sleep for two weeks (chronic) in groups of 4h, 6h, 8h per night as well as a total restriction group with 0 hours for 3 days
- Chronic restriction of 6h or less per night produced similar cognitive deficits to total restriction for two days.
  - Perhaps even more concerning, the chronic deprivation group were seemingly unaware of growing deficits due to a lack of increase in ”sleepiness” ratings as time went on.
- Suggest a “critical wake period” of ~16 hr, beyond which there is a linear increase in cognitive performance lapses

Chronic vs Acute Sleep Restriction

- Demonstration of the effect of acute and chronic sleep restriction for vigilance performance lapses (top left), a subjective sleepiness score (top right), digit symbol substitution tasks (bottom left) and addition/subtraction tasks (bottom right)
- As expected, acute restriction (black boxes) led to rapid declines in performance in all categories, as well as increased sleepiness
- Interestingly, cognitive ability varied drastically between the three chronic conditions, however subjective sleepiness remained nearly equivalent between moderate and severe restriction

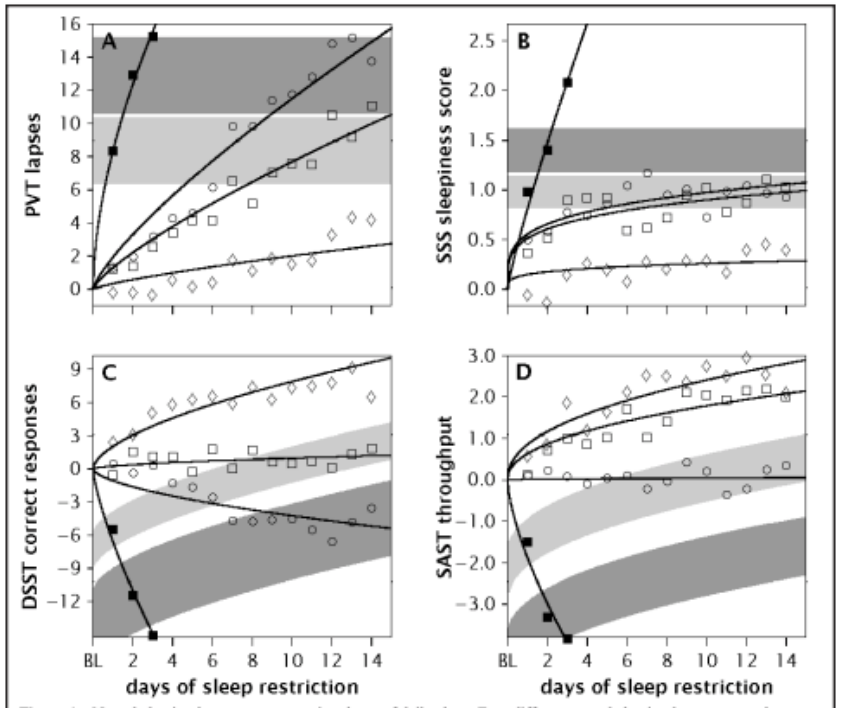


Figure 1—Neurobehavioral responses to varying doses of daily sleep. Four different neurobehavioral assays served to measure cognitive performance capability and subjective sleepiness. Each panel displays group averages for subjects in the 8 h (◇), 6 h (□), and 4 h (○) chronic sleep period conditions across 14 days, and in the 0 h (■) sleep condition across 3 days. Subjects were tested every 2 h each day; data points represent the daily average (07:30–23:30) expressed relative to baseline (BL). Panel A shows psychomotor vigilance task (PVT) performance lapses; panel B shows Stanford Sleepiness Scale (SSS) self-ratings; panel C shows digit symbol substitution task (DSST) correct responses; and panel D shows serial addition/subtraction task (SAST) correct responses per min. Upward corresponds to worse performance on the PVT and greater sleepiness on the SSS, and to better performance on the DSST and the SAST. The curves through the data points represent statistical non-linear model-based best-fitting profiles of the response to sleep deprivation (equation (1)) for subjects in each of the four experimental conditions. The mean ± s.e. ranges of neurobehavioral functions for 1 and 2 days of 0 h sleep (total sleep deprivation) are shown as light and dark gray bands, respectively, allowing comparison of the 3-day total sleep deprivation condition and the 14-day chronic sleep restriction conditions. For the DSST and SAST, these gray bands are curved parallel to the practice effect displayed by the subjects in the 8 h sleep period condition, to compensate for different amounts of practice on these tasks.

Sleep Deprivation and Medicine

- Study of Shift work for nurses – lower scores in general intellectual ability, math, response inhibition, attention, simple reaction time and working memory among those with sleep deprivation (Kaliyaperumal et al, 2017)
  - 69% of shift working nurses had disturbed sleep patterns.
  - Decreased general intellect, attention and memory tests for night-shift workers
  - No studies have directly looked at the impact of sleep restriction or sleep hygiene factors on the performance of radiologists

The Radiologist and Sleep

- The effect of fatigue towards the end of long radiology shifts has been well-established as detrimental to a radiologists focus and detection accuracy (Krupinski et al, 2010)
- One study found that sleep deprivation correlated with an unaware decline in visual function for radiologists (Maeda et al, 2011)
- Subjective measurements of sleepiness as well as self-reported sleep length do suggest some effect of sleep deprivation on radiologist performance
- Prospective sleep restriction studies as well as studies of sleep hygiene and habits for radiologists are lacking

Methods for Improvement

- Despite a lack of research into sleep hygiene for radiologists, some general applications can be suggested based on research in other fields.
- Assessment of sleep hygiene habits can be a helpful tool. The best supported sleep hygiene factors include alcohol avoidance, regular exercise, stress management techniques and bedroom noise reduction.
- Studies of sleep deprivation among medical professionals as well as the observed effects of fatigue on radiologist performance suggests that it may be a particularly susceptible field to poor sleep quality
- Optimization of call-scheduling is a crucial, well-demonstrated component of radiology performance

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