

Sleep, Disturbances of Sleep, Stress and Obesity: A Narrative Review

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Abstract

Introduction: Obesity is a burgeoning health problem with few successful strategies to counter this epidemic or to truly comprehend preventable aspects of the problem.

Objective: The present objective was to examine an increasing volume of research on obesity, stress, and sleep deprivation, and the possible implications of this research for obesity prevention.

Methods: Data from major electronic data bases extending from 2000-2015 using the key words-stress, sleep, obesity, eating practices, and health were used to extract relevant peer reviewed literature and basic information. English language articles related to the topic were accepted if they discussed one of the issues of interest and were peer reviewed.

Findings: A reasonable body of evidence documents an association between stress, abnormal eating behaviors, sleep deprivation and obesity, although not necessarily in that order.

Conclusion: Teasing out the differential role of these overlapping factors and heightening public awareness of their linkages is of potential utility in efforts to prevent or reduce the obesity epidemic at both the individual and national level.

Keywords: Eating practices; Health; Obesity; Sleep; Sleep deprivation; Stress

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Introduction

The ability to sleep for an adequate time period, plus the quality of sleep encountered on a daily basis are emerging as issues of high import in the context of efforts to impact optimal health and wellbeing [1]. Stress, a widespread health-associated determinant is one factor that can seriously impact sleep quality and sleep duration. In turn, sleep deprivation and fragmentation can increase the risk of stress. Stress, can also directly impact weight gain due to its effect on eating behaviors, and if not resolved, both the eating behavior pattern, plus the ensuing problem of sleep deprivation may produce unwanted changes in body weight among other factors. As such, although not commonly cited as a primary determinant of obesity, sleep deprivation, restriction, or sleep fragmentation, along with stress appear to be important risk factors for weight gain. However, a review of the literature

reveals very few reports that specifically discuss the role of stress in either the context of obesity or in the context of sleep deprivation, despite the fact both sleep and eating practices are partly governed by co-existing neural mechanisms. This brief was designed to provide an overview of the topics of sleep, stress, and sleep disturbances in the context of health, and specifically examines their individual or collective relationship to obesity or weight gain.

Methods

Peer reviewed data from the key electronic data bases including Academic Search Complete, PUBMED, and Web of Science published over the last 15 years were specifically sought to examine what we currently know about this topic. It was believed that examining these issues and their related research simultaneously might reveal how they can interact to impact the current obesity epidemic. Key words included, *eating practices*,

health, obesity, sleep, sleep deprivation. All articles relevant to the topics in question were carefully read first to ascertain their possible value and the articles were eliminated if they did not relate to the specific topics of interest, were non English manuscripts without an English abstract, or were not obtainable readily. Chosen articles were those deemed to support the relevance of conducting future analyses of these issues.

Results

Sleep

Ideal sleep is defined as the optimal amount of sleep required for an individual to remain alert and fully awake so that he or she can function adequately throughout the day. The difference between the ideal sleep duration and the actual duration of sleep is called the sleep debt. Whether we get enough sleep depends on our psychological and physiological needs or state (how we feel). Environmental factors, such as light and darkness, normally synchronize one's sleep pattern in accord with the prevailing day-night cycle. That is, the existence of environmentally-autonomously generated rhythms suggests that we have an internal biological clock that determines how long we sleep. This internal clock is located in the suprachiasmatic nuclei (SCN) of the hypothalamus above the optic chiasm. The suprachiasmatic nucleus receives photic information from the retinohypothalamic tract and sends signals through multiple synaptic pathways to other parts of hypothalamus, the superior cervical ganglion and the pineal gland where melatonin is released. In turn, the neurons in the SCN are responsible for generating circadian rhythms implicated in many physiologic processes, including the sleep-wake cycle, body temperature, and neuro-endocrine secretion processes. Melatonin, secreted mostly during the night, reaches its maximum value between 3:00 a.m. and 5:00 a.m. after which it decreases to low levels during the daytime. It helps to regulate sleep and wakefulness [2] and functions as an antioxidant as well as an anti-inflammatory agent. However, these functions can be altered by factors such as traveling to different countries that have different seasons, different time zones or different climates. In addition, a change in the amount of noise we experience, the presence of intrusive thoughts, excess heat or cold, or an increase or change in our work hours can disrupt our daily sleep routines. Researchers have found that loss of sleep and fatigue in the night shift working population is more common than in the day work population [3], although the implications for obesity are not clear in this respect. However, one's work schedule clearly affects one's physiological and psychological functions, including the circadian rhythm, and those who do not adjust well to this situation may be more clearly at risk for health issues than those that do. Food intake and type of food can also impact sleep duration and quality. For example, foods high in carbohydrate content are found to induce more sleepiness compared to foods high in protein [4,5]. However, even if they act as soporific agents, those exposed to short sleep duration may suffer from adverse carbohydrate metabolic functions, as well as endocrine functions, even if they experience more caloric usage than those who sleep adequately [6]. Thus, simply falling asleep, but not having enough sleep, can still prove hazardous, rather than helpful as far as weight control goes. Unfortunately, our environment and the demands

imposed on us by our work, families and society are constantly exerting forces on our physiological and psychological response mechanisms that may foster sleep deprivation and diets high in carbohydrates that cannot be responded to in a physiologically sound way. If the individual continues to place excessive and unrelenting demands on the body, and is not able to adapt in an effective manner to their external environments, and life's demands, the compounding stress, if unabated, can clearly affect the individual in an extremely negatively, especially if they become sleep deprived [7].

Sleep requirements for an average adult are approximately eight hours regardless of environmental or cultural differences [1]. Many studies have shown that those individuals who consistently experience less than eight hours of sleep may, in turn, suffer from exhaustion, irritability, have less concentration and may be more prone to suffer from arterial disease (especially those that sleep less than four hours). Also they have higher cancer, depression and anxiety rates. They perform less well at work and suffer more car accidents and work related accidents due to lower alertness. Work in animal models has shown that sleep restriction consequences may last for a protracted period, and can be observed to be a predisposing factor for weight gain and insulin resistance [8]. According to these researchers [8], sleep restriction seems to prime adipose tissue, thus potentially increasing harmful effects of diet induced obesity, among other health factors mentioned above.

Stress

Stress is produced by stressors or factors that impose excessive or unrelenting demands on the body that impacts its state of balance or homeostasis. It can affect one's physical, as well as psychological wellbeing and requires action to restore balance or equilibrium to avoid unwanted adverse health repercussions. Our daily lives are however, replete with stressors, and the extent to which we can minimize these is confounded by actual or perceived events including our self-esteem, problem solving and coping skills, past experiences, presence of social support, perceived self-efficacy, our genetic predisposition to stress and our perception of the cause of stress. Many of us perceive unpredictable events as a threat to our wellbeing, and our perceptions of an event can also be affected by our abilities to predict and perceive the time and place of an event and if we have the tangible skills to deal with it. If stressors are overwhelming or prolonged and intense, or if we do not know how to deal with them, they can result in immense physiological and psychological health problems. These include depression, sleeplessness, insomnia or other negative adjustments to social and environmental situations, and changes in eating patterns that promote increasingly negative health states [9]. With no plans on how to cope with this, many may resort to eating practices that become habitual, while increasing the risk for obesity because many foods that appear to reduce stress are addictive [9]. As outlined by Yau et al. [9], at a neurocircuitry level, chronic stress may affect the mesolimbic dopaminergic system and other brain regions involved in stress/motivation circuits. Together, these may synergistically potentiate reward sensitivity, food preference, and the wanting and seeking of hyper palatable foods, as well as induce metabolic changes

that promote weight and body fat mass. As well, if a pessimistic attitude prevails, and sleep disturbances continue, especially if 'food' issues are a possible source of stress, for example, among those trying to lose weight or adapt to a new diet, the motivation to remain active may be seriously compromised. Both these factors are strongly associated with obesity risk. Hence, if the affected individual cannot accept or dissociate themselves from stressful situation (s), professional help is duly indicated. This is because how one handles stress will in turn affect how they sleep, and in the context of obesity, sleep deprivation not only causes immune suppression, impairment of performance and vigilance, loss of attention and concentration, and lowers survival rate, but is an increasingly recognized predisposing factor for weight gain [10]. As well, metabolic changes during sleep restriction appear to prime adipose tissue, thus further aggravating the detrimental effects of diet-induced obesity [10]. In terms of empirical support for the aforementioned associations, St. Onge and Shechter [11] found fairly robust evidence across both cross-sectional and longitudinal studies confirming a relationship between short sleep duration and weight gain. Gutierrez-Repiso et al. [12] too found a relationship between night time sleep duration and the incidence of obesity examined over an 11 year period, and Bayon et al. [13] found an association between short sleep duration and elevated body mass index in epidemiological studies.

Discussion

As outlined in the available research, sleep is crucial for healthy functioning, and factors such as stress that can reduce the ability to sleep, can hence predictably mediate or moderate weight gain and the onset of obesity [14-18]. That is, those experiencing excess stress, plus those who are experiencing sleep disruptions, or sleep disorders, which may itself be a stressor, or a factor influencing food intake patterns and metabolic processes adversely [11] may be at risk for excess weight gain. Conversely, although it is often difficult for people to slow down in their daily activities, or to cope with unremitting or severe unexpected stresses, reducing stress and enhancing sleep duration and quality may well be protective against obesity and diabetes [12], even if these factors are not currently the focus of most obesity prevention approaches. Alternately, one way to optimize one's ability to deal with stress is to get a good sleep. Although reducing intrusive thoughts, anxiety, and depression that impact sleep may be difficult, intervention in this regard may permit enough sleep to foster those important functions dependent on sleep that are necessary for optimal health. Some of the benefits of a good sleep are higher productivity at work, better coping skills, better concentration and better memory, possibly a better ability to make careful health behavioral decisions. Adequate sleep can also help maintain or improve the immune system and help the body to recover from the day to day stresses imposed on it. Moreover, adequate sleep promotes optimal body and tissue restoration, increases the secretion of anabolic hormones (such as growth hormone, prolactin, testosterone, and luteinizing hormones) and decreases levels of catabolic hormones (such as cortisol) that can be harmful if prolonged. People usually feel refreshed after a good sleep and sleep helps us to conserve energy by lowering blood pressure and slowing metabolism.

Sleep is consequently an extremely important adaptive behavior that helps in the maintenance of the synaptic and neural network integrity necessary to preserve a multitude of key CNS (Central Nervous System) functions, and those who sleep an adequate number of hours may have less chance of becoming stressed, and especially of becoming overweight [19]. Importantly, thermoregulatory homeostasis is maintained during NREM (non-rapid eye movement) sleep, whereas severe thermoregulatory abnormality is observed during total sleep deprivation [2]. Moreover, decreases in REM (rapid eye movement) sleep are likely to play a large role in the development of negative body weight outcomes [11]. Recent research reveals that alone or in combination, sleep deprivation can foster weight gain due to several converging mechanisms, including as a result of circadian clock disruptions [15], increased food intake, decreased energy expenditure, and appetite-regulating hormonal changes, for example in leptin and ghrelin levels [13].

Sleep deprivation or reduced self-reported sleep duration is also associated with an increased incidence of type 2 diabetes, and cardiovascular disease, as well as obesity [14]. Thus stress, which reduces sleep quality and duration or both, along with possible dietary changes due to stress, and increased sedentary behavior due to depression, may arguably decrease insulin sensitivity and glucose tolerance [14]. In addition, although sleep restriction can increase energy expenditure, it can hence lead to a disproportionate increase in food intake, a decline in physical activity and weight gain [14], and cardio metabolic syndromes that make it challenging to maintain an optimal weight, especially in those at risk for obesity, or those who are already obese. In light of this converging data, we propose that although the topics of sleep deprivation and stress may not have received much attention in the context of the obesity debate, efforts to lower stress levels that impact sleep quality and duration are clearly indicated. Additionally, we believe improved sleep hygiene and education about the importance of sleep can potentially reduce stress, while enhancing physiological and psychological wellbeing, plus caloric energy consumption. Educating individuals about the importance of stress control is of potential value as well, in this respect, given the ignorance that some of our own choices are favoring weight gain and ill health through long work hours, and excessive technology use [13]. In summary, insufficient sleep and unresolved stress may both be associated with weight gain and related eating patterns, although it is difficult to isolate one factor from another, as well as their cause-effect relationships. Consequently, it appears future research to more closely examine the stress, sleep and obesity relationship could prove highly valuable. Indeed, given that there is a strong relationship between obstructive sleep apnea and energy balance that favors obesity [11] and rising rates of obesity, world-wide, and that the consequences of sleep restriction may last for long periods [8] we believe comprehensive innovative and interdisciplinary work in this realm is urgently needed in the near future. Moreover, we feel this work is a priority because being obese is undoubtedly a highly stressful psychological and physiological state that is not readily amenable to change, but may be hindered if sleep duration and quality are less than desirable. Moreover, unresolved stress, along with poor sleep characteristics may individually or collectively

interfere with weight loss, an issue not always discussed in the relevant literature, where eating practices requiring modification may become unwarranted stressors in their own right.

Clinical Implications

Sleeping well is essential to good health. People who are healthy, in turn, usually sleep well. However, sleep disruptions, even if minor, can markedly influence one's physical wellbeing as well as their emotional wellbeing and mental health. Poor sleep levels may also decrease one's ability to deal effectively with stressors encountered on a day to day basis, and inadvertently induce unhealthy eating practices that can raise the chances of becoming obese. As outlined in the aforementioned background material, sufficient research has supported the view that insufficient sleep increases the risk of becoming obese [16]. Less well supported is the link between stress and poor sleep quality that can lead to obesity, even though stress is a well established risk factor for participating in unhealthy dietary behavior (s) and food intake practices. The impact of eating practices on sleep patterns-for example caffeine intake has also been reported, but rarely in conjunction with the cycle depicted in **Figure 1**. Fortunately, most sleep problems can be addressed successfully by carefully examining their causes, and treating or eliminating these where possible. These causes can include pain, lifestyle factors, the use of certain medications, and stress, a focus of this review. Possible solutions are stress reduction interventions, where this is indicated, or joining a sleep clinic if the problem becomes unmanageable. Education about the desirable amount of sleep for an average adult, which is eight hours per night, plus the link between stress, sleep and weight gain may also be helpful especially for those at risk for obesity. Explaining that lack of sleep is correlated with weight gain because: 1. We require more calories when we are awake than asleep; 2. When tired, we eat out of boredom; 3. We lose body heat when sleep deprived and we make up for it by consuming more food; 4. The human bodies thermostat will increase when an individual hasn't slept enough, requiring the individual to eat more calories [20]; 5. Those with higher stress levels, who are sleep deprived, will be more likely to gain weight and become obese because they do less than optimal amounts of physical activity [21] may be especially advantageous. Additional education concerning the less well publicized fact that stress may not only lead to sleep deprivation and indirectly to weight gain, but directly because individuals who are stressed unremittingly may resort to high fat content foods for comfort [9]. When college students were asked reasons for their observed weight gain in college, their perceived determinants for this situation included: 1. The availability of food on campus; 2. Drinking alcohol and alcohol-related eating; 3. Lack of time; 4. Eating at fast-food and other restaurants; 5. Negative experiences using the on-campus recreation center; 6. Food in dorm rooms, and 7. Eating for reasons other than hunger. The latter is where the students discussed eating in response to stress [22]. In turn, stress is a potential risk factor for suboptimal sleep quality and/or duration, and can inadvertently foster unwarranted weight gain through this pathway. Consequently, it is our view, efforts to overcome obesity among vulnerable populations might be more successful if they not only routinely assess an individual's body fat

content, plus their sleep patterns using valid measurement tools, but their stress and coping attributes as well [23]. Helping individuals to comprehend the association between stress, and obesity [9] and between short-sleep duration and obesity [10] plus stress [22], and the impact of chronic sleep deficiency on cardiovascular and metabolic health [23] is also likely to prove highly valuable. As well, given the global epidemic of obesity, apprising national stakeholders and the medical schools that train future practitioners of the observed role of primary sleep disorders in increasing the risk of a shortened lifespan, due to obesity and impaired glucose metabolism [24,25], and that several immune cell types can be impacted by sleep deprivation thus heightening disease risk in obese individuals is recommended [26]. More awareness about the impact of sleep fragmentation, a frequent occurrence in many disorders, especially sleep apnea, which can be mediated or moderated by stress should also be carefully considered as a unique modifiable obesity determinant, owing to its potent impact on insulin resistance [27] metabolic disturbances and altered feeding schedules [28]. Raising awareness that acute sleep deprivation due to the aforementioned factors or others affects the brain reward systems, and that this can potentially increase responsiveness to hyper palatable foods [29] and energy balance disturbances is also strongly indicated in medical education programming. Other recent research supporting the importance of this topic shows a deficiency of melatonin, one of the consequences of sleep deprivation, is significantly correlated with obesity, and energy metabolism, and also functions as an antioxidant and as an anti-inflammatory agent [30]. Another unexplored area maybe the fact that those who are sleep deprived and ingest excess caffeine in unsweetened or sweetened versions of energy products to stay alert may experience harmful effects regardless of their sugar content, due to headaches that produce stress and disrupt sleep patterns, a risk factor for obesity. Energy drink consumption is also associated with lower breakfast frequency and higher sugar-sweetened soda intake, video game use-a sedentary behavior, use of unhealthy weight-control behaviors, and trouble sleeping [31]. The topic of stress reactivity dysfunctions as one mechanism linking poor sleep with detrimental physical health outcomes, and the possible impact on normal hypothalamic-pituitary-adrenal functioning in an acute psychosocial stress situation after falling prey to low sleep quality has recently been discussed [32]. Thus, a maladaptive stress response has been found to be implicated in mediating the onset of metabolic disorders, such as obesity, via its impact on the hypothalamic-pituitary-adrenal axis, and obesity, in turn, can adversely affect the stress response [33], and cannot be ignored. In short, a wide array of epidemiological studies supports previous arguments that show impaired sleep is an independent risk factor for many chronic health conditions such as metabolic syndrome, obesity and Type 2 diabetes and that a sound physiological basis for explaining this exists [34]. Other independent research links both stress and sleep deprivation independently to impaired cognitive control [35], and the use of alcohol or energy drinks to sleep dysfunction [36]. Other data reveal eating practices in response to stress can increase the risk for obesity [34]. Yet, although the prevailing body of research reveals a plethora of studies focused on sleep and obesity [37], as well as on stress and sleep, and stress and abnormal eating practices, the connection

between these topics covered here is less well documented. In light of the burden imposed by obesity on the individual and society, this review sought to examine current knowledge on the role of sleep disturbances in the development of obesity and stress, as well as the impact of stress on sleep, along with obesity, in the belief that continued exploration of these independent health situations and their implications might be of great import in the context of unraveling why obesity is so prevalent and challenging to prevent or minimize even though multiple programs exist. That is, it was felt the even though we know stress is linked to overeating, and sleep deprivation is linked to obesity, applying this information collectively and insightfully to reduce the obesity crisis, which is relatively unexplored, could help to advance both research and practice. To provide some background information and ideas for furthering research that others might pursue concerning the associations between sleep disturbances, stress and eating behaviors [9], obesity, and food

consumption or dietary patterns and sleep duration [38], obesity as an independent stressor, as well as possible strategies for preventing the burgeoning global obesity epidemic and its deleterious consequences current literature deemed relevant to this topic was identified and reported here. Although no systematic review was possible, the relationships discussed here are we believe very salient to the public health burden of obesity prevention and intervention and are surely worthy of continued study. **Figure 1** conceptualizes some of these overlapping issues and shows that there may be multiple therapeutic opportunities to decrease the obesity epidemic if sleep health and stress are added to the possible mix of factors that exacerbate this health condition. We encourage exploration of one or more of these factors in future research and clinical studies, and predict this line of endeavor will prove highly valuable.

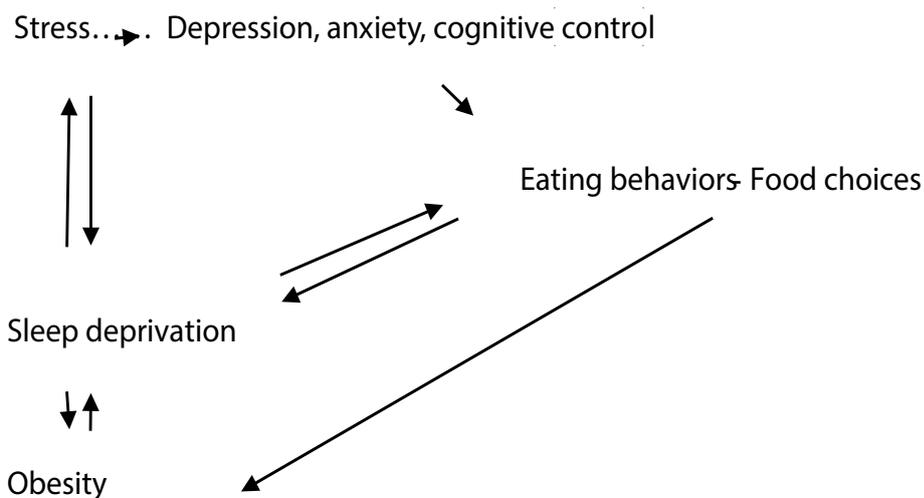


Figure 1 Hypothetical associations between stress, sleep deprivation and obesity.

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