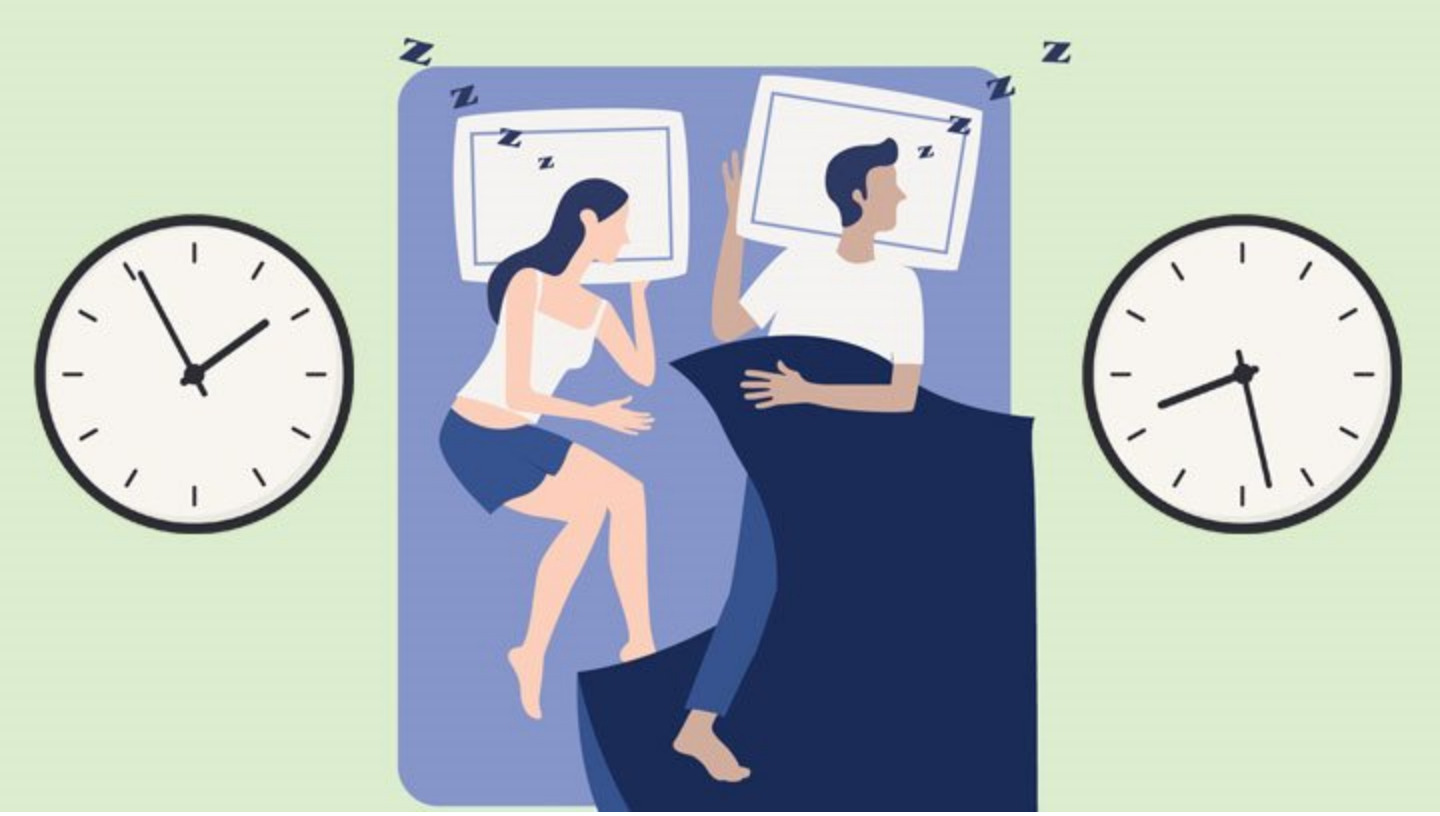
Everyday Health Sleep Disorders Sleep

Everything You Need to Know About Your Circadian Rhythm and How It Affects Your Sleep

Kenneth P. Wright, PhD, sleep and chronobiology researcher at the University of Colorado, explains how our body clocks are connected to our health — and how they differ when it comes to our biological sex.

By Sue Treiman

Medically Reviewed by Samuel Mackenzie, MD, PhD



The body's master clock orchestrates complex physiological processes, like sleep, metabolism, and immune function, all day, every day.

You've likely heard of your body's internal clock or circadian rhythm. But did you know there's a physical location in the brain where this clock exists? It's called the suprachiasmatic nucleus, or SCN for short, and it's best thought of as your body's master clock — the one that orchestrates the complex physiological processes involved in our daily cycles of sleep, waking, and activities. Synced to sunrise and sunset, it works to keep the body in balance, or homeostasis, explains Kenneth Wright, PhD, professor of integrative physiology and director of the sleep and chronobiology laboratory at the University of Colorado in Boulder.

But as it turns out, there are a lot of things we do that may be throwing off that balance.

Dr. Wright's research investigates the health and safety consequences of poor sleep and disrupted body clocks. His work has contributed to a growing field of evidence that time-shifted schedules, overly long workdays, intermittent or oddly timed meals, and reliance on artificial light long after sunset have increased our risk for disease, chronic health problems — like diabetes, obesity, and heart disease — dysfunction, and deterioration.

"Circadian misalignment, not living according to the natural clock, interferes with biological pathways involved in immune function, metabolism, cancer, and with altered glucose and energy metabolism," Wright says.

"In women, we see evidence of this in the effects of overnight shift work, which increases the incidence of breast and endometrial cancers."

In a phone interview, Wright explained more about our circadian rhythms and the role they play in getting a good night's sleep and overall, long-term health.

Everyday Health: What is our body clock and what does it do?

Kenneth Wright: Our circadian rhythm, which most of us refer to as the body clock, is actually controlled in the suprachiasmatic nucleus [SCN] located in the brain's hypothalamus — and synced to solar day and night. It predicts and prepares for our daily activities, coordinating the bodily functions that accompany those activities from the time we wake up through our sleep.

This master controller orchestrates the autonomic nervous system, which controls bodily functions we're not conscious of (like breathing and

heartbeat). It also coordinates the release of cortisol, the hormone thought to prepare the body for the waking day, and it directs the release of melatonin, the hormone that signals to the body it's time to sleep about two hours before our normal bedtime.

The human SCN's roughly 100,000 neurons coordinate the many cellular biological clocks that exist throughout the body, ensuring that the right sequence of events occurs for every activity [each day]. The presence of these clocks — which exist in our fat cells, liver, pancreas, muscles, and organs — was not common scientific knowledge until the early 2000s.

EH: So, we actually have multiple internal body clocks — but the master clock controls them all? How are all of these clocks connected?

KW: We've learned that while there is a master clock in the brain, almost every cell in the body has its own biological clock, too. Each cell keeps time through the expression of certain genes and proteins [becoming active] at certain times during a 24-hour period. The explanation of that mechanism earned a Nobel Prize in 2017 and, since then, other researchers have gone on to find these clocks everywhere across the body.

In the natural world, sunlight is the strongest time cue for these clocks. It sets the timing of the master clock, which then coordinates the processes that occur throughout the body, including the early morning processes that promote wakefulness, as well as when we eat, when we are active, and the processes that control sleep.

Another example: The master clock prepares the body to eat by ensuring that our cells and tissues work together in anticipation of meal time. It also varies body temperature during the day. It's purpose [that of the master clock] is to keep things operating in synchrony.

EH: In addition to all the functions that occur while we're awake, our master body clock also controls when we sleep, right?

KW: Yes, the circadian rhythm promotes sleep at night in humans. In the natural world, our physiology is matched to daylight, so that when light diminishes, the processes that prepare us for sleep are triggered. During sleep itself, the SCN remains involved in the peak timing of the different stages of sleep (including REM, the rapid eye movement sleep), and at dawn it initiates the changes that increase alertness.

Light has always been critical to this circadian process, but it's historically been natural light from the sun.

As we've removed ourselves from direct exposure from sunlight during the day, spending time indoors at work or at school, we've separated ourselves from receiving important bodily cues.

When we come home at night and turn on bright lights, we again interfere with the natural cycle. Bright lights during the evening and night tend to push the biological clocks later than normal.

EH: What do you mean by "push the clock later"?

KW: It means that we're not getting the circadian signals to our body to prepare for sleep. The cues are timed later, and so we're having more trouble falling asleep and, subsequently, waking in the morning for work and school. The research conducted by my team [published in April 2013 in the journal *Proceedings of the National Academy of Sciences (PNAS)*] has shown that this circadian misalignment leads to lower insulin sensitivity — one reason why short sleep may elevate risk of diabetes.

Short sleep duration and misalignment of natural circadian rhythm are also believed to contribute to obesity, metabolic syndrome, heart disease, mood disorders, cognitive impairment, and sleepiness-related accidents.

EH: Does the master clock differ for men versus women?

KW: In the broadest possible terms, men and women differ in the speed of their biological clocks. (I'm referring to biological sex in answering this, rather than self-reported gender.) A faster clock leads to an earlier timed circadian rhythm.

We know from research that the SCN's control of melatonin and temperature, both of which affect sleep, run over a shorter day-night period in young adult women than in men. That means that women — women in the aggregate, that is — have a circadian cycle that is roughly 30 minutes shorter relative to their sleep time than men [causing the cycle to start that much earlier in the day].

EH: You're saying that women's body clocks run, on average, 30 minutes ahead of schedule everyday compared with men's clocks? How does this difference affect our functioning?

KW: This “running ahead of schedule” makes women more likely to be "morning people." As a result, they are better matched to the typical business and school day, where you tend to wake up earlier and go to bed earlier. Conversely, men tend to do better later and have less trouble with overnight shift work than women. It can also impact how people feel throughout the day.

We know from our [2013 PNAS] research that when women and men get the recommended amount of sleep (at least seven hours) and are allowed to eat as much as they want, men overeat and gain weight, whereas women tend to eat what they need and maintain weight. However, when men and women both do not get enough sleep, dietary restraint is reduced for both sexes.

We think that eating more during too-short sleep is a biological adaptation that occurs as the body seeks the energy it needs to maintain wakefulness.

We also know that the interconnected functions of the body are no longer properly coordinated when the circadian rhythm is disrupted. For instance, eating at night alters the timing of the biological clock cells in the liver, so that it is out of sync with the master clock, as well as overall physiology. We have physiological processes that are meant to work with others, and those mechanisms are thwarted. As a result, over time, eating at biologically inappropriate times taxes the body and can lead to some serious health problems.

EH: Do women and men have different sleep patterns (when we’re actually asleep) because of the differences in our body clocks?

KW: We know that children, both boys and girls, get the deepest sleep around age 12, when we have the highest number of brain cells. This heightened sleep is required to prune these brain cells during the growth period.

After puberty, girls and boys start to go to bed later because it's easier for them to stay awake longer, with their lengthening circadian cycle. At this time, research reveals that boys adopt later bedtimes than girls — becoming later still in the early twenties.

As adults, statistics from the U.S. Department of Health and Human Services show that 1 in 4 women develop insomnia symptoms, which makes them 10 times likelier to later report depression and 17 times more susceptible to anxiety issues. Meanwhile, it's believed that men account for more sleep apnea cases until women are postmenopausal.

This sex difference in sleep timing is maintained throughout adulthood until around age 50, when men and women converge a bit more in their sleep, as well as in their sleep problems. By age 60, research suggests an estimated 57 percent of the general population reports a sleep complaint.

It's also worth noting that beyond this general rule that the female clock is timed earlier, men and women don't have different body clocks. Their circadian rhythms are more similar than different.

EH: Are there other differences (besides those determined by circadian rhythm) that distinguish the way men and women sleep?

KW: Although their circadian rhythms are pretty much the same, there are differences in the way men and women sleep. These begin in infancy, when baby boys face a higher risk for sudden infant death syndrome that infant girls.

As they enter puberty, girls can have their sleep interrupted by severe premenstrual syndrome and its painful cramps. Polycystic ovarian syndrome (PCOS) in females is another sex-related problem of hormonal imbalance, and it tends to be associated with an increased risk of sleep apnea.

And, again, insomnia is more prevalent among women, where it also increases the risk for depression. Sleep-related eating disorder (SRED), a condition where people involuntarily eat and drink during the nighttime sleep period, tends to affect more women than men. There's some speculation that it could be related to hunger caused by daytime dieting.

EH: We've covered a lot, including the point that a lot of our daily routines could be interfering with how our body clock naturally functions. Do you have any tips for keeping the clocks running on time?

KW: I'd like people to stop shortchanging sleep. I'm often asked whether it's more important to get an extra half-hour of sleep or spend 30 extra minutes working out. I think they're both important. And if we have to take time away from something, let it be the TV, computer, or the smartphone screen. Sleep and exercise are both critical to maintaining a healthy lifestyle.

Remember, there was a time not too long ago when we couldn't convince people that smoking was unhealthy. The general public came around slowly,

but now everyone accepts that it causes disease. I think we'll see the same thing happen with sleep.

Those who understand that shortchanging sleep is unhealthy but haven't yet figured out a way to establish good sleep habits themselves will eventually take time from other activities and devote it to sleep. And for those who still struggle, we have good treatments that can fix sleep problems and promote sleep and circadian health.

Until then, I'd like to emphasize daylight and its impact on circadian system. We need bright light in the morning and soft, diminishing light as we approach bedtime. We should do our best to get out and soak up sunshine early. And if it's not possible, at least exercise near a window and turn up the lights during the daytime, while taking care to reduce lighting as we get closer to bedtime. Remove electronic devices from the bedroom and stop using them within an hour or two of sleep.

Remember; health is a three-legged stool. You have to eat well, be active, and get adequate sleep and daylight to ensure good health. Eliminate one of the legs and the stool breaks.

Last Updated:3/4/2019

You Know Sleep Is an Important Part of Health — Here's Why It's an

Important Women’s Health Issue, Too

Katherine Sharkey, MD, PhD, of The Alpert Medical School of Brown University, explains the role of sleep in good health from girlhood to menopause and beyond.

By Sue Treiman

Medically Reviewed by Samuel Mackenzie, MD, PhD

Women are more likely than men to have insomnia and greater problems initiating and sustaining sleep — particularly after menopause.

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You likely know that sleep (or lack of it) affects health and well-being. Not getting enough shut-eye can impair thinking, make us more accident prone, and dampen mood on a day-to-day basis. Over the long run, too much sleep debt can contribute to problems like weight gain, obesity, type 2 diabetes, dementia, heart disease, and more.

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Women should also know that how well they're sleeping also comes to bear on other aspects of their health, like pregnancy, the postpartum period, perimenopause, menopause, and aging, explains Katherine Sharkey,

MD, PhD, associate professor of medicine and of psychiatry and human behavior at Brown University in Providence, Rhode Island. Women, for example, are more likely to have insomnia and greater problems initiating and sustaining sleep — particularly after menopause.

Dr. Sharkey, who is also medical director of the Brown Medicine Sleep Center and associate director of the Sleep for Science research laboratory at Brown, researches sex-based differences in sleep and circadian rhythm, and how they affect mood and particularly women's health issues. She says new research in the field has the potential to improve women's health outcomes.

"Getting to the bottom of disturbed sleep," she says, "is often the key to making a difference in other health domains."

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Here's what she had to say on the subject in a recent phone interview:

Everyday Health: Do men and women sleep differently? Does good or poor sleep affect men's and women's health differently?

Katherine Sharkey: Young children of both sexes are similar in their sleep. Both boys and girls need 8 to 10 hours of sleep per night for optimal health.

Around puberty, research shows that boys and girls diverge, with menstruating girls showing a higher tendency to develop insomnia than boys. The exact reasons for this are unknown, but it may be caused by slight variations in circadian rhythm between boys and girls.

Girls also face more fragmented sleep, possibly related to the hormonal fluctuations that occur during the menstrual cycle.

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[Several studies suggest the presence of different sex hormones in men and women yield different effects on sleep, according to a review published in February 2016 in the journal *Philosophical Transactions of the Royal Society B*.]

Adult women continue to report more insomnia and remain more prone to sleep disorders in general.

Research [from a review published in 2016 the journal *BioMed Research International*] has also revealed that undiagnosed sleep apnea is a major problem, with as many as 90 percent of women unaware they have the condition, possibly because they have different symptoms than men do.

While men present with snoring, women tend to report excessive fatigue, a strong need to sleep during the day, and mood or concentration lapses.

Doctors often misdiagnose [these symptoms as being caused by] depressionor anxiety and prescribe medications that cause weight gain, worsening the problem when the extra pounds further compromise breathing. The Society for Women's Health Research has recognized this and created a task force to address symptoms in women.

Again, it's hard to pinpoint a single cause [when it comes to these differences]. It's probably due to the interplay of hormones, physiology, and many other factors.

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EH: What about during pregnancy? We tend to assume that being pregnant makes it more difficult to sleep, but does it represent a potential health problem?

KS: There's a definite uptick in all kinds of sleep disorders during pregnancy. Many women report having trouble finding comfortable sleeping positions. Breathing may be difficult because the fetus restricts their lungs, or women will have back pain or require frequent bathroom trips.

Plus, restless legs syndrome becomes more common in pregnancy, probably because of iron deficiencies in pregnancy [research published in May 2015 in the journal *Sleep Medicine* added more evidence that this is the case].

And there can be psychological issues, too. Some studies have shown that intrusive thinking and worrying can increase during pregnancy.

Some of my current research explores ways to help treat this. Even at this early research stage, interventions seem likely to significantly improve mood. But without treatment, mothers can be seriously exhausted when they bring their babies home, which can affect mood and increase the likelihood of developing postpartum depression.

EH: Do pregnancy-related sleep issues tend to disappear after the child's birth?

KS: Most women do fine and improve — but not everyone. Teri Pearlstein, MD, Carmen Monzon, MD, Ellen Flynn, MD, and I are currently examining whether extreme sleep deprivation plays a role in postpartum depression.

There's also research investigating whether a hormonal variant or subphenotype (the link between genetics and environment) predisposes certain women to mood disorders that begin in pregnancy and worsen with sleeplessness. We still have to carefully explore all the risk factors, since most new mothers are sleep-challenged to some degree. But it's a promising area.

There's good news when it comes to the relationship between nursing and sleep, however. A study published in *The Journal of Perinatal & Neonatal Nursing* found that women who breastfed their children (by nursing or through stored breast milk) slept an average of 40 to 45 minutes longer than parents of bottle-fed children.

Other studies confirm that bottle-feeding parents not only get substantially less sleep, but they take much longer to reestablish preparenting sleep levels, too. The current speculation is that prolactin, the pituitary gland hormone that produces milk, plays a role in stabilizing sleep.

Individual variability in sleep is enormous. In my studies, most of these women sleep about six hours a night and only four to six hours right after the birth. They grab naps whenever possible but it's not adequate to replace missing sleep. I've actually had patients insist, even two decades later, that they haven't slept well since they had infants.

EH: How does sleep change during menopause?

KS: Women report many sleep problems from perimenopause right through menopause itself. Hot flashes are associated with disturbed sleep, although Fiona Baker, PhD, [senior program directorf for the Human Sleep Research Program at the Center for Health Sciences at SRI International in Menlo Park, California] has shown that the effect is bidirectional; that is, hot flashes wake women up, and women who are awakened get hot flashes [according to a study published in December 2014 in the journal *Fertility and Sterility*]. Whichever comes first, we know that the alterations in hormone levels implicated in hot flashes can affect the brain and impact mood.

Wendy Troxel, PhD, [a senior behavioral and social scientist at RAND and adjunct professor of psychiatry at the University of Pittsburgh in Pennsylvania] has published research showing that personal issues, like an unhappy marriage, can threaten sleep in women at midlife.

EH: Do those changes (and problems) persist beyond menopause?

KS: Sleep tends to improve a bit [after] women transition from perimenopause to menopause. The hormones settle into a state of greater constancy. We all wish there was more data on this, but we don't have much yet.

Meanwhile, the sleep disorder "gender gap" narrows as both sexes become increasingly susceptible to conditions like Alzheimer's and untreated pain.

Unfortunately, older people with sleep issues are often given drugs for their medical problems, which then create sleep issues. And it's typical for older women to find that sleeping pills prescribed earlier in life no longer work properly.

EH: It seems to have taken a long time for researchers to appreciate sleep's particular impact on women. Would you agree?

KS: Yes. People are starting to take it seriously. As a result, we now know some things, but not everything. And the unknowns are greater for women than for men. But we're making real progress.

For instance, I'm encouraged by our awareness of the relationship between sleep apnea and atrial-fibrillation [afib] — an irregular and often rapid heartbeat — in women. We learned that afib can result from undiagnosed sleep apnea, so any woman with the diagnosis should probably be considered for a sleep study before being prescribed medication or an ablation (a procedure that destroys the malfunctioning heart tissue). The afib could turn out to be a reversible situation that could be addressed by the CPAP (continuous positive airway pressure) treatment.

We discovered this only after women were finally included in NIH-funded sleep research. Previously, these were considered “men-only” conditions.

EH: Do you think the current research will lead to real change in addressing sleep problems (including sleep deprivation) in both men and women?

KS: Some things are extremely encouraging. Airline crews and truckers now have to follow strict regulations about sleep. On the other hand, medicine still has its share of macho boastfulness about not getting enough sleep. Male or female, doctors are not impervious to the need for sleep.

I believe we can work in new ways to break these barriers by creating more opportunities for doctors to team with public health researchers and other specialists, as well as actual sleep medicine patients.

Until then, we have to focus on teaching good sleep behaviors. We need to create new habits, teaching people to keep the bedroom quiet, dark, and devoted to nothing but sleep; to follow evening “winding down” rituals that may include meditation or a warm bath; to ban electronics from bedroom; and to treat the room as a dark sanctuary. And, of course, they have to adhere to a decent, consistent bedtime.

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EH: Is there any good news to lull us to sleep tonight?

KS: Good sleep is dependent on the individual — and behavior modification and medication can help almost anyone. You can defeat bad sleep, and you can find the right people to help you do it.

Last Updated:2/26/2019

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