

The importance of sleep as a direct and indirect factor in eating behavior

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There is an extensive literature on different psychological factors that contribute to either facilitating healthy eating or decreasing unhealthy eating, such as inhibitory control (Bartholdy, Dalton, O'Daly, Campbell, & Schmidt, 2016), emotion (Cardi, Esposito, Clarke, Schifano, & Treasure, 2015) and intentions (McDermott et al., 2015). Sleep, as a behavior, could be considered yet another factor in determining eating behavior. This article shows that the influence of sleep on eating behavior takes places through direct and indirect routes by discussing literature on the relations between sleep and eating behavior, between sleep and psychological factors and linking it to literature on the relation between psychological factors and eating behavior.

Firstly, there is a body of literature that shows a direct relation between sleep parameters and eating patterns and/or overweight and obesity. For example, research has shown an link between sleep deprivation and increased food intake as well as food choice; short sleep duration – which is defined as less than 7 hours of sleep a night (Knutson, Spiegel, Penev, & Van Cauter, 2007) – is found to be associated with obesity, BMI (Taheri, 2006; Taheri, Lin, Austin, Young, & Mignot, 2004) and with an altered, often unhealthy, food choice (Hogenkamp et al., 2013). This relationship between sleep, body weight and metabolic disturbances has been found across various ethnicities and all age groups (Taheri, 2006). Markwald and colleagues (Markwald et al., 2013) note that this may reflect an adaptive physiological response, which is to provide sufficient energy in

order to maintain wakefulness, but that, in cases of abundant food availability, more food will be consumed than actually needed. Furthermore, in this adaptive physiological response to eat more when people sleep less there is a changed preference for food and an increase in the desire for energy-dense food, which often contains high levels of fat (Taheri, 2006). In line with Taheri's findings, Hogenkamp and colleagues (Hogenkamp et al., 2013) state that more snacks are eaten after sleep deprivation. Heath and colleagues (Heath et al., 2012) found similar results of an overall increase in snack consumption after sleep deprivation. Thus, it seems that sleep loss leads to increased portion size, and an altered food choice.

Note that sleep is not only just another factor of interest as illustrated by the literature described above; research has shown that over the past decades the average sleep duration has actually decreased steadily. The average sleep duration in 1960 was found to be 8.0-8.9 hours a night, whereas it dropped to 7 hours in 1995, and eventually, the total amount of sleep per night decreased to 6 hours in more than 30% of adult women and men (Knutson, 2007). Simultaneously this decrease in sleep is mirrored by an increase in obesity prevalence. It suggests a real necessity to investigate this relationship between sleep and eating behavior. A prolonged sleep deprivation could be a predicting factor in the development of the current obesity epidemic.

Next to a direct pathway between sleep and eating behavior, sleep will influence eating behavior indirectly as well; sleep has an impact on psychological functions that in turn have a direct relationship with eating behavior; previous

research has shown, for example, that both positive and negative emotions can heighten caloric intake (Evers, Adriaanse, de Ridder, & de Witt Huberts, 2013). Studies on memory and eating show that recent recollection of meals decreases subsequent food intake (Higgs, 2008; Higgs, Williamson, & Attwood, 2008). Different aspects of executive functioning such as executive attention, inhibitory control and affect regulation have been shown to all have their separate contribution in keeping impulses to eat unhealthily in check (Bartholdy et al., 2016; Hofmann, Friese, & Roefs, 2009). Therefore, in the following paragraphs the role that sleep has in psychological domains such as emotion, memory, and executive function will be discussed in more detail with the idea in mind that this in turn can affect eating behavior. Furthermore, it will be discussed that overall cognitive speed and attention are influenced by sleep, which in turn are needed for these same psychological processes involved in eating behavior.

When considering emotion, results from a recent study by Wassing and colleagues (Wassing et al., 2016), for example, have shown that in people with sleep problems fragmentation of REM sleep leads to a slower dissolving of distress, which in turn leads to an accumulation of arousal. Hyperarousal is a typical key symptom of people with clinically diagnosed insomnia. It can therefore be argued that sleep will affect eating behavior indirectly through emotion as well: poorly regulated emotions due to sleep problems will result in lingering negative emotions, which are known to have a direct effect on eating behavior (Tice, Bratslavsky, & Baumeister, 2001).

Studies on memory processes have shown similar effects of poor sleep. A study on declarative memory and sleep revealed that even a mild disruption of sleep resulted in both a lower hippocampal activation during visual encoding of new material the next day as well as in lower memory performance in a task aimed at retrieving

previously encoded visual material (Van Der Werf et al., 2009). An impaired memory encoding has been shown to increase snack intake as well (Higgs, 2008).

In addition to this finding, integrative executive functioning, such as multitasking, monitoring one's own behavior, planning, self-organization, and prioritizing, is found to be reduced after sleep deprivation (Nilsson et al., 2005). These researchers were able to show that executive function performance of subjects was significantly impaired after sleep deprivation. As mentioned before, inhibitory control, which can be seen as a component of executive functioning (Diamond, 2013), is one of the important factors when it comes to being able to eat healthily or changing an unhealthy diet (Bartholdy et al., 2016).

Furthermore, research showed that overall cognitive speed declines in a situation of sleep deprivation as well (Van Dongen & Dinges, 2005). Ratcliff and Van Dongen (Ratcliff & Van Dongen, 2009) found a loss of accuracy and a slower reaction time after sleep deprivation in comparison to sleeping normally. In other words, their research shows that processes that are important for decision process such as deciding what to eat in eating behavior could be impaired by sleep deprivation as well.

A meta-analysis lastly suggests that alertness, vigilance and attention are cognitive capacities which are affected most by sleep deprivation (Lim & Dinges, 2010). The results from this analysis show that without some degree of attention or alertness, it is very difficult to engage in situations or tasks in which more complex psychological processing is required (e.g. emotion regulation, memory, executive functioning). Studies by Alhola and Kantola (Alhola & Polo-Kantola, 2007) and Durmer and Dinges (Durmer & Dinges, 2005) corroborate this by stating that cognitive deficits, which occur after (prolonged partial) sleep deprivation, are mediated through attentional lapses, periods in which subjects fail to respond to

a cue, and brief moments of inattentiveness. This would mean that keeping a long-term dieting goal in mind and making decisions based on these goals, for example, would be affected by a lowered vigilance and attention due to sleep deprivation as well.

To summarize, previous studies found that little or poor sleep is associated with increased BMI and increased prevalence of obesity (Taheri, 2006; Taheri et al., 2004), sleep deprivation results in higher preference for high calorie food, more snacking, and bigger portion size (Heath et al., 2012; Hogenkamp et al., 2013; Knutson et al., 2007) showing a direct effect of sleep on eating behavior. Next to these direct effects, sleep deprivation also results in a decline in cognitive and psychological performance in different domains such as emotion (Wassing et al., 2016), memory (Van Der Werf et al., 2009), executive function (Nilsson et al., 2005) and is mediated by attentional lapses and decreased vigilance performance (Alhola & Polo-Kantola, 2007; Durmer & Dinges, 2005; Lim & Dinges, 2010; Ratcliff & Van Dongen, 2009; Van Dongen & Dinges, 2005). All of these cognitive and psychological functions influenced by sleep have been suggested to be involved in influencing eating behavior (Bartholdy et al., 2016; Evers et al., 2013; Higgs, 2008; Higgs et al., 2008; Hofmann et al., 2009). Therefore, given this short overview of the possible contribution of sleep as a behavior in eating behavior not only through a direct route, but perhaps more importantly through the various indirect influences of sleep on a myriad of psychological functions, it would be tempting to suggest to always consider and measure sleep parameters when researching eating behavior.

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