Overview of the Biology of Sleep and Circadian Rhythms

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The 4 pillars of health

Behavioral Health Risk Factors

- Alcohol use
- Physical inactivity
- Obesity
- Poor nutrition
- *Short or long sleep duration*

1 Berkman LF, Breslow L. *Health and Ways of Living: the Alameda County Study*, 1983.
Sleep is related to individual health

Insufficient Sleep

Diabetes

Coronary Heart Disease

Obesity

Hypertension

Early Mortality
Overview of the biology of sleep and circadian rhythms

▪ What are *circadian rhythms*, and what controls them?
▪ What is *sleep*, and what controls it?
▪ Can we optimize teen sleep for *better health*?
### The rhythms of life

<table>
<thead>
<tr>
<th>Time</th>
<th>Examples</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than a second</td>
<td>Brain (EEG) waves</td>
<td><strong>Ultradian</strong> = Rhythm that cycles in &lt;24 hrs</td>
</tr>
<tr>
<td>Seconds</td>
<td>Heart (EKG) waves</td>
<td></td>
</tr>
<tr>
<td>Minutes</td>
<td>Breathing</td>
<td></td>
</tr>
<tr>
<td>Hours</td>
<td>Sleep stages</td>
<td></td>
</tr>
<tr>
<td>Day</td>
<td>Sleep-wake cycle</td>
<td></td>
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<tr>
<td>Month</td>
<td>Childbirth</td>
<td><strong>Circadian</strong> = Rhythm that cycles in ~24 hrs</td>
</tr>
<tr>
<td>Year</td>
<td>Heart attacks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blood pressure</td>
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<td></td>
<td>Menstrual cycle</td>
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<tr>
<td></td>
<td>Hibernation</td>
<td><strong>Infradian</strong> = Rhythms that cycles in &gt;24 hrs</td>
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<tr>
<td></td>
<td>Migration</td>
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</tbody>
</table>
The suprachiasmatic nucleus (SCN) is the “master clock” of the circadian timing system.
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Videnovic, Nat Rev Neurol, 2014. 10:683–693
Every cell has a circadian clock

“Clock genes” regulate their own activity on a 24-hour cycle…

…and are present in every cell and tissue in the body.

How do we measure circadian rhythms?

Munich Chronotype Questionnaire

1. I go to bed at [__] o'clock.
2. Note that some people stay awake for some time when in bed!
3. I actually get ready to fall asleep at [__] o'clock.
4. I need [__] minutes to fall asleep.

Melatonin Concentration (Saliva or Blood)

Time of Peak

Time of Threshold Crossing = Dim Light Melatonin Onset (DLMO)

Control (N=27)
Insomnia (N=35)
What is sleep?

- “A recurring, reversible neuro-behavioral state of relative perceptual disengagement from and unresponsiveness to the environment”

- Typically accompanied (in humans) by postural recumbence, behavioral quiescence, and closed eyes

Carskadon and Dement, *Principles and Practice of Sleep Medicine*, 2005
Brain control of wakefulness and sleep

Wake-Promoting Systems

Sleep-Promoting Systems

How do we measure sleep?

Self-Report

Sleep Diary

Actigraphy (Behavioral)

Daytime rest periods

Irregular wake times

Irregular bedtimes
How do we measure sleep? Polysomnography

Delta EEG Activity (Quantitative)

Polysomnographic recording

Hypnogram
What controls sleep? The hourglass, the clock, and the alarm

How long you’ve been awake

Time of day

Level of arousal

Sleep drive

Circadian sleep-wake rhythm

Moment-to-moment arousal
What happens in adolescence?

How long you’ve been awake

Time of day

Circadian sleep-wake rhythm: Later timing

Level of arousal

Moment-to-moment arousal: Increases

Sleep drive: Takes longer to build up

Arousal Level

Sleep Propensity

Awake
Teen sleep: Biology vs. Environment

**Development, Biology**

- **Sleep Amount**: Sleep need unchanged
- **Sleep Timing**: Timing moves later
- **Sleep Consolidation**: Consolidated sleep is restorative

**Social Environment**

- **Sleep Amount**: Sleep amount reduced
- **Sleep Timing**: Social demands push later
  School start pushes earlier
- **Sleep Consolidation**: Social, electronics disrupt sleep
Sleep Health: Can We Define It? Does It Matter?

Sleep health is a multidimensional pattern of sleep-wakefulness... that promotes physical and mental well-being.

Regularity
Satisfaction
Alertness
Timing
Efficiency
Duration

↑ Health

RUSATED?

Buysse, SLEEP 2014; 37(1):9-17
# Sleep health matters!

<table>
<thead>
<tr>
<th>Sleep Dimension</th>
<th>Mortality</th>
<th>Metabolic Syndrome/Obesity</th>
<th>Diabetes/impaired glucose metabolism</th>
<th>Hypertension</th>
<th>Coronary Heart Disease</th>
<th>Depression</th>
<th>Impaired neuro-behavioral performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality/satisfaction</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+/-</td>
</tr>
<tr>
<td>Alertness/sleepiness</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Timing</td>
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<td>+</td>
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<td>+</td>
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<tr>
<td>Efficiency</td>
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<td>Duration</td>
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<td>+</td>
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<td>+</td>
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<tr>
<td>Regularity</td>
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<td>+</td>
<td>+</td>
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<td>+</td>
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Every cell has a circadian clock

“Clock genes” regulate their own activity on a 24-hour cycle... ...and are present in every cell and tissue in the body.

Can you sleep your way to better health?

Can we use this...  
To change these...  
Acting through these...  
To optimize these?

Interventions

Circadian Timing System

Sleep

Nutrition, Obesity

Physical Activity

Changes in Physiology

• Epigenetics
• Inflammation
• Immunity
• Hormones

Health Outcomes

• Physical Health
• Mental Health
• Cognitive Health

Genes, Environment, Social Interactions
Overview of the Biology of Sleep and Circadian Rhythms

- Circadian rhythms govern our physiology
- Sleep comes from the brain, but benefits the entire body
- Circadian rhythms and sleep change during adolescence
- Good sleep and circadian health is essential for good health
- Healthy sleep and circadian behaviors may improve our health

For better sleep health, ask yourself: RU SATED?
Regularity • Satisfaction • Alertness • Timing • Efficiency • Duration