Chronically sleep deprived? You can't make up for lost sleep

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We've all experienced that occasional all-too-short night of sleep -- staying out too late at a party on a weeknight, studying into the wee hours for a morning exam or being kept up during the night with a sick child. Our bodies try to catch up by making us sleep more and/or more deeply the following night.

It is well established that following an acute period of sleep loss, the body responds this way in order to maintain a homeostatic balance between sleep and wakefulness. Very little is known, however, about the health consequences of chronic partial sleep loss -- losing a little bit of sleep over a period of days, months or even years.

Now sleep researchers at Northwestern University have discovered that when animals are partially sleep deprived over consecutive days they no longer attempt to catch up on sleep, despite an accumulating sleep deficit. Their study is the first to show that repeated partial sleep loss negatively affects an animal's ability to compensate for lost sleep. The body responds differently to chronic sleep loss than it does to acute sleep loss.

The results, which shed light on a problem prevalent in industrialized nations with 24/7 societies such as the United States, where Americans get nearly an hour less sleep a night than they did 40 years ago, were published online recently by the Proceedings of the National Academy of Sciences (PNAS).

“We now know that chronic lack of sleep has an effect on how an animal sleeps,” said Fred W. Turek, professor of neurobiology and physiology and director of Northwestern’s Center for Sleep and Circadian Biology and an author of the paper. “The animals are getting by on less sleep but they do not try and catch up. The ability to compensate for lost sleep is itself lost, which is damaging both physically and mentally.”

In the study, the researchers kept animals awake for 20 hours per day followed by a four-hour sleep opportunity, over five consecutive days. The team monitored brain wave and muscle activity patterns in order to precisely quantify sleep-wake patterns.

After the first day of sleep loss, animals compensated by increasing their intensity, or depth, of sleep, which is indicative of a homeostatic response. However, on the subsequent days of sleep loss, the animals failed to generate this compensatory response and did not sleep any more deeply or any longer than they did under non-sleep deprived conditions (baseline measurements). At the end of the study, the animals were given three full days to sleep as much as they wanted. Amazingly, they recovered virtually none of the sleep that was lost during the five-day sleep deprivation period.

The findings support what other scientists have discovered in recent experimental studies in humans. Chronic partial sleep loss of even two to three hours per night was found to have detrimental effects on the body, leading to impairments in cognitive performance, as well as cardiovascular, immune and endocrine functions. Sleep-restricted people also reported not feeling sleepy even though their performance on tasks declined.

The Northwestern team’s results suggest that animals may undergo a change in their need for sleep, or in their sleep homeostat, in situations where normal sleep time is prohibited or where sleep could be

detrimental for survival. An extreme but realistic example of this, says Turek, would be how animals respond to catastrophic environmental conditions, such as Hurricane Katrina. No matter how sleep deprived an animal or human may be, it would not be adaptive for the sleep homeostat to kick in and to make the animal fall sleep when it is in the midst of a flood or forest fire. Therefore, the body undergoes some change that allows it to counter its homeostatic need for sleep and to stay awake to avoid danger.

Turek and his team propose that this change in the sleep regulatory system is reflective of an allostatic response. In the short term, allostatic responses are adaptive, but when sustained on a chronic basis, such as in their study, an allostatic load will develop and lead to negative health outcomes. The allostatic load resulting from the accumulating sleep debt loops back to the sleep regulatory system itself and alters it.

“Even though animals and humans may be able to adapt their sleep system to deal with repeated sleep restriction conditions, there could be negative consequences when this pattern is maintained over a long period of time,” said Turek. “This brings us back to the idea that repeated partial sleep restriction in humans has been linked to metabolic dysfunction and cardiovascular disease.”

“Our lab is very interested in the interactions between sleep loss and metabolic function,” said Aaron D. Laposky, research assistant professor at the Center for Sleep and Circadian Biology and an author of the paper. “As Americans have been getting less sleep per night, there has been a parallel trend for body mass index to significantly increase. We believe that when partial sleep loss occurs repeatedly over a long period of time, individuals are predisposed to alterations in the function of many physiological systems.”

Source: Northwestern University