Brain response to food stimuli may explain link between inadequate sleep and obesity

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Sleep restriction might lead to a greater propensity to overeat due to increased activation of the brain in response to food stimuli, according to US researchers from Columbia University and St Luke's-Roosevelt Hospital in New York.

Past studies provide evidence that an increase in obesity may be linked to reduction in average sleep duration. A proposed mechanism is that restricted sleep affects key hormones related to appetite regulation and energy balance – insulin, leptin, and ghrelin.

Few studies have focused on how reduced sleep affects the way various regions of the brain are activated in response to food stimuli. Therefore, the researchers of the present study aimed to determine the effect of habitual sleep versus restricted sleep on the activity of neurons (cells transmitting the nerve impulse) in different areas of the brain in response to seeing pictures of different foods.

Twenty-six men and women from the New York City area participated in the study. They were between the ages of 30 and 45, and their Body Mass Index (BMI) ranged from 22-26 kg/m$^2$. The study consisted of two phases. In the first phase, participants were randomly assigned to six days of habitual sleep (9 hours per night) or restricted sleep (4 hours per night). After three weeks, participants returned for the second phase in which they were assigned to the other sleep condition. Participants were inpatients during each sleep phase. For the first four days of each phase, they were given controlled diets based on their calculated energy needs. For the remaining days they could eat as they pleased. Exercising was allowed on all days of each study phase.

On the morning of the sixth day, after an overnight fast, participants were shown images of different food and non-food items while their brain activity was scanned using functional Magnetic Resonance Imaging (fMRI). Food items included low- and high-calorie foods such as oatmeal, carrots, doughnuts, and hamburgers. Non-food items included office supplies, a rope, marbles, and stuffed animals.

In the restricted sleep condition, the pictures of food (food stimuli) increased the activity of neurons in several regions of the brain: the orbitofrontal cortex (OFC), insula, regions of the basal ganglia and limbic system, and others. Under the habitual sleep condition, food stimuli also increased brain activity in areas of the OFC, but the activity was reduced and less widespread. The regions of the brain that were most activated after restricted sleep are the areas most involved in motivation, rewards, cognitive processing, decision-making, and self-control.

Greater activity of neurons in these different regions of the brain gives insight into how people respond when they see food. Greater neuronal activity in brain reward centres after restricted sleep could mean people are more susceptible to food stimuli when not getting enough sleep. People might have an
increased motivation to seek food as a reward or they may be more aware of the rewarding properties of food. The nucleus accumbens and putamen regions were also activated to a greater extent after sleep restriction, and these regions are associated with reward, pleasure, reinforcement of learning, and drug addiction.

In addition, the researchers found that after restricted sleep, the activity of neurons in the brain was similar to the neuronal pattern that is present in someone who has lost weight and is aiming to restore initial body weight.

This study did not look at differences in brain activity after seeing high-calorie versus low-calorie foods. It was also not able to determine if there is a difference in brain activity between individuals with obesity and lean individuals because the majority of participants were a relatively normal weight (BMI <26). The sample size was too small to determine differences between men and women. Still, it shows that the link between sleep restriction and obesity may not be solely hormonal. It could be in part due to increased neuronal activity in brain regions linked to motivation and reward, which may lead people who do not sleep enough to seek out food.

For more information, see