Sleep Deprivation in Adults: Health Effects and Implications for Practice

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Table of Contents

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Abstract

Many adults experience sleep deprivation. The effects of sleep deprivation can have both short- and long-term effects on the mind and body. Negative changes occur in multiple body systems when individuals consistently obtain less than seven hours of sleep per night. The purpose of this project was to expand our knowledge of sleep deprivation and its effects on the body through a scientific review of the literature dating from 2001–2015.

Implications for practice as a family nurse practitioner include: obtaining a thorough, subjective history from individuals seeking medical guidance, identifying potential risk factors for developing the negative side effects of sleep deprivation, and providing education regarding medications and lifestyle changes necessary to help individuals obtain more restful sleep. Further research is needed to identify the long-term effects of sleep deprivation.

Keywords: sleep insufficiency, poor quality sleep, chronic sleep, insufficiency, circadian rhythms, sleep stages, REM, NREM, sleep architecture, depression, anxiety, clinical manifestations, insomnia, sleep length, sleep quality, young adult, adult, drug effects, sleep, sleep deprivation, caffeine, diet, lifestyle, complementary and alternative medicine, pharmacologic sleep aids, herbal sleep aids, non-pharmacologic sleep aids, sympathetic response, normal versus late sleepers, food consumption, weight gain, hormones, sleep hygiene, exercise.

Sleep Deprivation in Adults: Health Effects and Implications for Practice

Sleep is an integral part of every human body. In order to maintain homeostasis within all body systems, the body must have adequate and restful sleep. Sleep allows the body to repair and revitalize itself; however, one third of American adults are sleep deprived and sleep less than six hours per night (Kondracki, 2012). As recommended by the Center for Disease Control and Prevention (CDC), adults require seven to eight hours of sleep per night (CDC, 2015). Sleep deprivation can be defined as an acute or cumulative process. Acute sleep deprivation is sleep missed in a 24-hour period, while cumulative sleep deprivation is sleep missed over a period of several days (McCance, Huether, Brashers, & Rote, 2014).

The impact of sleep deprivation on the body is multifactorial. If sleep is not adequate by quality and/or quantity, an individual's health, lifestyle, diet, and activity levels can be negatively impacted. Negative impacts on body systems include: inability to focus, impaired judgment, increased health risks, decreased memory, and lack of coordination (McCance et al., 2014). Health risks include metabolic disorder (which consists of hypertension, hyperlipidemia, truncal obesity, and hyperglycemia), depression, and anxiety (Chaput, McNeil, Despres, Bouchard, & Tremblay, 2012). Regardless of the type of sleep deprivation, the effects can be immediate and longstanding.

There are multiple reasons that sleep deprivation and its associated negative health impacts are important to health care providers. Sleep deprivation is a costly disorder with 32.4 billion dollars spent each year in the United States (Mackey, 2012). Costs are associated with pharmacological and non-pharmacological interventions, such as sleep studies, laboratory tests, medications, medical devices, and sleep-related products (CDC, 2015). Providers need to have an adequate ability to recognize sleep-related issues and disturbances. Being well versed in how to improve outcomes for health promotion and treatment can reduce healthcare costs (Mackey, 2012).

Adults have varying bedtimes due to modern lifestyles, various work schedules and unhealthy dietary habits. These factors have altered the quality and quantity of sleep for most of the adult population. Geographic location is an example of a barrier that influences bedtimes for adults (Gregoire, 2014). Other examples of barriers related to inadequate sleep include caffeine consumption, substance use (i.e., alcohol intake, nicotine, or other drug use), excessive screen time, lack of knowledge of proper sleep hygiene (i.e., lifestyle habits and practices related to sleep), and a lack of knowledge regarding the importance of sleep (CDC, 2015).

Multiple barriers exist while attempting to treat and manage sleep deprivation. For example, patients typically request a quick fix when they come in for sleep troubles. Additionally, patients do not understand the risk of addiction, dependency, or other adverse side effects that are associated with sleep medications. Even after educating patients about these possible side effects, most individuals opt for a pill rather than choosing to alter their lifestyle or incorporate sleeping hygiene into their daily schedule. Another challenge to properly treating sleep deprivation is that many patients attempt to self-treat instead of seeking medical advice and evaluation first (Lynch, Jarvis, DeBellis, & Morin, 2007). In order to properly diagnose and treat patients' sleep disorders, providers must be able to effectively evaluate their patients in order to ensure the best possible outcomes. As we explore obstacles contributing to sleep deprivation, we will present evidence-based practice guidelines on effective resolutions to overcome this epidemic (CDC, 2015).

The purpose of this paper is to examine correlations between sleep deprivation, diet, and exercise among healthy adults, ages 18–64 years of age. First, we will describe the importance of sleep, its varying stages, and restorative properties. Then, we will examine the hormones related to sleep along with the correlations between sleep deprivation, weight gain, exercise, and dietary habits. The information gathered and presented will help medical providers educate and inform their patients about the importance of adequate sleep, psychological consequences, and physiological risks for the body.

Sleep and its stages

> Sleep is an active, multiphase, complex brain process that provides restorative functions and promotes memory consolidation. Several areas of the brain are associated with sleep and sleep-wake cycles. A small group of hypothalamic nerve cells, the suprachiasmatic nucleus (SCN), controls the timing of the sleep-wake cycle and coordinates this cycle with circadian rhythms (24-hour rhythm cycles) in other areas of the brain and body tissues using electrical, endocrine, and metabolic signaling pathways (McCance et al., 2014, p. 502).

Normal sleep has two phases: rapid eye movement (REM) and non-REM (NREM). Non-REM has three stages followed by REM sleep. REM and NREM sleep follow each other in 90 to 110 minute intervals in a predictable pattern, with four to six cycles occurring during a normal sleep period in healthy adults. Sleep patterns can be demonstrated and confirmed with electroencephalography (EEG). Once an individual falls asleep, they will alternate between periods of REM and NREM sleep throughout the night, with intervals of REM sleep getting longer and deeper, and stages of NREM sleep getting shorter throughout the night. For example, when a person falls asleep, they will advance through stages N2, N3, and REM sleep, with each following cycle beginning with stage N2, moving through N3, and then entering into REM sleep. With each subsequent cycle, the amount of time spent in stage N3 decreases and the amount of time spent in REM sleep increases. Once an individual is awakened, the next sleep cycle will start again with stage N1 (McCance et al., 2014).

Sleep cycle

Awake—Wakefulness with eyes closed and predominated by alpha waves (8–25 Hz)

N1—Light sleep, with alpha waves (6–Hz) interspersed with low-frequency theta waves; slow eye movements (3–8% of sleep time)

N2—Further slowing of the EEG (4–7 Hz) with the presence of sleep spindles and slow eye movements (45–55% of sleep time)

N3 (NREM)—Low-frequency (1–3 Hz), high-amplitude delta waves with occasional sleep spindles—also known as slow-wave sleep; no slow eye movements (15–20% of sleep time)

REM sleep—Time of most dreaming (20–25% of sleep time) (McCance et al., 2014, p. 502) (see Tables 1 and 2)

NREM (slow-wave) sleep—Accounts for 75–80% of sleep time and is triggered by the withdrawal of neurotransmitters from the reticular formation, inhibiting the arousal mechanisms in the cerebral cortex. Multiple changes happen to the body during NREM sleep. These changes include: respiration controlled by metabolic activities; basal metabolic rate (BMR) slows by 10–15%; body temperature decreases by 0.5–1° C (0.9–1.8° F); heart rate drops by 10–30 beats per minute; respiration, blood pressure, and muscle tone all decrease; patellar reflexes are absent, and pupils are constricted. During the beginning stages of sleep, specifically, stages N1 and N2, cerebral blood flow to the brainstem and cerebellum is decreased. During N3, cerebral blood flow to the cortex is decreased, growth hormone is released, and levels of corticosteroids and catecholamines are depressed (McCance et al., 2014).

In contrast to NREM, "Rapid eye movement (REM) sleep accounts for 20%–25% of sleep time and is characterized by desynchronized, low-voltage, fast activity that occurs for 5–60 minutes about every 90 minutes beginning after 1–2 hours of NREM sleep" (McCance et al., 2014, p. 503). During REM sleep, the brain is active; it is also known as paradoxical sleep because the EEG pattern during REM sleep is similar to the awake pattern. During REM sleep, the individual experiences vivid dreams; bursts of conjugate rapid eye movement in all directions; atonia; suppressed temperature regulation; changes in heart rate, blood pressure, and respiration; penile erection in men; and clitoral engorgement in women. It is also known that loss of REM sleep impairs learning and memory. During REM sleep, a person may experience loss of normal voluntary control in the tongue and upper pharynx, which may cause respiratory obstruction. Also, cerebral blood flow to both hemispheres of the brain is increased (McCance et al., 2014).

How sleep is regulated

The hypothalamus controls many mechanisms inside the human body and is the main regulator of the sleep center. It does this, in part, by secreting neurotransmitters, such as hypocretin, prostaglandin D2, I-tryptophan, serotonin, adenosine, melatonin, gamma-amino butyric acid (GABA), and growth hormone (McCance et al., 2014).

The neurotransmitters responsible for promoting wakefulness are hypocretins (orexin), acetylcholine, and glutamate, while prostaglandin D2, I-tryptophan, serotonin, adenosine, melatonin, GABA, and growth hormone promote sleep. The mechanism of sleep is complex and not clearly understood. However, it has been demonstrated that growth hormone is associated with initiation of sleep, cortisol levels rise in the morning just before waking, and acetylcholine and somatostatin help with the stages of sleep transition. Disrupted and forced awakening may lead to increased difficulty returning to sleep, sleep progression disturbance, or both. The full extent of sleep, its purpose, and benefits are still unclear. However, we know that sleep offers restorative processes, particularly neuronal repair and generation of new neural pathways (McCance et al., 2014).

The circadian rhythm

According to the *National Institute of Health*, “Circadian rhythms are physical, mental and behavioral changes that follow a roughly 24-hour cycle, responding primarily to light and darkness in an organism's environment. They are found in most living things, including animals, plants, and many tiny microbes” (National Institute of General Medicine Sciences, 2015).

Circadian is Latin for “around the day,” and our circadian rhythm is controlled by our body’s biological clock. This clock is also known as the suprachiasmatic nucleus or

SCN; it is a pair of pinhead-sized structures that rest on the hypothalamus, just above the point where the optic nerves cross. Light that reaches photoreceptors in the retina sends signals from the optic nerve to the SCN. As a result, the circadian rhythm is regulated by the SCN, because the sleep/wake cycle is directly influenced by alterations in light. As day progresses to night and darkness falls, the body's level of melatonin increases, preparing and prompting the body for sleep. As night turns to day, the pineal gland switches off the production of melatonin in response to light-induced signals (National Institute of Neurological Disorders and Stroke, 2014).

The circadian rhythm is sensitive to external stimuli and thus can be affected to some extent by these cues. External stimuli may be anything from light to the sound of a garbage truck, alarm clock, lawn mower, or even the timing of one's meals. Because sunlight and other bright lights can reset the SCN, our biological cycles normally follow the 24-hour cycle of the sun. However, scientists have learned that when humans are deprived of light and external time cues, their biological clocks run on a 25-hour cycle rather than a 24-hour cycle. For example, many individuals with total blindness experience lifelong sleep problems, because their retinas are unable to detect light. As a result, the SCN has no influences on the sleep/wake cycle; their circadian rhythm follows their innate cycle, which is 25 hours, rather than the 24-hour cycle governed by the sun (National Institute of Neurological Disorders and Stroke, 2014).

A common complaint of circadian disruption and sleep disturbance is jet lag. When a traveler goes from one time zone to the next, for example, from Utah to Washington D.C., hours are "lost" according to the body's clock. Following this example, when the traveler wakes the next morning at 8 a.m., the body consequently feels it is only 6 a.m., so the traveler is still tired. Adjusting to a new time zone and correcting jet lag can take several days (National Institute of Neurological Disorders and Stroke, 2014).

Sleep pattern in adults and older adults

Sleep patterns of older adults differ from those of the pediatric population and younger adults. The number of hours of sleep decreases as an individual gets older, and it takes longer for older adults to initiate sleep and remain asleep. In addition, older adults tend to go to sleep earlier in the evening, wake more frequently during the night, and rise earlier in the morning. Older adults experience more side effects when sleep deprived. The stages of sleep in older adults are also different compared to those in younger adults in that REM and NREM sleep decreases; such changes may be due to diminished levels of cortisol and growth hormone. Furthermore, multiple factors contribute to changes in sleep for older adults. These changes include lifestyle, presence of chronic disease(s), lack of daily routine, desynchronization of circadian rhythm, and medications. Gender also plays a role in sleep pattern. Age-related alterations in sleep patterns typically appear approximately 10 years later in women than in men (McCance et al., 2014), as illustrated in Table 2.

We found other studies that used subjective rather than objective measurements of sleep. The most useful studies used evidence-supported sleep tools and questionnaires to measure sleep (Lauderdale et al., 2009)—the majority showed that short sleep duration impacts the younger populations negatively (Patel & Hu, 2008), as shown in Tables 7 and 8.

Sleep and exercise

The body has normal physiologic responses to exercise, which include changes in heart rate, blood pressure, respiratory rate, body temperature and changes in insulin resistance. The heart rate increases within the first 5–15 minutes following initiation of exercise. During exercise, the heart rate reaches a steady state and remains within a five-beat range if there is sustained effort. Following exercise, the heart rate should recover by at least twelve beats at minute one of recovery and at least twenty beats by minute two of recovery. Systolic blood pressure increases with exercise, while diastolic blood pressure will remain the same or slightly decreased. Systolic blood pressure should increase by at least ten mmHg during exercise and ideally exceed 140 mmHg but not go above 250 mmHg. Blood pressure should return to baseline within five minutes of exercise cessation (Katch, Katch, & McArdle, 2001).

Respiratory rate increases during exercise along with tidal volume, allowing the body to bring in enough oxygen to meet the metabolic demands of exercise. Body temperature increases with exercise and is influenced by the individual's environmental temperature. For example, if the environment is hot or humid, the individual's body will reach their target heart rate faster and will experience a more dramatic body temperature increase, due to blood flow distribution needed from the skin. Finally, exercise increases body cell's sensitivity to insulin, making insulin more efficient at maintaining blood glucose levels (Katch et al., 2001).

When the body goes without adequate quantity or quality of sleep, it responds differently to exercise. Significant differences were found when comparing hemodynamic response and heart rate recovery in individuals who are poor sleepers versus good sleepers: Poor sleepers had higher resting heart rates prior to the initiation of exercise and less heart rate variability with exercise (Yuksel et al., 2014). Additionally, heart rate recovery was diminished at minutes one and three following exercise, while higher diastolic blood pressures were found at rest, and higher systolic blood pressures occurred with exercise (Yuksel et al., 2014).

These findings may represent potential lifelong complications for poor sleepers, due to increased heart rates and blood pressures at rest. This can lead to hypertension, elevated nervous system activity, and increased salt and water retention due to adrenergic hormones. Short- and long-term sleep deprivations are independently associated with an increased risk of coronary events. Another interesting finding from this study was that poor sleepers were found to be more likely to smoke cigarettes, only adding to the problem of increased heart rates and potential for lifelong complications and diseases (Yuksel et al., 2014; Chennaoui, Arnal, Sauvet, & Léger, 2015).

Another study found that poor sleep leads to an increase in insulin resistance and a decrease in glucose tolerance that both contribute to disease processes (Chennaoui et al., 2015). This is due to the increase in cortisol and the decrease in growth hormone found in the body during times of sleep deprivation. Melatonin levels are affected by both lack of sleep and exercise, but the studies we found were inconclusive as to response and effect. The increase in cortisol and subsequent increase in blood glucose levels lead to a faster time to peak exertion and exhaustion during exercise. These findings were verified when looking at athletes' abilities to perform when sleep deprived (Fullagar et al., 2015; Chennaoui et al., 2015).

One's ability to perform during exercise is effected by sleep deprivation; however, the studies we found show that some sports and exercises affect individuals differently. Exercises that require little thinking and less focus, such as running or biking, are affected by sleep deprivation, because the time it takes to reach peak exertion and exhaustion is decreased. Exercises and activities that require mental focus and concentration, such as golf, tennis, basketball, playing darts, goalkeeping, or gun and arrow shooting are all affected negatively during periods of sleep deprivation due to a decrease in cognitive functioning and a reduction in alertness, reaction time, memory, decision-making abilities, and accuracy with hand-eye coordination (Fullagar et al., 2015).

One's risk for developing fatigue-related injuries, particularly over-strain injuries, increases when an individual is sleep deprived. This is partly caused by the down regulation of the protein synthesis pathway, which is in charge of repairing muscle damage and tactile function deficits while the body is in recovery. Another study found these injuries and inability to fully recover could be prevented or reversed if resistance exercise is added into the individuals' exercise routine (Chennaoui et al., 2015). Interestingly, over-training has shown to produce similar effects on the body and the inability to recover, despite an individual having adequate quality and quantity of sleep (Chennaoui et al., 2015; Fullagar et al., 2015).

Exercise has many positive effects on one's ability to sleep. The studies we found show that individuals who get regular, moderate-intensity exercise, for at least 150 minutes a week, have better quality and quantity of sleep. These individuals have increases in slow-wave sleep, increased total sleep time, and a decrease in REM sleep. Many have also questioned exercise timing in relation to one's ability to sleep. Some have thought that sleep is disrupted if an individual exercises too close to regular sleeping time. However, more recent studies have suggested that any exercise, regardless of when the exercise takes place during the day (unless it is preventing one from getting adequate hours), has positive effects on sleep quality and quantity (Chennaoui et al., 2015; Fullagar et al., 2015).

Sleep deprivation is a risk factor for developing stress, anxiety, and depression. Conversely, inability to sleep may be a sign of depression and anxiety. Exercise is associated with a decrease in anxiety and can reduce the prevalence of depression, thereby improving the mental health of large populations (Chennaoui et al., 2015; Bowen, Balbuena, Baetz, & Schwartz, 2013).

Other findings connecting exercise and sleep were conducted by observing individuals who have obstructive sleep apnea (OSA) and those who use sleep medications to help with sleep. Individuals with OSA that is untreated or not properly treated have reduced aerobic capacity and increased post-exercise blood pressures. However, these symptoms can be reversed or prevented by proper treatment with weight loss and continuous positive airway pressure (CPAP) therapy. In those who use sedative antihistamine or benzodiazepine hypnotic drugs to aid sleep, studies showed experiences of increased daytime sleepiness, confusion, nausea, and muscle weakness. The use of sedative antihistamine or benzodiazepine hypnotic drugs in individuals who have OSA is contraindicated, and we did not research complications associated with their relationship (Alves, Lira, Santos, Tufik, & de Mello, 2011; Chennaoui et al., 2015).

Sleep and hormones

Recent studies suggest that pathological changes occur when individuals experience sleep deprivation. There are many proposed factors that contribute to this and have been researched and investigated in numerous studies. The endocrine system is involved by affecting the body's levels of hormones (leptin, ghrelin, cortisol, epinephrine, and thyroid stimulating hormone [TSH]) that increase appetite. The function of the hypothalamus has been shown to increase in states of sleep deprivation or short sleep duration. Hypothalamus activity is responsible for signaling to the brain the sensation of hunger. Additionally, specific areas of the brain that involve reward seeking, self-regulation, and the ability to resist temptation are at an intensified state due to sleep deprivation (St-Onge et al., 2012).

Leptin

Leptin is a hormone that is made by adipocytes in the stomach and during pregnancy in the placenta. The placental production of leptin is regulated by estradiol and suggests that women, in particular pregnant women, have higher levels of leptin than men. The leptin produced in the stomach is released into the intestines where it is absorbed with food intake and has also been found in breast milk. Levels of leptin decline during periods of starvation, due to a rapid reduction in adipocytes. Leptin crosses the blood-brain barrier, which suggests the entrance of leptin into the brain. Leptin also controls the intake of food in individuals—this shows a correlation between leptin levels and obesity—and it provides a communicative channel between immune function and nutritional status. Individuals with decreased amounts of leptin have impaired levels of immune function (Bray, 2014).

Leptin levels rise during sleep. It is hypothesized that leptin levels stay elevated due to melatonin-influenced leptin production, which further suggests that the effects of high ghrelin levels during the early part of the night may be softened by leptin, preventing sleep waking due to hunger (Alonso-Vale et al., 2005). Individuals who sleep less than seven hours per night have been shown to have lower levels of leptin and are more likely to be overweight. One study conducted by Spiegel et al. (2004) suggested that sleep deprivation lowered leptin levels by 19%, as compared to those with longer sleep duration.

Ghrelin

Ghrelin has various actions throughout the body, such as stimulating growth hormone production and release, increasing food intake, and affecting bone mineral density. The function of ghrelin has been more recently discovered not only to play a role in appetite, but also in many other body processes, including the sleep/wake cycle and reward-seeking behaviors, such as eating highly satisfying foods (Liddle, 2015). The majority of ghrelin is found in the fundus of the stomach and the duodenum. Ghrelin production increases during periods of fasting and rises before mealtimes. After eating meals, ghrelin levels decrease. These surges and recessions help regulate mealtime hunger and one's desire to initiate having a meal (Bray, 2014).

Low amounts of ghrelin have been found in individuals with obesity and are associated with weight gain and insulin resistance. Contrarily, individuals who are obese and have binge eating habits also have low ghrelin levels, indicating that ghrelin is an after-effect rather than an origin of the disorder. Ghrelin is low in individuals who with low calorie diets, exercise routines, malnutrition, and sickness. Ghrelin levels increase during periods of fasting or under conditions associated with negative energy balance (e.g., starvation or anorexia) (Bray, 2014; Liddle, 2015).

Human studies have shown that there is a notable rise in ghrelin during sleep. However, the levels of ghrelin tend to decrease during the later parts of the night, despite maintaining a period of fasting (Dzaja et al., 2004). Schmid, Hallschmid, Jauchara, Born, and Schultes (2008) found that one night of sleep deprivation in young, healthy men increased ghrelin levels but not leptin levels.

Cortisol

Cortisol is a glucocorticoid hormone made by the adrenal cortex. Cortisol is regulated by the hypothalamic-pituitary-adrenal (HPA) axis, peaking in the early morning and dropping in the evenings. Its main function is to regulate body homeostasis after periods of stress. Cortisol has been shown to impact immune function and ion transport across cell membranes. St-Onge et al. (2012) states, “Glucocorticoids act directly on the adipose tissue and increase leptin synthesis and secretion in humans. Cortisol release via activation of the hypothalamic-pituitary-adrenal axis could lead to overeating in the presence of highly palatable food” (p. 818).

Spiegel et al. (2004) found that plasma cortisol levels were elevated by up to 45% after sleep deprivation, an increase that has implications that include immune compromise, cognitive impairment, and metabolic disruption. Dietary consumption and sleep deprivation also affect levels of cortisol throughout the body. When individuals go without sleep, they often consume high amounts of caffeine, which can put stress on the body. When the body undergoes stress, the HPA axis releases more cortisol into the bloodstream. Episodes of acute stress and prolonged sleep deprivation can result in lower levels of general health (McCance et al., 2014).

Epinephrine

Epinephrine is also known as adrenaline and is one of the hormones secreted by the medulla of the adrenal glands. It is also known as a stress hormone. Other stress hormones are cortisol and norepinephrine. Emotions and bodily stress cause the release of epinephrine, known as the “fight or flight response,” which can cause physical effects on the body, such as increase in heart rate, muscle strength, blood glucose metabolism, increase in blood pressure, and decrease of blood flow to the gastrointestinal tract (McCance et al., 2014). Dixit, Thawani, Goyal, and Vaney (2012) also found that sleep deprivation causes stress on the body, resulting in increased epinephrine, and thus causes the aforementioned bodily function sequela to occur.

Norepinephrine

Norepinephrine, also known as noradrenaline, serves as both a hormone and a neurotransmitter in the body. As a hormone, it is secreted by the medulla of the adrenal gland and works with epinephrine. As a neurotransmitter, norepinephrine sends communicating signals between nerve synapses. These levels continue to rise in times of bodily stress or danger during activation of the “fight or flight response.” This type of response causes an increase in both heart rate and blood pressure, while also enhancing glucose metabolism, increasing muscle strength, and reducing blood flow to the gastrointestinal system (McCance et al., 2014). Low levels of norepinephrine have been linked to depression and anxiety; conversely, high levels are linked to feelings of joy and euphoria. Norepinephrine reaches lowest levels during periods of sleep and rises as the body returns to a state of wakefulness (Dixit et al., 2012).

Thyroid (TSH, T4, T3)

Thyroid hormones are thyroxine (T4), triiodothyronine (T3), and TSH. These hormones exert physiological effects on all tissues that consume oxygen and require nutritional metabolism of proteins, carbohydrates, lipids, and vitamins. The pituitary gland releases TSH, which controls the release of T4 and T3 via negative feedback (McCance et al., 2014). One study we found suggests that sleep deprivation in adults increases levels of TSH, T4 and T3. Poor sleep for one night shows acute changes in serum levels of TSH. Contrarily, when the body undergoes exposure to chronic stress accompanied by constant cortisol exposure, there is decreased thyroid function, along with impaired cognition and increased accumulation of abdominal fat, which has implications for the health of the cardiovascular system (Kessler, Nedeltcheva, Imperial, & Penev, 2010).

Orexins

Orexin A and B are excitatory hormones released from the hypothalamus. The hypothalamus regulates energy expenditure and helps maintain energy homeostasis. Similar to leptin and ghrelin, orexins are affected by metabolic cues (McCance et al., 2014). These may prove to have a role in metabolism and sleep duration. When orexin levels are high, food intake increases, and energy and wakefulness are stimulated (Inutsuka & Yamanaka, 2013). Orexin has been identified to be lowest in individuals with narcolepsy, increased body mass index (BMI), type II diabetes, and decreased energy intake (Siegel, 2004).

Sleep and diet

Sleep deprivation has been shown in numerous studies to influence dietary choices. It has also been demonstrated that adequate sleep is associated with healthy dietary choices. It is important for us to understand the relationship between inadequate sleep and poor dietary choices.

Physiological changes that influence appetite

One of the many studies conducted by the American Society for Nutrition focused on sleep-deprived individuals. Researchers used magnetic resonance imaging (MRI) to observe increased neuronal activity in specific regions of the brain that lead to food-seeking behaviors (American Society for Nutrition, 2012).

> Signals of hunger and satiety is thought to involve the hypothalamic arcuate nucleus, which allows for the inflow of dietary hormones, including insulin and ghrelin, from the blood stream to the brain. Hypothalamic cells involved in energy regulation project to many centers of the brain, including the cortex, thalamus, brainstem, limbic structures, and forebrain. The hippocampus is believed to contain insulin and leptin receptors and is connected to the hypothalamus and amygdala, which are also thought to play important roles in appetite and motivation. The thalamus may also integrate visual signals of food, which leads to an increase in appetite and the motivation to eat (St-Onge, 2012, p. 819).

Another study was conducted on neural responses to food desire with sleep deprivation. MRI imaging was done in this investigation and found similar results concluding that “areas in the frontal cortex of the brain which included anterior cortical regions of the frontal lobe, play a role in signaling stimulus in appetite and food desire. This area had disrupted functional activity, which is considered to be one hallmark of sleep loss” (Greer, Goldstein, & Walker, 2013, p. 3).

Sleep deprivation and food choice

There is speculation as to why sleep deprivation leads to unhealthy food choices. One theory proposes that it becomes more difficult to prepare healthier foods rather than reaching for an unhealthy snack. When sleep loss occurs, people report choosing foods outside of their dietary, weight management, nutritional, economic, and ethical goals (Wells & Cruess, 2004). A recent study on nutritional intake related to sleep deprivation described behaviors such as frequent snacking, skipping breakfast, lack of preparation for meals, and irregular meal patterns (Peuhkuri, Sihvola, & Korpela, 2012), as shown in Table 3.

Alterations in appetite can be affected by various conditions, such as depression and anxiety. Sleep deprivation is commonly found in these conditions and is only one of many factors that influence unhealthy food choices. Short-duration sleepers have a tendency to consume more calories, which is more likely a response to external cues (see Table 3). Individuals should be more prudent, because this eating behavior trait is likely to be augmented with sleep loss. Collectively, excess energy intake associated with not having adequate sleep seems to be preferentially driven by hedonic rather than homeostatic factors (Chaput et al., 2012).

Knowing that there is an increased propensity to seek food when sleep deprived, many researchers have conducted studies to find out if particular food groups become more desirable. In articles reviewed, published information over the last decade showed that when sleep deprived, (6 hours or less a night of sleep) subjects' choice in food was altered such that energy- rich foods with higher calories from fats or refined carbohydrates were preferred over vegetables and fruits. One study concluded that the vast majority of subjects who were sleep deprived indicated increased desire and consumption of food choices with the highest calorie counts per serving. These food choices also contained high contents of fats and carbohydrates. There is strong evidence that sleep deprivation does increase the likelihood of consuming less healthy foods, more particularly, foods higher in fats, carbohydrates, and sugars (Greer et al., 2013).

Nutrition.

***Carbohydrates*.** The first choice and most widely consumed over any other food selection in all studies was carbohydrates. It was also reported to be the topmost craved food (Speath, Dinges, & Goel, 2014).

Fats, salty snacks and desserts. Percentage of calories derived from protein was significantly lower, and percentage from fat was significantly higher during periods of sleep deprivation (Speath et al., 2014). Cravings of salty snacks and desserts were also increased with sleep deprivation (Greer et al., 2013).

Juice and caffeine free soda. African Americans had increased intake of juice and caffeine free sodas as compared to Caucasians (Speath et al., 2014). Speath et al. (2014) also found that women preferred soda and sweet beverages more than men during periods of sleep deprivation.

Caffeine. There have been various studies on caffeine consumption and its relation to sleep deprivation. Caffeine is consumed daily by approximately 80% of the population. Consumption of caffeinated beverages was highest in coffee (71%), soft drinks (16%) and tea (12%) (Lodato et al., 2013). Another study focusing on behaviors with sleep deprivation reported that bedtime hours were delayed and late morning waking was related to intake of caffeinated drinks, fast food, and minimal dairy products (Fleig & Randler, 2012).

Research shows that caffeine consumption from beverages such as soda, energy drinks, coffee and tea have been shown to delay sleep time and cause morning drowsiness. Most individuals consuming moderate to high amounts of caffeine later in the day report having difficulty sleeping (Ortuno & Noore, 2004).

Alcohol. Alcohol intake has been known to disrupt sleep and cause insomnia and daytime sleepiness. In 2014, the United States reported that over $18 billion was spent on managing alcohol-related sleep disturbances (Chaput et al., 2012). Compared with other studies we found related to alcohol and sleep, the results have been consistent throughout. Alcohol consumption in the late evening close to bedtime delays sleep onset, increases NREM sleep, and results in multiple awakenings in the night. This has also been observed in acute alcohol withdrawal and alcohol relapse (Mahesh & Rishi, 2014). The overall effect of alcohol consumption alters sleep homeostasis and is disruptive to sleep. Short sleep duration is associated with greater alcohol consumption in adults (Chaput et al., 2012; Thakkar, Sharma, Sahota, 2015).

Sleep deprivation, gender and food choices. Females have shown a propensity to eat more sweets when sleep deprived. Another study by the American Society of Nutrition indicated that women who were short sleepers had higher intakes of sugar and caffeine (Ashima & Graubard, 2014). Men have shown a higher intake of bread, cereal, plain rice, and pasta when they are sleep deprived (Speath & Goel, 2014).

Calorie Consumption. We found similar findings when examining studies related to sleep deprivation and caloric consumption: Sleep-deprived individuals had a moderate to high increase in caloric intake. We reviewed four studies and found that, on average, an extra 542 k/cal were consumed every day by sleep-deprived individuals as compared with those who were not sleep deprived (Calvin & Carter, 2013; Chaput, 20123; Greer et al., 2013; Speath et al., 2014).

Sleep and weight

Sleep serves as a restorative process for the body, helping our metabolism stay regulated and body systems to maintain their proper functions. Thirty percent of Americans reported getting six hours of sleep or less; additionally, two in three Americans are considered overweight or obese (CDC, 2015). In a sleep-deprived society, the relationship between the effects on the body's hormonal regulatory functions and weight warrants being explored. Grandner, Jackson, Gerstner, and Knutson (2013) found that when sleep is received in small amounts (i.e., fewer than five hours), individuals reported increased BMI measurements. Those who slept fewer than five hours per night regularly had BMI measurements 1.9 points higher than those who reported sleeping more than nine hours per night (Grandner et al., 2013). Patel et al. (2008) found that the odds of obesity had increased differently among men and women. Compared to adults who slept to seven to eight hours nightly, women who slept five hours or less per night were shown to have a 2.3 times greater likelihood of being obese, and men were 3.7 times more likely to be obese (Patel et al, 2008).

Sleep deprivation can slow metabolism and cause an increase in appetite. Increased appetite leads to unnecessary caloric intake, greater than that of energy expenditure, which results in weight gain. Recent studies have hypothesized that due to these changes in sleep deprived individuals, central nervous systems and endocrine systems experience changes in metabolism and have altered hormone release (Greer et al., 2013).

The increased rate of obesity throughout the United States over the past few decades has been paralleled by a decrease in nighttime sleep duration. This could suggest that Americans' lack of sleep could be contributing to the rise in obesity. Sleep deprivation negatively influences the ability to achieve and maintain a healthy weight. Inadequate sleep can lead to increased hunger and therefore make attempts to cut caloric intake more difficult (Xiao, Arem, Moore, Hollenback, & Matthews, 2013).

Deprivation of sleep has also been shown to have effects on the type of weight lost and gained. Those who experience poor or deficient sleep tended to lose muscle mass over fat. In order to maintain a proper weight, individuals and healthcare providers should put sleep in the same category of importance as adequate exercise and proper dietary intake (Taheri & Mignot, 2010). Future studies are needed to further investigate the possible causal relationship between weight gain and sleep duration.

Interventions and treatment options for sleep deprivation

Pharmacological treatment has become more popular over the past decade (CDC, 2015). The CDC has found that nine million Americans are currently using prescription sleep aids. There are several different options for treating individuals who suffer from sleep deprivation. These options include prescription, over-the-counter (OTC) pharmacological agents, and non-pharmacological interventions. Non-pharmacological options include herbal supplements, sleep hygiene, and lifestyle modifications.

Sleep hygiene

Sleep hygiene is an important component to maintaining and restoring a healthy sleep pattern. In *The American Journal of Lifestyle Medicine*, Meltzer, Moreno, and Johnston (2014) define sleep health as “a multidimensional pattern of sleep-wakefulness, adapted to individual, social, and environmental demands, that promotes physical and mental well-being. Good sleep health is characterized by subjective satisfaction, appropriate timing, adequate duration, high efficiency, and sustained alertness during waking hours” (p. 380).

Healthy sleep hygiene practices, as a matter of natural homeostasis, have significantly more long-term benefits than pharmacologic therapy. Pharmacologic therapies only provide short-term benefits and satisfactions for sleep duration and quality. Lynch et al. (2007) found that at follow-up appointments 6–24 months later, patients who were treated solely with pharmacologic therapies had less satisfaction with their sleep, and their sleep complaints returned. When individuals establish and practice healthy sleep hygiene behavior, the benefits are long term and follow-up appointments show more satisfaction with little to no continuing sleep complaints (Lynch et al., 2007).

Sleep hygiene, behavioral changes, and therapies are recommended as follows:

- Create a healthy sleeping environment.
    - This includes only allowing the bedroom to be used for sleep and sex. Turn off the technology and do not allow it in the bedroom. Lights from cell phones, televisions, tablets, and reading lamps prevent the body from releasing adequate amounts of melatonin, in turn, making it more difficult to fall asleep. These distractions also prevent the mind from relaxing and

can make one think about life stressors, again, making it difficult to fall asleep. (Meltzer et al., 2014; Thorpy, 2003)

- Create a healthy bedtime routine.
    - Creating a healthy bedtime routine has many aspects. One must commit to going to bed at the same time every night and waking at the same time every morning, only allowing for an hour leeway of time on either side. This sets the circadian rhythm to be in sync and on a regular schedule. (Meltzer et al., 2014)
    - Start nightly rituals 15 to 30 minutes before going to bed. These rituals can involve things like drinking a warm cup of bedtime herbal tea, reading a book on the couch, or meditating. One can build a routine of washing their face and brushing their teeth, or taking a warm bath and listening to soothing music. (Meltzer et al., 2014)
    - Avoid alcohol intake for at least two hours prior to starting a bedtime routine. Alcohol interferes with the ability to stay asleep. (Meltzer et al., 2014)
    - Avoid caffeine intake for at least 4–6 hours prior to beginning a bedtime routine. Caffeine is found in sodas, some teas, coffee, chocolate, maple syrup, and beef jerky. (Meltzer et al., 2014)
    - If unable to fall asleep within 20 minutes of lying down, get up and perform some kind of relaxation exercise or drink some warm tea to help relax the mind and body, and then try to go to sleep again. (Lynch et al., 2007)

- Be awake and active during daylight hours.
    - Exercising during the day, for at least 30 minutes, has countless benefits; one is to help with sleep. Exercise helps one fall asleep and stay asleep. (Meltzer et al., 2014: Horne, 2014)
    - Being in the sunlight also helps the body to regulate its circadian rhythm. It is recommended to get outside in the morning and see the brightness of the sun. (Meltzer et al., 2014)
    - Avoid napping, even if feeling tired during the day. Napping can prevent one from being able to fall asleep at night because it alleviates the sleep pressure, or sleep homeostasis. (Meltzer et al., 2014)
- Try some relaxation techniques and exercises once in bed and figure out what works best.
    - The 4-7-8 Relaxing Breath Exercise: This is done by placing the tongue lightly on the roof of the mouth and breathing in quietly for four counts. One then holds their breath for seven counts and breathes out their mouth with a whooshing sound for eight counts. This exercise can be repeated four times. (Weil, 2015)
    - Progressive Muscle Relaxation: This technique is performed by progressively and systematically tensing and relaxing each muscle group. This is most helpful in individuals who have more muscle tension and stress.
    - Meditation: This technique involves focused attention on repetitive thoughts and mantras.

- Biofeedback: This is a more difficult technique and often requires coaching and therapy to master. With successful and proper biofeedback behavior, one is able to lower their heart rate and blood pressure in order to force the body into relaxation.

An important note for the healthcare provider is the need for education, support, and encouragement for the individual to stay committed. Individuals will want something that is going to make them sleep better quickly. The average time for results with behavioral therapy and sleep hygiene is four to eight weeks for real improvements. If the individual is not given realistic expectations or supported properly, the healthcare provider could be setting them up for failure and even more sleepless nights. Education and resetting their biases may help relieve some of the apprehension and anxiety they have about being able to sleep (Lynch et al., 2007).

Non-pharmacological/Complementary and alternative medicine

Non-pharmacological treatment is also known as complementary and alternative medicine (CAM). CAM has been increasingly studied over the past two decades for the treatment of sleep disorders. CAM includes herbal supplements, essential oils, acupuncture, yoga, and massage (Sarris & Byrne, 2011).

Herbal supplements. Herbal supplements have been used for hundreds of years for healing and treatment of ailments. Some of the more common herbs used for sleep disorders include: melatonin, chamomile, valerian, and kava. There is a wide variety of evidence supporting the efficacy of these agents and some prove to be more beneficial than others (McCance et al., 2014; Yurcheshen, Seehuus, & Pigeon, 2015).

Melatonin. Melatonin is a hormone released by the pineal gland, located in the brain, which is synthesized by tryptophan then converted to serotonin before it is finally made into melatonin. The release of melatonin is inhibited when an individual is exposed to light and it is released when there is exposure to dark. Melatonin is a major hormone used in regulating the circadian rhythm and plays an important role in immunologic health. Melatonin can be taken orally as an OTC sleep aid to help individuals who have a hard time falling asleep and those who may be suffering from jetlag or shift work sleep disorder (McCance et al., 2014; Woo & Wynne, 2012).

Chamomile. Chamomile is a gentle herb derived from *Matricaria chamomillahas*. It has a number of uses, including aiding in anxiety and depression, and possibly having anti-inflammatory and healing properties (although we found these have only been indicated in studies with rats) (Bystritsky, Stein, & Hermann, 2015). Chamomile is widely used as a sleep aid or sedative to aid in falling asleep. There are many ways to prepare and use the herb, but when used as a sleep aid, it is most commonly prepared as an oil or a hot herbal tea to drink before going to sleep. Chamomile exerts its effects through its many active metabolites, including flavonoids such as apigenin, and terpenoids that cause sedating and medicinal effects (National Center for Biotechnology Information, 2010). Chamomile is very safe to use with the exception of individuals who are on anticoagulation therapy, because chamomile has the potential to increase the anticoagulation effects of these medicines (Taslaman, 2014).

Valerian. Valerian is derived from valerian root, or *Valeriana officinalis*. It is believed to "…inhibit uptake and increase presynaptic release of GABA…" (Woo & Wynne, 2012, p. 111). However, valerian is not readily absorbed in the body and becomes unstable and decomposes rapidly making it difficult to determine the appropriate dose. The most common ways to ingest Valerian is either by an extract or as a hot herbal tea. Valerian as a tea has been proven to have relaxing properties, allowing individuals to fall asleep spontaneously. Valerian has been shown to be safe to use if used at recommended doses, but increasing the dose could cause severe reactions like cardiac disturbances, excitability, headaches, worsening insomnia and nausea (Woo & Wynne, 2012).

Kava. Kava is a root from the plant *Piper methysticum* and is in the black pepper family (Woo & Wynne, 2012). It originated in the Pacific Islands where it is used as a drink similar to alcohol. Kava acts on the limbic system along with the GABA receptors. It is shown to decrease emotional excitability, reduce seizure activity, and produce a mild euphoria. Appropriate doses for inducing sleep or causing sedation cannot be determined, because the effects are dependent upon the root itself and how it was prepared. Kava has been shown to be beneficial and has very few negative side effects when used short-term and at appropriate doses. However, if used long term or at inappropriate doses, an individual can develop hepatotoxicity, pulmonary hypertension, thrombocytopenia, shortness of breath, weight loss and dry, flaky skin (Woo & Wynne, 2012).

Essential oils. There are many different essential oils used for sleep disorders, both to help relax the mind and body and to cause sedation. The more common oils available for sleep include lavender, basil, peppermint, sweet marjoram, jasmine, rosemary, juniper, and many blended oils. Oils may be used topically or infused through a vaporizer. Efficacy seems to be difficult to prove consistently throughout our research due to different brands and preparations with inconsistent standards of quality. There are some potential negative side effects associated with the use of essential oils, such as potential for local skin reactions, accidental ingestion, interaction with other medications, and excessive or inappropriate use of the oils. There is a lack of understanding regarding the exact mechanism of action of essential oils and their impact on sleep and relaxation. (Lillehie & Halcon, 2014; van der Watt & Janca, 2008).

Yoga, meditation, and acupuncture. Practicing yoga, yogic breathing, and meditation have shown to improve sleep duration and sleep quality by reducing stress and tension.

Sobana, Parthasarathy, Jaignanesh, and Vadivel (2013) found that breathing techniques utilized during yoga and meditation "allows the uptake of more oxygen in the body, thus providing clarity of mind" (p. 56). Mindfulness-based stress reduction (MBSR) combines meditation with light yoga to make individuals more aware of their own body and become more mindful to their own thoughts. This practice does not provide immediate relief of insomnia, but when utilized long term, it has been shown to have significant benefits in all aspects of sleep and mood (Gross et al., 2011).

Acupuncture has been shown to improve quality and quantity of sleep by helping to treat the actual cause of sleep deprivation. Ling, Jiang, Xue, Wang, and Ke (2008) believe that insomnia is an "…imbalance between *yin* and *yang* and the disorder of *qi* and blood in the heart, gallbladder, spleen and kidney, resulting in malnutrition of the heart and mental disturbance. Therefore, insomnia should be attributed to dysfunction of the *zangfu* organs…" (p. 272). Acupuncture targets these organs viscerally, on the surface of the body, to help bring balance, or harmony, to the individual's *zangfu* organs (Ling et al., 2008).

Over-the-counter pharmacological treatment options

The Food and Drug Administration (FDA) has approved OTC medications for individuals who are 12 years old and older who suffer from sleep deprivation. The FDA recommends that if the use of sleep aids needed is greater than two weeks, the individual should seek advice from a healthcare provider. OTC sleep aids have been shown to cause more rebound insomnia and daytime sleepiness than prescription medications (FDA, 2015). Most OTC sleep aids contain an antihistamine. Antihistamines block histamine 1-receptors and are primarily used to treat allergic responses. However, antihistamines also cause drowsiness, which is why they are found in OTC sleep aids. The most common antihistamines are diphenhydramine, chlorpheniramine, hydroxyzine, and doxylamine. These medications can be used alone or in combination with a pain reliever, such as acetaminophen or ibuprofen, and are then marketed as a sleep aid or a bedtime formula. OTC diphenhydramine and doxylamine doses are higher when used as a sleep aid versus when used solely as an antihistamine (Gulyani, Salas, & Gamaldo, 2012) (see Table 4 & 5).

There are mixed reviews regarding OTC sleep aids and their potential to be habit-forming (Schutte-Rodin, Broch, Buysse, Dorsey, & Sateia, 2008). Most individuals find them to be beneficial due to their rapid absorption and long elimination times. However, these positive aspects are what make them have the potential to be habit-forming, and this is what causes some individuals to experience rebound insomnia and daytime sleepiness (Neubauer, 2014).

The intent of OTC medications is not to cure insomnia or sleep-related disturbances. Instead, they can be used for short periods of insomnia or sleep deprivation and used only as directed. It is thought that overuse, or chronic use, of OTC sleep aids can cause drug intolerance, dependency, and unintentional interactions with other medications (Gulyani, Salas, & Gamaldo, 2012). Knowing that antihistamine-based medications are not likely to improve insomnia symptoms over an extended period of time makes them a less-than-ideal long-term treatment.

Compared to prescription medications, OTC sleep aids have a decreased risk of allergic reaction (National Institutes of Health [NIH], 2005). However, there is still potential for adverse side effects with the use of these medications. The majority of the adverse side effects experienced are due to the anticholinergic effects of the antihistamine medication (Krystal, Richelson, & Roth, 2013). Additional side effects include: dizziness, constipation, un-coordination, dry mouth, blurred vision, difficulty urinating, and cognitive impairment (Krystal et al., 2013).

The use of OTC sleep aids is contraindicated in some patient populations. Caution should be taken when recommending the use of OTC sleep aids to adults over 60 years of age. Older adults have a higher incidence of adverse side effects due to increased time to metabolize some medications (Woo & Wynne, 2012). According to AGS Beers Criteria, first generation antihistamines are contraindicated for older adults, due to their potential for increased adverse side effects and decreased efficacy (Campanelli, 2012). There is an increased risk of nighttime falls with subsequent injury, agitation, delirium, excessive sedation, and impaired performance of daily activities (Bonnet & Arand, 2015).

Diphenhydramine and doxylamine are not recommended for people who have closed-angle glaucoma, asthma, chronic obstructive pulmonary disease, sleep apnea, severe liver disease, digestive system obstruction, or urinary retention. Pregnant women, those who are breastfeeding, and those over 65 have an increased risk of stroke when using OTC sleep aids (Woo & Wynne, 2012).

The use of OTC sleep aids in conjunction with prescription sedatives and/or alcohol is contraindicated. This is due to potential for increased antihistaminic effects on the body causing increased drowsiness (Neubauer, 2014). There is a warning to avoid operating heavy machinery or driving while under the influence of sleep aids, which is due to a decrease in mental alertness and response time. After long-term use, there is risk for rebound insomnia if sudden discontinuation occurs (Krystal et al., 2013). There are many causes of insomnia and some are more researched than others. We found evidence supporting the treatment of the underlying cause first. However, this may be problematic; we found, for example, if depression is treated properly, insomnia symptoms will subsequently improve, but treating insomnia will also improve the symptoms of depression. It can be difficult to know which disorder to treat first (Riemann, 2009).

Treating sleep deprivation and insomnia continues to be an area of focused research. In the last decade, an overwhelming amount of OTC sleep aids have been released and are available to the public. Longitudinal studies on the long-term use of sleep aids indicate that more research is needed. The use of OTC sleep aids should be based on the individual's age, other medication use, and medical history and conditions in order to provide the most effective and therapeutic options.

Pharmacological treatment options

When prescribing pharmacological agents for sleep, it is important for the healthcare provider to assess the underlying cause related to the sleep disturbance. Additionally, providers must assess if the individual is having difficulty falling asleep or if the individual is having difficulty staying asleep. Obtaining a thorough history will guide the provider toward choosing the most appropriate treatment option.

Special considerations should be made prior to prescribing sleep medications. Individuals who have a history of drug tolerance, dependence, and withdrawal may experience unintended drug interactions, such as rebound insomnia, and have increased potential for drug tolerance and dependence related to the sleep medication (Woo & Wynne, 2012). Establishing realistic treatment goals for improving sleep quality and duration is essential. Additionally, discussing potential for rebound insomnia and daytime drowsiness are important factors to consider when choosing a medication. Habit-forming sleep aids are not indicated for long-term use, and treatment should include other modalities to successfully improve long-term sleep habits. Clinical reassessment is indicated for follow up any time a prescription intervention is initiated. This should occur within the first few weeks of starting a new medication, and then every month to reassess the goals and evaluate efficacy (Schutte-Rodin et al., 2008) (see Tables 7 and 8).

There are several medications that can be used to help an individual fall asleep and/or stay asleep. Some are labeled as sleep aids, and others can be used off label as a sleep aid. Examples of these include antidepressants, antianxiety, and antiepileptics medications.

On-label medications. Short- to intermediate-acting benzodiazepine receptor agonists (BzRA's) are labeled as sleep aids and are potentially habit-forming. These include zolpidem eszopiclone, triazolam, and temazepam. Alternative BzRAs, such as ramelteon, are indicated for individuals with a history of substance abuse and sleep difficulty such as falling asleep (Woo & Wynne, 2012).

Off-label medications. Benzodiazepines are anti-anxiety medications used off label to treat sleep deprivation. These include alprazolam, lorazepam, and clonazepam. The half-lives vary in the benzodiazepine group, but all have shown to have positive effects on sleep. Because tolerance and dependence can develop, they are recommended for short-term use only (Woo & Wynne, 2012). Providers must closely monitor patients every two to four weeks and re-evaluate every six months if a longer duration of use is necessary (Schutte-Rodin et al., 2008).

Sedating, low-dose antidepressants can be used as off-label medication for insomnia. They are non-habit forming and are proven to be safe and effective long term. These include trazodone, mirtazapine, doxepin, amitriptyline, and trimipramine (Schutte-Rodin et al., 2008) (see Table 6).

Conclusion and recommendations

As healthcare providers, we believe in providing optimal, up-to-date, and evidence-based care for our patients. Based on studies we reviewed, we found conflicting information regarding hormones and neurotransmitters related to sleep. The impact of specific neurotransmitters, hormones, and their function is understood. However, their impact in situations regarding sleep cycles, poor sleep quality, sleep deprivation, weight gain, exercise, and dietary intake all suggest that there is need for further study in order to better understand their relationship and function.

The data collected in the studies we found conflict in regard to BMI measurements and diseases associated with sleep deprivation such as sleep apnea, diabetes, or hormonal imbalances. Further studies regarding how sleep quality and duration influence metabolism are needed. There are differences between genders related to metabolism, but the information we found here is inconsistent and incomplete.

Therefore, according to our research on sleep deprivation, we recommend consistently obtaining a minimum of seven hours of sleep per night. We recommend providing individuals with tools to be able to achieve their best nights' sleep as possible. A thorough history and evaluation of individuals' sleep patterns and lifestyle practices should be taken. Sleep evaluation and education should be incorporated into every well visit and as needed thereafter. Sleep education consists of lifestyle modifications, including sleep hygiene and nutrition improvements. If healthcare providers apply sleep education into their practice routinely, sleep deprivation can be prevented, therefore preventing the potential negative sequela. We have designed a sleep deprivation treatment protocol to use as a reference in daily practice. The goal of our treatment protocol is to reduce the frequency and use of pharmacologic medications for sleep, as well as to promote sleep hygiene and lifestyle modifications (see Table 9).

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Appendices

Table 1

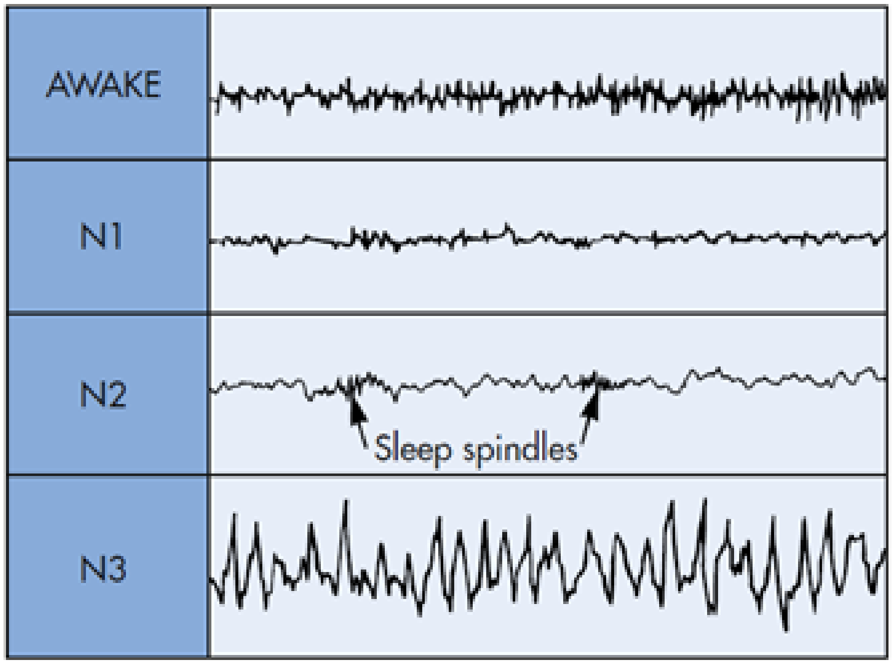


FIGURE 16-9 Electroencephalogram (EEG) Stages of Wakefulness and NREM Sleep. *Awake,* Low-voltage fast activity; *stage N1,* falling asleep; *stage N2,* light sleep with sleep spindles; *stage N3,* slow delta waves. Rapid eye movement (REM) sleep looks similar to awake and stage N1 sleep. Sleep spindles are bursts of brain activity associated with onset of sleep.

(McCance at al., 2014, p. 502)

Table 2

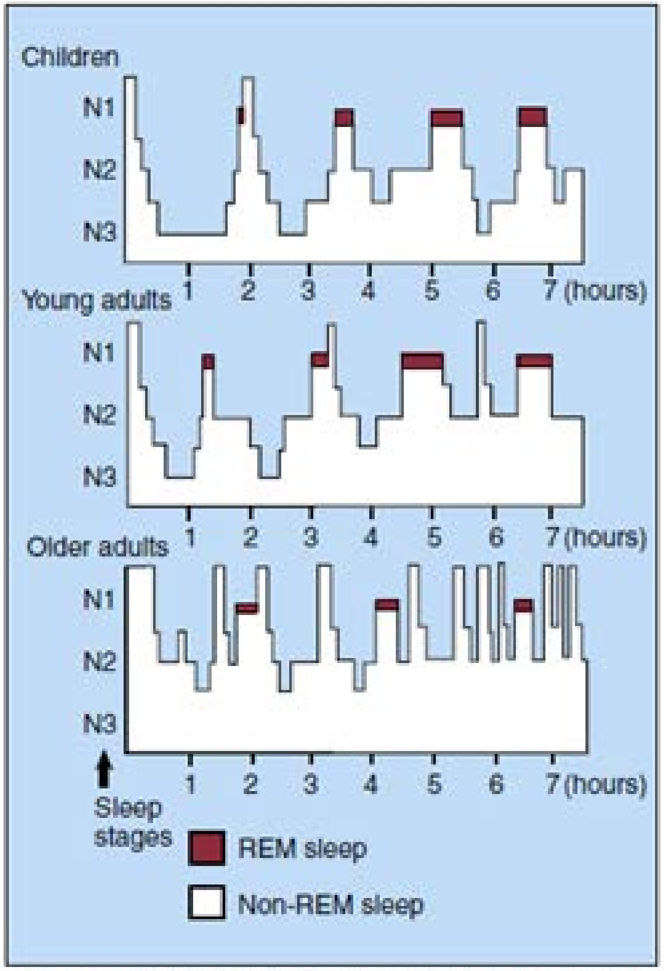
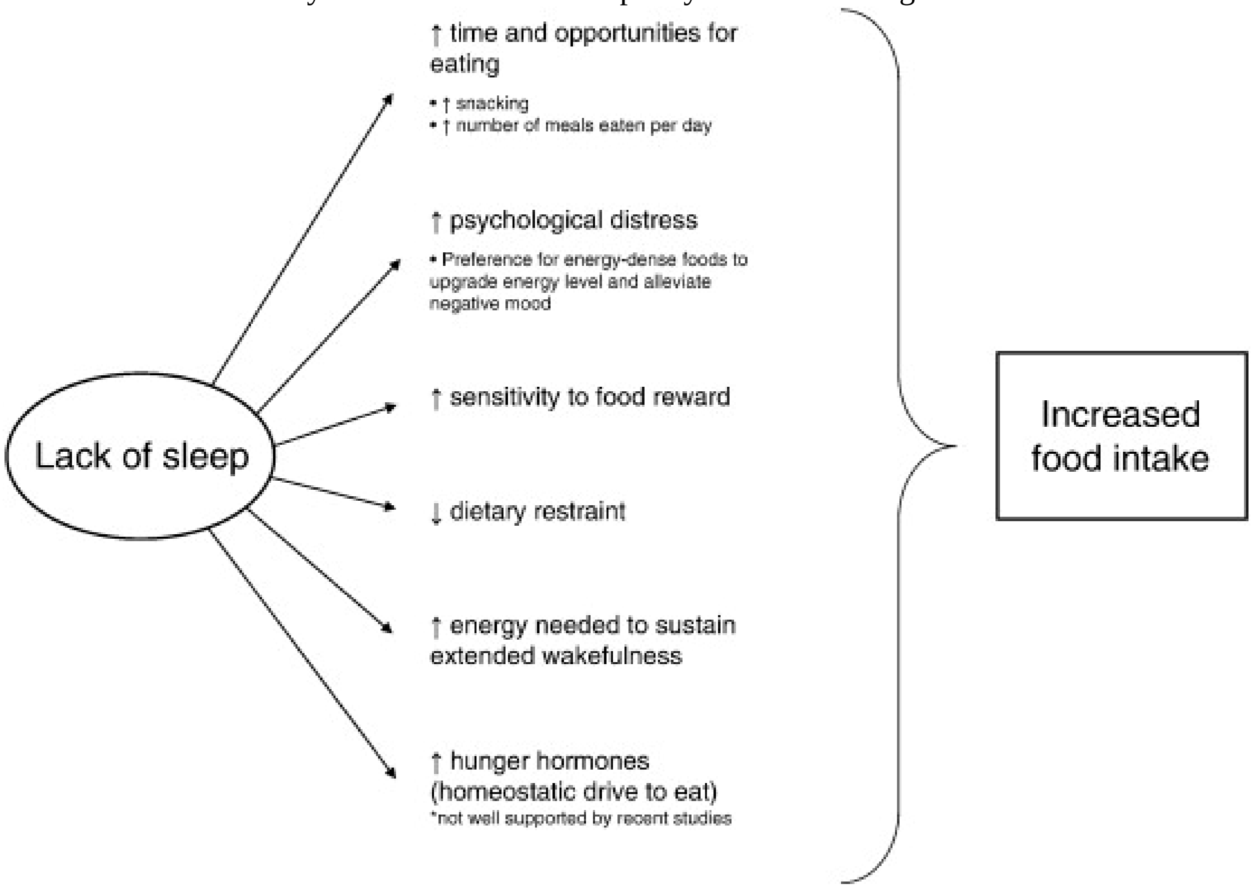


FIGURE 16-10 Normal Sleep Cycles. Rapid eye movement *(REM)* sleep occurs cyclically throughout the night at intervals of approximately 90 minutes in all age groups. REM sleep shows little variation in the different age groups, whereas stage N3 sleep decreases with age. In addition, older adults awaken frequently and show a marked increase in total time awake.

(McCance et al., 2014, p. 503)

Table 3

Potential mechanisms by which insufficient sleep may facilitate the ingestion of calories.



(Chaput, 2013, pg. 89)

Table 4

Common brand names of over-the-counter sleep aids

Diphenhydramine	Chlorpheniramine	Hydroxyzine	Doxylamine
Benadryl	Chlor-Timeton	Atarax	Nighttime Sleep Aid
Benadryl allergy		Vistaril	Unisom
Compoz			Sleeptabs
Nytol			
Sleep			
Sominex			
ZzzQuil			

(Woo & Wynne, 2012)

Table 5

Common Over-the-Counter Sleep Aids

Name	**Mechanism of Action**	**FDA Indication (Insomnia)**	**Common Side Effects**	**Half-life**
Nytol (GlaxoSmithKline, PLC plc)	H1 receptor antagonist	Yes	Daytime drowsiness/grogginess, daytime impairment, dizziness, dyskinesia, xerostomia, urinary retention	4-8 h
Sominex (GlaxoSmithKline, PLC plc)	H1 receptor antagonist	Yes	Same as Nytol	4-8 h
Sleepinal (Blairex Laboratories, Inc.)	H1 receptor antagonist	Yes	Same as Nytol	4-8 h
Unisom (Chattem, Inc.)	H1 and H2 receptor antagonist	Yes	Daytime grogginess effect, daytime impairment	6-8 h
Melatonin	MT_1 and MT_2receptor agonist	No	Daytime grogginess effect, daytime impairment, confusion	30-50 min
Tryptophan	Modulation of serotonin	No	Drowsiness, headaches, dizziness	1-3 h
Combination drugs				
Diphenhydramine hydrochloride[a]	H1 and H2 receptor antagonist	No	Daytime drowsiness, daytime impairment	N/A[b]
Tylenol PM (McNeilEIL-PPC, Inc)	H1 receptor antagonist	No	Same as Nytol	N/A[b]
Anacin PM (InsightNSIGHT Pharmaceuticals, LLC)	H1 receptor antagonist	No	Same as Nytol	N/A[b]
Nyquil (Procter & Gamble)	H1 and H2 receptor antagonist	No	Daytime grogginess	N/A[b]
Herbal aids				
Valerian, kava, chamomile	Unknown	No	Hepatotoxicity	N/A[b]

FDA = Food and Drug Administration; H = histamine; MT = melatonin; N/A = not applicable.

a Made by various companies as a combination- product as a sleep aid.
b N/A, because different ingredients in combination drugs have different half-lives.

http://journal.publications.chestnet.org.ezproxy.westminstercollege.edu/article.aspx?articleid=1474874 Accessed <10/15/2015>

Table 6

Common Pharmacologic Prescription Medications for Insomnia

Drug Category	**Medication**	**Dose**	**Comments**
Nonbenzodiazepine benzodiazepine receptor agonist	zaleplon (Sonata)	5–-20 mg	Useful for problems falling asleep only.
	zolpidem tartrate (Ambien)	5–-10 mg	Useful for problems falling asleep only.
	zolpidem tartrate extended-release (Ambien CR)	6.25–-12.5 mg	Biphasic release; useful for problems both falling asleep and staying asleep; do not crush or split tablets.
	eszopiclone (Lunesta)	1–-3 mg	Useful for problems both falling asleep and staying asleep; do not take with or right after meal.
Benzodiazepine	alprazolam (Xanax)	0.25–-2 mg	Higher risk of withdrawal; side effects: lack of motor coordination, falls, and cognitive impairment.
	lorazepam (Ativan)	0.5–-4 mg	Side effects: lack of motor coordination, falls, and cognitive impairment.
	clonazepam (Klonopin)	0.5–-4 mg	Side effects: lack of motor coordination, falls, and cognitive impairment.
	temazepam (Restoril)	15–-30 mg	Side effects: lack of motor coordination, falls, and cognitive impairment.
Melatonin receptor agonist	ramelteon (Rozerem)	8 mg	Little negative effect on cognition, somnolence, motor coordination, or nausea; useful for problems falling asleep only.
Antihistamine	diphenhydramine (Benadryl)	25–-100 mg	Useful for problems falling asleep only; good side-effect profile.
	hydroxyzine (Vistaril, Atarax)	10–-100 mg	Useful for problems falling asleep only; anticholinergic side effects.

Tricyclic antidepressant	doxepin (Sinequan)	10–-25 mg	Lower doses used for treatment of primary insomnia when antidepressant effect not needed; risk of anticholinergic side effects and weight gain.
	amitriptyline (Elavil)	10–-15 mg	Lower doses used for treatment of primary insomnia when antidepressant effect not needed; risk of anticholinergic side effects and weight gain.
	nortriptyline (Pamelor)	10–-50 mg	Risk of anticholinergic side effects and weight gain.
Second-generation antidepressant	trazodone (Desyrel)	25–-200 mg	Risk of orthostatic hypotension and falls.
	mirtazapine (Remeron)	7.5–-45 mg	If depression not a concern, 7.5–-15 mg best for sleep, hot flashes, increased appetite, and less morning sedation. Be aware of falling risk.
Antipsychotic	quetiapine (Seroquel)	25–-100 mg	Risk of weight gain, metabolic syndrome, abnormal/involuntary movements; possible cardiovascular effects (e.g., prolonged QT interval).
	chlorpromazine (Thorazine)	10–-50 mg	Risk of weight gain, metabolic syndrome, abnormal/involuntary movements; possible cardiovascular effects (e.g., hypotension).
Chloral derivative	chloral hydrate	0.5–-1.0 g	Used mainly for sleep maintenance; risk of gastric irritation; risk of dependence and withdrawal; lethal in overdose.

http://cancer.gov/cancertopics/pdq/supportivecare/sleepdisorders/HealthProfessional. Accessed <10/25/2015>, p. 6-7.

Table 7

Examples of Insomnia Questionnaires Used in Baseline and Treatment Outcome Assessment

Questionnaire	**Description**
Epworth Sleepiness Scale	ESS is an 8-item self-report questionnaire used to assess subjective sleepiness (score range: 0–24; normal <10).
Insomnia Severity Index	ISI is a 7-item rating used to assess the patient's perception of insomnia.
Pittsburgh Sleep Quality Index	PSQI is a 24-item self-report measure of sleep quality (poor sleep: global score >5).
Beck Depression Inventory	BDI (or BDI-II) is a 21-item self-report inventory used to measure depression (minimal or no depression: BDI <10; moderate to severe: BDI >18).
State-Trait Anxiety Inventory-Form Y- Trait Scale	STAI is a 20-item self-report inventory used to measure anxiety (score range: 20–80; minimum anxiety: T-score <50; significant anxiety: T- score >70).
Fatigue Severity Scale	FSS is a 9-item patient rating of daytime fatigue.
Short Form Health Survey (SF-36)	SF-36 is a 36-item self- report inventory that generically measures quality of life for any disorder (range from 0 (poorest) to 100 (well-being).
Dysfunctional Beliefs and Attitudes about Sleep Questionnaire	DBAS is a self-rating of 28 statements that is used to assess negative cognitions about sleep.

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2576317/table/T8/, p 493.

Table 8

Subject's Initials________________ID#__________________Date_______________Time_____ AM PM

PITTSBURGH SLEEP QUALITY INDEX

INSTRUCTIONS:
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

   BED TIME ___________

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

   NUMBER OF MINUTES ___________

3. During the past month, what time have you usually gotten up in the morning?

   GETTING UP TIME ___________

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

   HOURS OF SLEEP PER NIGHT ___________

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

b) Wake up in the middle of the night or early morning

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

c) Have to get up to use the bathroom

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

d) Cannot breathe comfortably

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

e) Cough or snore loudly

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

f) Feel too cold

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

g) Feel too hot

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

h) Had bad dreams

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

i) Have pain

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

j) Other reason(s), please describe____

____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

6. During the past month, how would you rate your sleep quality overall?

Very good ___________

Fairly good ___________

Fairly bad ___________

Very bad ___________

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all	___________
Only a very slight problem	___________
Somewhat of a problem	___________
A very big problem	___________

10. Do you have a bed partner or room mate?

No bed partner or room mate	___________
Partner/room mate in other room	___________
Partner in same room, but not same bed	___________
Partner in same bed	___________

If you have a room mate or bed partner, ask him/her how often in the past month you have had . . .

a) Loud snoring

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Long pauses between breaths while asleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Legs twitching or jerking while you sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Episodes of disorientation or confusion during sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

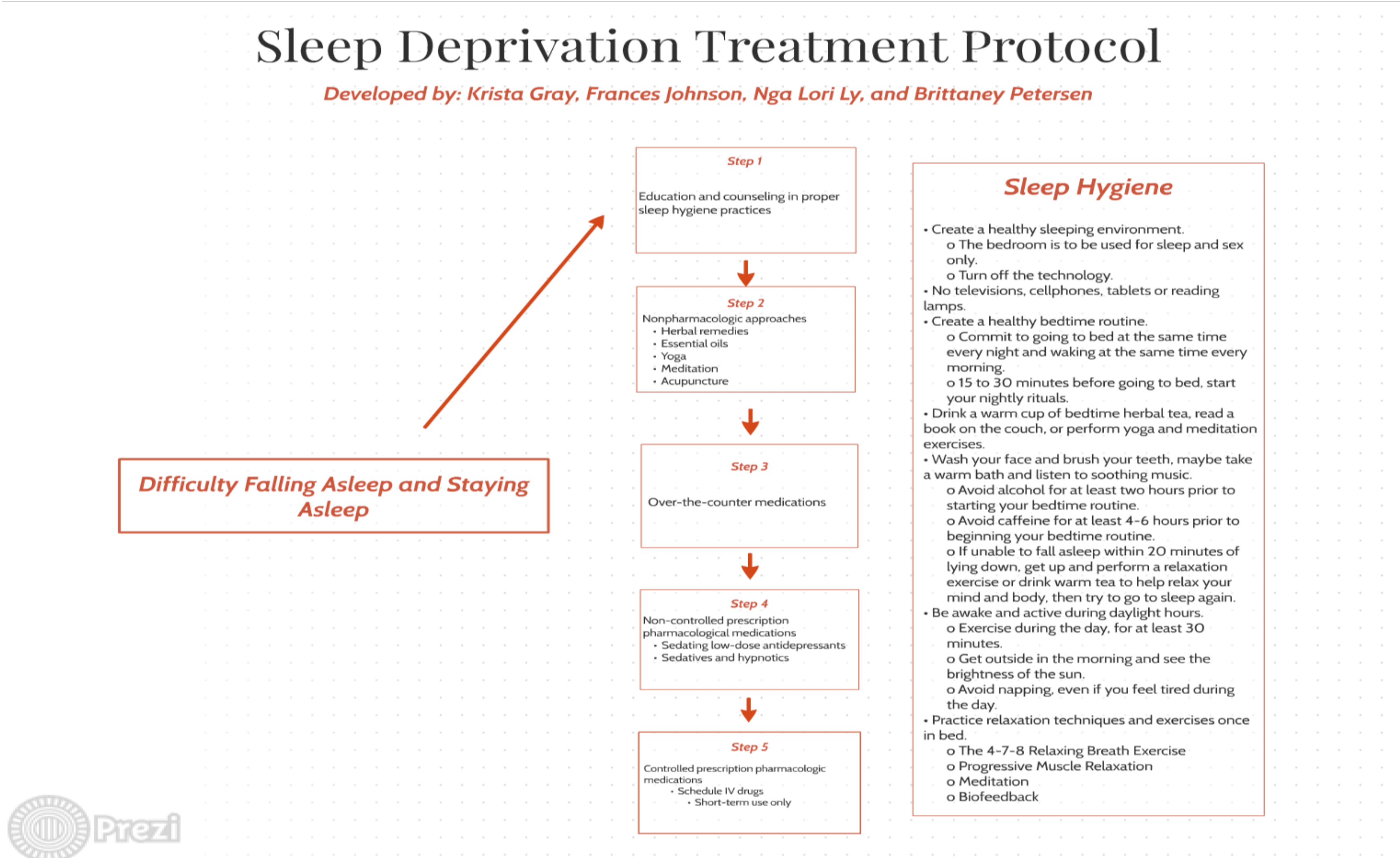
e) Other restlessness while you sleep; please describe__________________________________

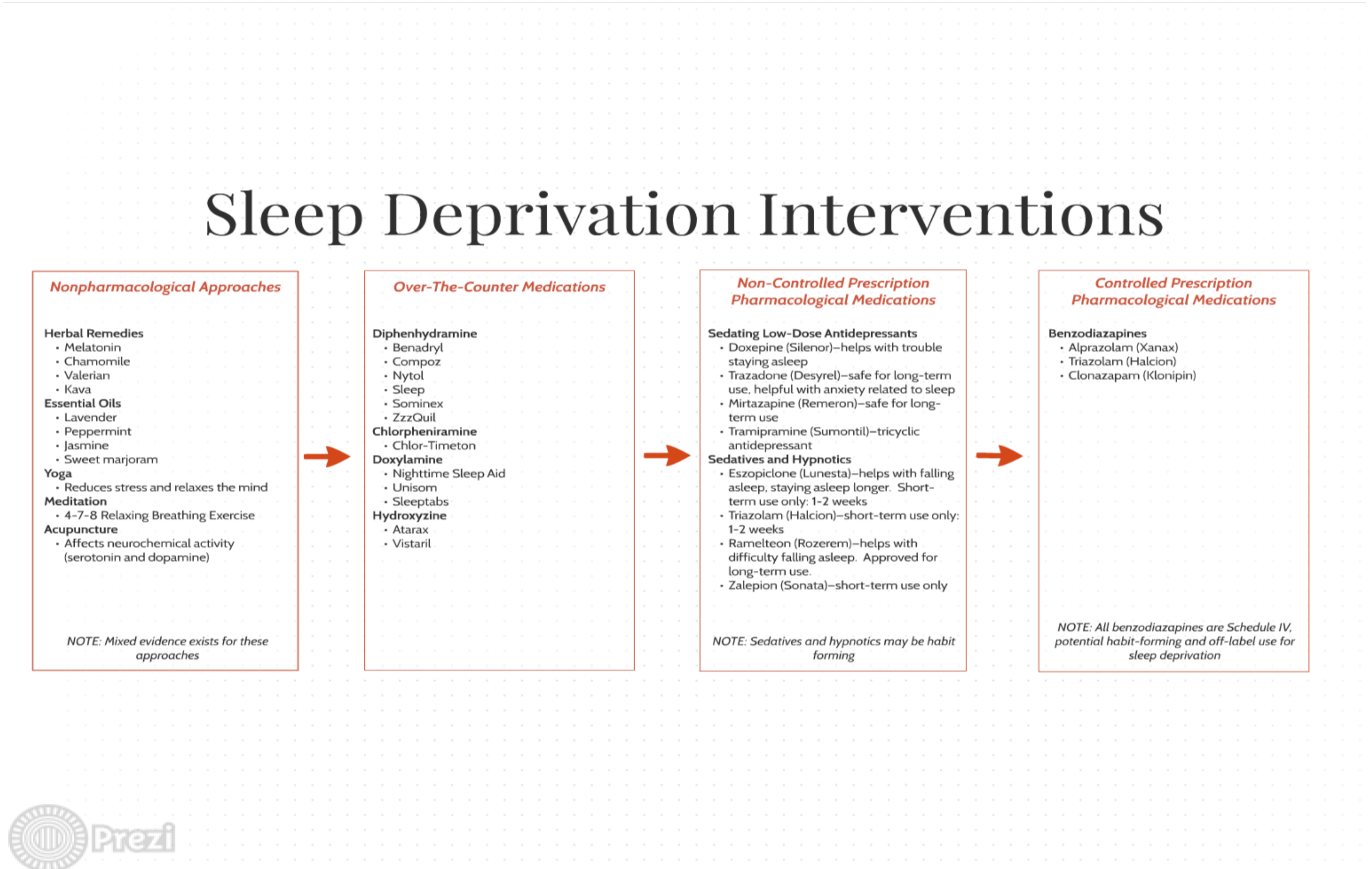
____

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ: Psychiatry Research, 28:193-213, 1989.

Table 9


Sleep Deprivation Treatment Protocol
Developed by: Krista Gray, Frances Johnson, Nga Lori Ly, and Brittaney Petersen
Difficulty Falling Asleep and Staying Asleep
Step 1
Education and counseling in proper sleep hygiene practices
Step 2
Nonpharmacologic approaches
• Herbal remedies
• Essential oils
• Yoga
• Meditation
• Acupuncture
Step 3
Over-the-counter medications
Step 4
Non-controlled prescription pharmacological medications
• Sedating low-dose antidepressants
• Sedatives and hypnotics
Step 5
Controlled prescription pharmacologic medications
• Schedule IV drugs
• Short-term use only
Sleep Hygiene
• Create a healthy sleeping environment.
o The bedroom is to be used for sleep and sex only.
o Turn off the technology.
• No televisions, cellphones, tablets or reading lamps.
• Create a healthy bedtime routine.
o Commit to going to bed at the same time every night and waking at the same time every morning.
o 15 to 30 minutes before going to bed, start your nightly rituals.
• Drink a warm cup of bedtime herbal tea, read a book on the couch, or perform yoga and meditation exercises.
• Wash your face and brush your teeth, maybe take a warm bath and listen to soothing music.
o Avoid alcohol for at least two hours prior to starting your bedtime routine.
o Avoid caffeine for at least 4-6 hours prior to beginning your bedtime routine.
o If unable to fall asleep within 20 minutes of lying down, get up and perform a relaxation exercise or drink warm tea to help relax your mind and body, then try to go to sleep again.
• Be awake and active during daylight hours.
o Exercise during the day, for at least 30 minutes.
o Get outside in the morning and see the brightness of the sun.
o Avoid napping, even if you feel tired during the day.
• Practice relaxation techniques and exercises once in bed.
o The 4-7-8 Relaxing Breath Exercise
o Progressive Muscle Relaxation
o Meditation
o Biofeedback
Prezi


Sleep Deprivation Interventions
Nonpharmacological Approaches
Herbal Remedies
• Melatonin
• Chamomile
• Valerian
• Kava
Essential Oils
• Lavender
• Peppermint
• Jasmine
• Sweet marjoram
Yoga
• Reduces stress and relaxes the mind
Meditation
• 4-7-8 Relaxing Breathing Exercise
Acupuncture
• Affects neurochemical activity (serotonin and dopamine)
NOTE: Mixed evidence exists for these approaches
Over-The-Counter Medications
Diphenhydramine
• Benadryl
• Compoz
• Nytol
• Sleep
• Sominex
• ZzzQuil
Chlorpheniramine
• Chlor-Timeton
Doxylamine
• Nighttime Sleep Aid
• Unisom
• Sleeptabs
Hydroxyzine
• Atarax
• Vistaril
Non-Controlled Prescription Pharmacological Medications
Sedating Low-Dose Antidepressants
• Doxepine (Silenor)–helps with trouble staying asleep
• Trazadone (Desyrel)–safe for long-term use, helpful with anxiety related to sleep
• Mirtazapine (Remeron)–safe for long-term use
• Tramipramine (Sumontil)–tricyclic antidepressant
Sedatives and Hypnotics
• Eszopiclone (Lunesta)–helps with falling asleep, staying asleep longer. Short-term use only: 1-2 weeks
• Triazolam (Halcion)–short-term use only: 1-2 weeks
• Ramelteon (Rozerem)–helps with difficulty falling asleep. Approved for long-term use.
• Zalepion (Sonata)–short-term use only
NOTE: Sedatives and hypnotics may be habit forming
Controlled Prescription Pharmacological Medications
Benzodiazapines
• Alprazolam (Xanax)
• Triazolam (Halcion)
• Clonazapam (Klonipin)
NOTE: All benzodiazapines are Schedule IV, potential habit-forming and off-label use for sleep deprivation
Prezi