Interaction of Sleep and Circadian Rhythmicity

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In humans, sleep is regulated by two physiological systems:

- the “Sleep-Wake Homeostat”
  - longer wake duration leads to increased sleepiness, going to sleep dissipates sleepiness
- the Circadian Timing System
  - within the 24-hour cycle, the biological clock promotes sleep at some times, and wakefulness at other times

A precise balance between circadian & homeostatic processes allows for consolidated sleep & wakefulness

Sex differences in circadian system in animals

- Period (cycle length)
- Entrained phase (timing of rhythm with respect to light-dark cycle)
- SCN (suprachiasmatic nucleus, master circadian pacemaker)
- Amplitude of some rhythms

Assessment of human circadian rhythms is complicated by human monophasic sleep-wake cycle

- Most model organisms for circadian rhythms and sleep are nocturnal, while humans are diurnal
- Unlike most other mammals, humans sleep in 1 long bout and are awake for an extended bout each day; most mammals have polyphasic sleep and wake
- Impact of light on the biological clock is phase-dependent; light at some times of day will shift rhythms earlier, at other times will shift rhythms later, and at some times has little effect.
- Control of lighting is critical in studies of human sleep and rhythms.

Reported sex differences in sleep in humans

- Timing (women earlier)
- Duration (women longer)
- Amount of slow-wave sleep (women more)
- EEG spectral power (women greater)
- Subjective quality (men better)
- Subjective-objective relationship (discrepancy)

Reported sex differences in circadian rhythms or circadian/sleep interactions in humans

- SCN (shape, relative size)
- Period (cycle length), but in study protocols that have since been discredited
- Amplitude of some rhythms
- Response to sleep at adverse time of day (shiftwork)
- Changes with age

Unknown sex differences in circadian rhythms, circadian-sleep interactions, in humans

- Phase at which sleep typically occurs (phase angle of entrainment)
- Period (cycle length)
- Influence of light (phase response curve)
- Impact of sleep loss on performance, alertness
- Tolerance to sleep loss

Challenges

- Basic sleep studies are mainly performed on male animals
- In humans, there is a feedback of sleep & associated behaviors (posture, light/dark, activity) on circadian rhythms, making measurements in field settings complicated, and requiring careful control of environment (and sex differences in sleep/dark duration) during lab measurements critical
- There is now inclusion of women in clinical studies, but many (?most) circadian and circadian/sleep studies are not designed to address sex differences