Effects of Sleep Deprivation on Hunger-Regulating Hormones

Sleep plays an important role in a person's mood, productivity, energy level, and even food intake. Abundant research indicates that getting adequate an amount of sleep is essential in maintaining health of the mind and the body. However, in the last 40 years the amount of sleep American’s have reported getting has declined. The number of hours of rest have dropped from an average of 8 hours and 30 minutes per night to 6 hours and 40 minutes (Hanlon and Cauter 2011). At the same time that the number of hours of sleep have decreased, the rate of obesity has dramatically increased. This correlation brings about the question: how does the amount of sleep effect food consumption, appetite, and energy balance? It is a complicated matter and the answer includes many different components, many which still require more in-depth research. In the last 5 years, many studies have been conducted to determine the relationship between sleep and appetite regulation and the mechanisms involved. Leptin and ghrelin are the two major hormones that are impacted by sleep deprivation and play a role in regulation of appetite and satiety.

Although it was formerly believed that adipose tissue only functioned to store triglycerides, it has more recently been discovered that it can also secrete hormones that stimulate or inhibit certain reactions. One of the major hormones that is synthesized and released from the adipose tissues was
discovered in 1994 and named leptin (Trayhurn and Bing 2006). It is a hormone that is made up of 167 amino acids and functions to provide the brain with information about the body’s energy status and promote satiety or fullness (Crispim et al. 2007). Larger adipocytes can release higher concentrations of leptin (Somogyi et al. 2011). When leptin levels are high, it sends the signal to the central nervous system that energy stores are full. This will decrease appetite and hunger and promote satiety and fullness. The hypothalamus of the brain plays a major role in this process because it controls many metabolic processes including hunger. The nuclei of the hypothalamus contain a large number of leptin receptors, so when leptin is released from the adipose it binds to the receptors in the hypothalamus (Hanlon and Cauter 2011). Normally, when there are sufficient concentrations of leptin, the binding simulates the message that there is plenty of energy available and it promotes fullness. Leptin is able to decrease feelings of hunger by signaling the hypothalamus that energy is high. High concentrations of leptin also decrease appetite by inhibiting ghrelin, the hormone which stimulates hunger (Campos 2006). Leptin inhibits orexigenic neurons like ghrelin that stimulate hunger by turning on lipolysis in the adipose tissue which leads to a high concentration of plasma non-esterified fatty acids (NEFAs). The NEFAs signal the hypothalamus to stop orexigenic neurons which then sends the signal to reduce hunger (Somogyi et al. 2011). Leptin and a high concentration of NEFAs from lipolysis send the signal to inhibit hunger; leptin also increases growth hormone and decreases insulin (Somogyi 2011). If leptin levels become low, such as the case of sleep deprivation, the body perceives energy stores to be low and the brain will not register fullness. Instead it continue to promote hunger as a survival mechanism.

At normal concentrations, leptin signals the brain that the adipocytes are full and the body is in a high energy state. However, when leptin levels dip low, the mechanism does not inhibit hunger. Lack of sleep has been shown in numerous studies to lower leptin concentration. In one study, 11 males were instructed to sleep for either 12 or 4 hours a night for 6 days in a row. The leptin levels in the male's who
slept for 4 hours a night had 20% lower leptin levels, which was unrelated to fat mass or energy consumption (Gutierrez and Willoughby 2010). Another study subjected a group of healthy men to sleeping for 4 hours for 6 consecutive nights and then 7 nights of sleeping for 12 hours. This study also showed similar results in that leptin levels dropped by 19% following sleep restriction (Cauter et al. 2007). There is abundant research that reinforces the notion that leptin levels drop with lack of sleep. This explains in part why hunger increases when sleep duration decreases. The effect is two-fold, however, because another hormone ghrelin plays an important role as well.

Under normal conditions, the hormone ghrelin acts in opposition to leptin. Leptin promotes satiety and feelings of fullness whereas ghrelin stimulates the appetite and increases hunger. Ghrelin contains 28 amino acids and the majority is synthesized by the endocrine glands of the stomach, duodenum, and brain (Crispim et al. 2007). Ghrelin concentration in the blood is increased when in the fasting state and is decreased in the fed state. When ghrelin is produced it stimulates the synthesis of neuropeptide Y (NPY) and agouti-related protein (AgRP) which are found in the hypothalamus and hindbrain and increase appetite (Campos 2006). AMP-activated protein kinase becomes activated by ghrelin which is the messenger to create NPY and AgRP. This the opposite mechanism of leptin which inhibits the production of NPY and AgRP in the brain. In humans, ghrelin is the only short-term hormone that increases food intake. When hormone levels are moderate after eating, the hormone promotes lipogenesis and inhibits lipolysis (Campos 2006). Lipogenesis occurs in the fed state and promotes fat storage. Ghrelin is said to be an antagonist of leptin; ghrelin in high concentrations increases appetite whereas leptin in high concentrations decreases satiation.

As suspected, sleep also has a large impact on ghrelin levels which therefore affects food intake. Ghrelin is considered a short-term regulator of food intake whereas leptin is more long term. Study
results for altered levels of ghrelin in regards to sleeping are even more powerful because of the short term effects (Schmid et al. 2008). In a crossover study, results demonstrated that ghrelin levels increased by 22% after only one night of sleep deprivation (Gutierrez and Willoughby 2010). Multiple studies show this same pattern for rising ghrelin associated with sleep deprivation. A randomized study, discussed by Gutierrez and Willoughby, found a 28% increase of ghrelin, 24% increased hunger and 23% increased appetite when participants slept for 4 hours (Gutierrez and Willoughby 2010). Nedeltcheva et al. discussed how serum ghrelin levels increased as well as appetite, food intake and fat retention with reduced sleep. The same study mentioned that ghrelin increases gluconeogenesis in the liver for tissues that are dependent on glucose such as the brain and red blood cells (RBCs) (Nedeltcheva et al. 2010). Gluconeogenesis is stimulated by high concentration of ghrelin is because when AMP concentration becomes high, it signals a low energy state and therefore gluconeogenesis will be turned on to provide energy and glucose for the cells. This reaction would be favorable if the body really was in a starvation mode, but with sleep deprivation promoting ghrelin (not low blood glucose or energy stores) it is unnecessary to synthesize glucose. Understanding that the body gets false messages that it is in starvation state during sleep deprivation can explain why lack of rest can be linked to weight gain, increased appetite, and obesity.

The consequences of not getting enough sleep causes hormone levels that signal satiety to decrease and hormones that signal hunger to increase. It is this combination, increased hunger and lack of fullness which may explain why people eat more without feeling satiated when they are tired. Researchers have proposed that this effect may be a results of the body actually requiring more fuel for the extra hours spent awake, thus explaining the flux in hormones. Several studies have been conducted to test this hypothesis in which participants were given a constant glucose infusion throughout the study (Cauter et al. 2007). The same ratio of ghrelin-to-leptin were seen when the glucose was given through
an IV, eliminating the prospect that the body is in need of glucose. The ratio of ghrelin-to-leptin plays a large role on hunger, which may explain why sleep deprivation may have an impact on obesity.

A plethora of studies have provided solid data to exhibit the effects of sleep loss on the hormones that regulate hunger. Although there are many different factors that affect hunger and sleep, ghrelin and leptin are two of the most researched and discussed proteins in regards to sleep. The studies show that leptin concentrations decrease and ghrelin levels increase when participants are exposed to short nights of sleep. These hormones circulate in the blood and send messages to the hypothalamus portion of the brain expressing the energy status of the body. These messages then stimulate metabolic pathways to occur. Under normal conditions leptin promotes fullness and tells the brain that no more food or energy is needed. Leptin levels dramatically lower with sleep loss, therefore stopping the mechanism to tell the brain that no more energy is needed by promoting satiety. Ghrelin signals hunger when the concentration is high and food intake is low. Regardless of food intake, many studies demonstrate that lack of sleep increases ghrelin and therefore increases hunger and food intake. One of the factors contributing to the rise in obesity in America may be the fact that many people are sleep deprived. The hormones that regulate hunger are altered with lack of sleep and may be a cause of weight gain, obesity, type 2 diabetes, and heart disease. The mechanisms that control hunger and satiety in regards to sleep are quite complex and still not fully understood. More research needs to be conducted to fully unveil the relationship between sleep and hunger. With more knowledge on the correlation, the importance of sufficient sleep will be emphasized as a way of maintaining health and regulating food consumption.
Works Cited


