“Sleep is the golden chain that ties health and our bodies together.”

Thomas Dekker

Mary ET Boyle, Ph. D.
Department of Cognitive Science, University of California, San Diego

Diego Rivera
First, then, this much is clear, that waking and sleep appertain to the same part of an animal, inasmuch as they are opposites, and sleep is evidently a privation of waking.

Aristotle

Sleep dwell upon thine eyes, peace in thy breast! Would I were sleep and peace, so sweet to rest.

Shakespeare

Think in the morning.
Act in the noon.
Eat in the evening.
Sleep in the night.

William Blake
“We are always hearing people talk about ‘loss of sleep’ as a calamity. They better call it loss of time, vitality and opportunities.”

Photos: Henry Ford Museum

“Sleep is a criminal waste of time and a heritage from our cave days.”

1800’s
Margaret Thatcher

“Sleep is for wimps!”

1980’s
Bill Clinton

"Every important mistake I've made in my life, I've made because I was too tired."
Sleep deprived bees cannot communicate the direction of the food source when they are sleep deprived.

Sleep deprivation impairs precision of waggle dance signaling in honey bees

Barrett A. Klein, Arno Klein, Margaret K. Wray; Ulrich G. Mueller, and Thomas D. Seeley
Sleep deprivation has been indicated as a cause in 7.8 percent of all the Air Force's Class A mishaps (Luna, 2003). Disasters such as Chernobyl, Three Mile Island, Davis-Besse, and Rancho Seco all occurred in the early morning (2:00 a.m. to 4:00 a.m.), a time when sleep deprivation effects are especially powerful, and all involved errors made by people working in groups (Harrison & Horne, 2000). Furthermore, sleep loss was specifically cited as a factor that contributed to the collective human error and poor judgment related to the Space Shuttle Challenger disaster (Presidential Commission on Space Shuttle Challenger Accident, 1986).
One Silicon Valley startup that encouraged its employees to think about work 24/7 found they missed market signals, tanked deals and became too irritable to build crucial working relationships.

https://www.npr.org/sections/health-shots/2016/04/26/475287202/many-grouchy-error-prone-workers-just-need-more-sleep
An Underappreciated Key to College Success: Sleep

Many college-bound students start out with dreadful sleep habits that are likely to get worse once the rigorous demands of courses and competing social and athletic activities kick in.
Studies show... "sleep quantity and sleep quality outrank such popular campus concerns as alcohol & drug use in predicting student's grades & a student's chances of graduating."

NYT J. Brody
“For me, nothing captures the idea of sleep debt quite like my years as a college student. In a story that repeated itself weekly, if not daily,...

I would squander my days soaking up the “college experience” (details spared) and spend all-nighters cramming, only to find myself wandering through a suffocating mire of brain fog as I walked into my exam the next morning.

Research has supported what I learned firsthand: that sleeping too little (or not at all) can inhibit your productivity and ability to remember and consolidate information.”

http://www.myhousecallmd.com/bq365-weeks-3-5-the-science-sleep/  
Brian Kim, MD, MS
This encourages all-mighty
The world's record for the longest sleep deprivation period is 11 days!

What happens when we don't sleep?

1. Cognitive & behavioral changes
2. ↓↓ ability to concentrate
3. ↓↓ short-term memory
4. Paranoia & hallucinations

http://www.online-clockalarm.com/facts/the-worlds-record-for-the-longest-sleep-deprivation-period-is-11-days
Moderate sleep deprivation produces impairments in cognitive and motor performance equivalent to legally prescribed levels of alcohol intoxication.
The Effects of Sleep Extension on the Athletic Performance of Collegiate Basketball Players

Cheri D. Mah, MS; Kenneth E. Mah, MD, MS; Eric J. Kezirian, MD, MPH; William C. Dement, MD, PhD

Stanford Sleep Disorders Clinic and Research Laboratory, Department of Psychiatry and Behavioral Sciences, School of Medicine, Stanford University, Stanford, CA; Department of Otolaryngology—Head and Neck Surgery, University of California, San Francisco, CA

Study Objectives: To investigate the effects of sleep extension over multiple weeks on specific measures of athletic performance as well as reaction time, mood, and daytime sleepiness.

Setting: Stanford Sleep Disorders Clinic and Research Laboratory and Maples Pavilion, Stanford University, Stanford, CA.

Participants: Eleven healthy students on the Stanford University men's varsity basketball team (mean age 19.4 ± 1.4 years).

Interventions: Subjects maintained their habitual sleep-wake schedule for a 2-4 week baseline followed by a 5-7 week sleep extension period. Subjects obtained as much nocturnal sleep as possible during sleep extension with a minimum goal of 10 h in bed each night. Measures of athletic performance specific to basketball were recorded after every practice including a timed sprint and shooting accuracy. Reaction time, levels of daytime sleepiness, and mood were monitored via the Psychomotor Vigilance Task (PVT), Epworth Sleepiness Scale (ESS), and Profile of Mood States (POMS), respectively.

Results: Total objective nightly sleep time increased during sleep extension compared to baseline by 110.9 ± 79.7 min (P < 0.001). Subjects demonstrated a faster timed sprint following sleep extension (16.2 ± 0.61 sec at baseline vs. 15.5 ± 0.54 sec at end of sleep extension, P < 0.001). Shooting accuracy improved, with free throw percentage increasing by 9% and 3-point field goal percentage increasing by 9.2% (P < 0.001). Mean PVT reaction time and Epworth Sleepiness Scale scores decreased following sleep extension (P < 0.01). POMS scores improved with increased vigor and decreased fatigue subscales (P < 0.001). Subjects also reported improved overall ratings of physical and mental well-being during practices and games.

Conclusions: Improvements in specific measures of basketball performance after sleep extension indicate that optimal sleep is likely beneficial in reaching peak athletic performance.

Keywords: Sleep extension, extra sleep, athletes, athletic performance, sports, basketball, collegiate, reaction time, mood, fatigue

Citation: Mah CD; Mah KE; Kezirian EJ; Dement WC. The effects of sleep extension on the athletic performance of collegiate basketball players. SLEEP 2011;34(7):943-950.
Participants: Eleven healthy students on the Stanford University men’s varsity basketball team (mean age 19.4 ± 1.4 years).
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For 6 weeks:

10 hrs sleep/night

(smiley face)
Results: STATS

* more accurate shooting
* faster reaction time
* ↑ mental health
* ↑ physical well-being
New Way to Think About Sleep
Sleep is important; our bodies demand it.
What regulates sleep?
Sleep wake cycle is regulated by the circadian system.

Light & Melatonin are the two most influential external cues that synchronize the circadian rhythm.
Superchiasmatic Nucleus in the brain is the “master clock” used to coordinate and synchronize most of the body clocks in the periphery.
If the sleep wake cycle is disrupted it can cause metabolic dysregulation, weight gain, obesity, impaired immunity, and cognitive malfunction.
Cyanobacteria is a photoautotrophic organism that has a self-sustained circadian rhythm. The sleep-wake cycle is regulated by the circadian system. The organism harvests energy and repairs DNA during its cycle.
Our metabolic clocks are based on the diurnal rhythm – it is in our genes.
Watch brain ticking

7 day timelapse recording

Day in the life of a cell 0-24 hours

Genes in cells cycle on and off every 24 hours
Every cell has its own clock!

Data from: David Welsh; Video: J. Takahashi (2013) https://www.youtube.com/watch?v=ocqn3wYTCRM#
One week of insufficient sleep alters gene expression in human blood cells.

Intensifies the effects of subsequent total sleep loss on gene expression.

Effects of insufficient sleep on circadian rhythmicity and expression amplitude of the human blood transcriptome


Insufficient sleep and circadian rhythm disruption are associated with negative health outcomes, but the mechanisms involved remain largely unexplored. We show (pp. E1132–E1141) that one wk of insufficient sleep alters gene expression in human blood cells, reduces the amplitude of circadian rhythms in gene expression, and intensifies the effects of subsequent acute total sleep loss on gene expression. The affected genes are involved in chromatin remodeling, regulation of gene expression, and immune and stress responses. The data imply molecular mechanisms mediating the effects of sleep loss on health and highlight the interrelationships between sleep homeostasis, circadian rhythmicity, and metabolism.
Shift workers are more prone to developing metabolic disorders

- Alcoholic liver disease
- 40% more likely to have cardiovascular disease
- Higher incidence of Diabetes Type II
- Higher risk of cancer — melatonin disruption

The Health Survey for England (2013); Davis S, Mirick DK. Cancer Causes Control. 2006 May; 17(4):539-45.
Circadian rhythm disruptions
- Body temperature
- Respiratory rate
- Hormonal production
- Menstrual cycle
- Urinary excretion
- Cell division

Brain effects
- Sleep loss
- REM sleep reduction
- Stage 2 sleep reduction
- Fatigue
- Reduced brain volume

Mental Health
- Stress
- Anxiety
- Depression
- Neuroticism
- Reduced vigilance
- ‘Burnout syndrome’

Gastrointestinal disorders
- Dyspepsia
- Heartburn
- Abdominal pains
- Flatulence

Cardiovascular disorders
- 40% increased risk for:
  - Angina pectoris
  - Hypertension
  - Myocardial infarction

Reproductive effects
- Spontaneous abortion
- Low birth weight
- Prematurity

Increased cancer
- Breast cancer
- Colorectal cancer

Adapted from: Nature Neuroscience Reviews
Disruption of the Circadian Clock in Mice Increases Intestinal Permeability and Promotes Alcohol-Induced Hepatic Pathology and Inflammation

SCN is not the only clock in the body. Zeitgeber "food" can be a zeitgeber for the gut. Intestinal activity and its ability to absorb nutrients are dependent on the time of day.
Time of eating has a huge effect on the liver and insulin efficacy

Cellular response to INSULIN is dependent on the circadian cycle.

Glucose uptake in muscle is dependent on the circadian rhythm.

Insulin-sensitivity is dependent on the peripheral clock in muscle cells.

Insulin stimulates the liver to remove glucose from the blood and stores it as glycogen. Beta cells release insulin. Insulin stimulates the liver to remove glucose from the blood and stores it as glycogen. Tissues take up glucose from the blood. Insulin lowers glucose levels in the blood.

Figure adapted from Kaidanovich-Beilin, O. et al. 2012
Glucagon stimulates the conversion of stored glycogen in the liver into glucose.

Increases glucose levels in blood

Figure adapted from Kaidanovich-Beilin, O. et al 2012
When you eat sugar determines how your body will respond.

Eating sugar at night → Higher blood sugar

Gif: JOHN KUCZALA
Insulin activates insulin receptors in the brain \(\rightarrow\) affects feeding behaviors, reward, body metabolism, normal emotion & cognitive behaviors.

Insulin stimulates the liver to remove glucose from the blood and stores it as glycogen.

Tissues take up glucose from blood.

Beta cells release insulin.

High blood glucose

Lowers glucose levels in blood

Insulin receptors are found throughout the brain – cortex, midbrain and hypothalamus.
The risk of developing Alzheimer's disease is increased by 50 percent in people with diabetes.

Craft, S. Nat. Rev. Neurol. 8, 360–362 (2012);
Circadian rhythm disruption → Metabolic dysfunction → Insulin resistance → Alzheimer’s Disease

The circadian clock has a profound effect on the physiology and behavior of organisms.
The circadian clock has a profound effect on the physiology and behavior of organisms.
A Single Night of Partial Sleep Deprivation Induces Insulin Resistance in Multiple Metabolic Pathways in Healthy Subjects

Esther Donga, Marieke van Dijk, J. Gert van Dijk, Nienke R. Biermasz, Gert-Jan Lammers, Klaas W. van Kralingen, Eleonara P. M. Corssmit, and Johannes A. Romijn

Departments of Endocrinology and Metabolic Diseases (E.D., M.v.D., N.R.B., E.P.M.C., J.A.R.), Neurology (J.G.v.D., G.-J.L.), and Pulmonology (K.W.v.K.), Leiden University Medical Center, 2300 RC Leiden, The Netherlands

donga, e., et al. (2010) J Clin Endocrinol Metab 95: 2963-2968
Average Number of Hours of Sleep per Night

- **1960**: 8+ hours
- **1995**: 7 hours
- **2004**: 6 hours

Are you getting enough sleep?

Imagine the benefits that would await you if you got one more hour of sleep?