

Symptoms appear when individuals attempt to go to sleep earlier than they'd choose to (e.g., 23:00) because of work or school demands requiring an early awakening. Individuals with DSPS may sleep only 2-5 hours on weekdays and recuperate on weekends or on vacation with 9-18 of hours of sleep daily. This pattern results in inability to attend school or work in the morning, excessive sleepiness and poor performance. This syndrome often emerges after puberty and is relatively common among adolescents and young adults. Since most secondary schools and universities begin classes early in the morning, DSPS can seriously affect academic performance.

Non-24-hour sleep-wake syndrome

Patients with this syndrome have sleep onset times that delay by 1-2 hours each day, reflecting a lack of entrainment and the presence of a free-running rhythm. When their rhythms are out of phase with the external world, these individuals show daytime sleepiness and severely disrupted sleep. During the period when they drift into phase, their schedules seem entirely normal. This condition is extremely uncommon (but has been reported) in people with normal vision, but among blind individuals lacking normal light input to the brain, 17-50% suffer from this syndrome.

Conclusion

Most behavioural and physiological functions show daily rhythms that are generated internally but synchronized by external cycles, especially those of light intensity. Conflicts between the dictates of the circadian clock and one's schedule of activities can lead to severe disturbances of sleep and waking. Careful control of exposure to light and dark, of sleep timing, and of other environmental factors can help many people with circadian rhythm disturbances become better adjusted to the requirements of their jobs and social lives.

Suggested readings

For more information on coping with night shifts see the CSS brochure: "Strategies for shiftworkers"
<http://www.css.to/sleep/brochures.htm>

Boivin DB and James FO. Insomnia due to circadian rhythm disturbances. In: Insomnia Management. MP Szuba, JD

Kloss, DF Dinges, Eds. Cambridge University Press, 2003; Part III, 10: 155-191.

Boivin DB and Santo JB. Circadian rhythm sleep disorders related to an abnormal escape of the sleep-wake cycle. In: Sleep: Physiology, Investigations, and Medicine (M. Billiard, ed.). Kluwer-Academic Publisher, Norwell (MA), 2003: 493-512.

Cermakian N and Boivin DB. A molecular perspective of human circadian rhythm disorders. Brain Res Rev 2003; 42 (3): 204-220.

Dunlap JC, Loros JJ, DeCoursey PJ. (Eds) Chronobiology: Biological Timekeeping. Sinauer Associates (Sunderland, MA), 2004.

Reppert, S. M., & Weaver, D. R. (2002). Coordination of circadian timing in mammals. Nature, 418(6901), 935-941.

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HUMAN CIRCADIAN RHYTHMS



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Circadian rhythms

The term circadian means “about a day”. Early studies found that humans isolated from the normal 24 hour cycle of light and darkness for several weeks in caves or in specially designed time-free laboratories still maintained a cycle of rest (sleep) and activity (wake), but with a period that differed from 24 hours (typically slightly longer). The persistence of such free-running circadian rhythms in the absence of daily changes in the environment demonstrates that they are endogenous, meaning that they are generated within our bodies by an internal timing mechanism, called a circadian clock.

In mammals, including humans, the main circadian clock is located deep in the brain in a structure called the suprachiasmatic nucleus (SCN). Destruction of the SCN disrupts most circadian rhythms, including those of rest and activity, body temperature and hormone secretion. Cells in the SCN generate circadian rhythms even when isolated from the rest of the body. Other tissues of the body can also express molecular rhythms similar to those of the SCN, but signals from the SCN appear to be responsible for regulating and coordinating these rhythms throughout the body.

Although circadian rhythms are not produced by the external cycles of day and night, they are synchronized by them through the process of entrainment. By this mechanism, environmental time cues (especially lighting cues, but also others such as meal times) keep our circadian clocks tightly linked to the local 24 hour environment. Because the average human circadian clock has a cycle length (period) longer than 24 hours, entrainment is necessary to keep our rhythms stably synchronized to local time, rather than free-running.

Effects of light on circadian rhythms

Light is the most powerful synchronizer of the human circadian clock, and the timing of light exposure during the course of a day is responsible for how the circadian clock is entrained. Thus, when humans are exposed to light late at night, their circadian rhythms delay to a later time and they will tend to go to bed and to wake up later. Light exposure in the early morning has the opposite effect, advancing circadian rhythms, including the sleep-wake cycle, to an earlier time. While light of any intensity may have some

effects, brighter light and longer exposures will cause the biggest shifts of circadian rhythms. The balance of these daily light-induced shifts keeps most of us on a regular schedule relative to local time.

Circadian influence on sleep

The periodic repetition of sleep and waking is one of the most easily observed daily rhythms. In normal individuals who are active and working during the day, two processes interact to keep them awake for ~16 hours and asleep for ~8 hours during each daily cycle. One process (a homeostatic mechanism) keeps track of the need to sleep, increasing the pressure to sleep as one stays awake longer. The other process (controlled by the circadian clock) provides strong physiological signals favoring sleep or waking at specific times of day.

Circadian rhythms disorders

Circadian rhythm disorders form a distinct subgroup of sleep-wake disorders, caused by a mismatch between an individual's sleep need and the timing of the signals from their circadian clock. These conflicts arise from a variety of external pressures or lifestyle choices (see below) and result in fatigue, poor job or school performance, and sleep disturbances, especially difficulty falling asleep or waking up at desired times.

Night shift work

People who work at night are typically performing their jobs at a time that conflicts with the sleep-wake regulating signals from their circadian clocks. This mismatch contributes to reduced alertness and job performance during the night shift, and inadequate daytime sleep when they return home. When on night shifts, workers may sleep 1-3 hours less than they sleep when working the day shift. Because the circadian clock sends a strong signal to sleep in the early morning hours (6:00-8:00), it is especially difficult to stay awake at the end of a typical night shift, including while traveling home.

Some workers adapt well to night shifts, but their circadian clock usually does not. Careful selection of the amount and timing of exposure to light and darkness, based on our understanding of how these affect the circadian clock, can to some extent, help to align the circadian clock with the selected work/rest schedule, thereby improving work performance,

safety during travel home and quality of daytime sleep.

Jet lag

Each year, millions of travelers suffer from jet lag after rapid flight across multiple time zones, causing substantial deterioration of vigilance and performance after arrival at their destinations. While jet lag is merely an annoyance for most passengers, it can have serious consequences for safety, commerce and even international relations, and is especially critical in the aviation industry and for military personnel. The severity of the symptoms depends on both the direction of flight and the number of time zones crossed. Eastward flights are associated with difficulty falling asleep, sleep disturbances in the first half of the night, difficulty awakening, and fatigue in the morning/early afternoon. Westward flights are associated with poor sleep quality in the second half of the night, early morning awakening, and fatigue in the late afternoon/evening. These sleep-wake disturbances arise when travelers attempt to function immediately on the schedule of their destination while their internal clocks are synchronized to their original schedule and adapt only slowly to new local time cues.

Advanced Sleep Phase Syndrome (ASPS)

ASPS was originally reported in older individuals and is rare in younger people. ASPS is characterized by evening sleepiness, early sleep onset around 18:00-21:00, and early morning awakening around 1:00-3:00. Sleep quality is generally normal if individuals initiate sleep early, but symptoms emerge if they attempt to conform to a sleep schedule that is more typical in our society by staying up later. Familial ASPS, which causes extreme “early-bird” tendencies in whole families, has been related to a clock gene mutation, supporting the idea that some circadian sleep disorders have a genetic basis.

Delayed Sleep Phase Syndrome (DSPS)

DSPS is characterized by a delay in the main sleep episode and an inability to fall asleep or wake up at the desired times. DSPS patients are extreme “night owls,” with bedtimes frequently observed around 3:00-6:00 and wake times around 12:00-15:00. Sleep quality and duration are normal when individuals are allowed to sleep at their preferred biological times.