VARYING CALORIE AND MACRONUTRIENT INTAKES OF INDIVIDUALS WITH DIFFERENT SLEEP QUALITY

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VARYING CALORIE AND MACRONUTRIENT INTAKES OF INDIVIDUALS WITH DIFFERENT SLEEP QUALITY (103 pp.)

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The purpose of this study was to examine if calories and macronutrient intakes were different amongst good and poor sleeping college students. Participants were selected using a convenience sample of undergraduate students enrolled in a nutrition fundamental course during spring 2017. Participants of any age, regardless race and sex, and with realistic and complete dietary intake data were included. Dietary nutrients were measured using 4-day dietary records, that were entered into ESHA Food Processor (version 11.4, 2017). Sleep quality was measured using the Pittsburgh Sleep Quality Index. Independent t-test was used to examine calories and macronutrient differences between good and poor sleepers. Calories were significantly higher for good sleepers compared to poor sleepers ($p = 0.028$). Macronutrients: carbohydrates, fat, and protein, were all found non-significantly different between good and poor sleepers after Bonferroni correction. Conclusion: calorie intake was significantly higher for good sleepers compared to poor sleeper, however, macronutrient intake was not significantly different between groups.

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INTRODUCTION

Adequate sleep is vital for optimal physical and mental health. Sleep is comprised of two phases: rapid eye movement sleep (REM), and non-rapid eye movement sleep (NREM), that usually occur four times per night (Carskadon, & Dement, 2011). NREM sleep is comprised of three stages, each with unique features and functions (Altevogt, & Colten, 2006). REM sleep is suggested to play an important role in bodily repair, and memory consolidation (Aletevogt, & Colten, 2006). Adequate sleep, is important for memory consolidation, bodily repair, emotional well-being, hormonal regulation, and learning (Hsu, Chen, Lee, Shih, & Lin, 2014; Curicio, Ferrara, & Gennaro, 2006).

The amount of sleep an individual requires depends on a number of factors, with a main one being age. Most adults need around 7-9 hours of sleep each day (CDC, 2011). Sleep may also be defined by sleep quality; with less arousals, proper daytime function, and less daytime sleepiness indicating better sleep quality. Sleep quality and duration may be more objectively measured by polysomnography and actigraphy (CDC, 2011). Although measures differ, sleep is considered adequate when one is without dysfunction and sleepiness during the day, and within normal ranges of sleep duration (Peuhkuri, Sihvola, & Korpela, 2012; CDC, 2011).

Inadequate sleep is associated with a number of health problems, and may increase susceptibility to infectious disease (Pandierumal, Srinivasan, Spence, & Cardinali, 2007). Decreased sleep quality and duration may increase the risk of developing cardiovascular disease, type-2 diabetes, osteoporosis, and obesity (Cappuccio, D'Elia, Strazzullo, & Miller, 2010; Cunningham, Brian, & Pace, 2015; Doo, & Kim, 2016; Al-Disi, Al-Daghri, Khanam, Al-Othman, Al-Saif, Sabico, & Chrousos, 2010). Less restorative sleep has been robustly studied in association with weight gain, with proposed mechanisms looking at sleeps' effect on hunger hormones, ghrelin and leptin, which may lead to increased caloric intakes (Al-Disi, et al., 2010). Sleep and the association with weight gain is a popular topic, considering the rise in obesity rates, and since higher weight status is associated with most morbidities, early death, and a lower quality of life (Willett, 2011).

A number of factors may lead to inadequate sleep, with weight status, smoking, alcohol, caffeine, and physiological problems, all having deleterious effects on sleep quality and duration (Peters, Fucito, Novosad, Toll, & O'malley, 2011; Hunsberger, Mehlig, Börnhorst, Hebestreit, Moreno, Veidebaum, & Lissner, 2011; Rosi, Calestani, Parrino, Milioli, Palla, Volta, & Scazzina, 2017; Vgontzas, Lin, Papaliaga, Calhoun, Vela-Bueno, Chrousos, & Bixler, 2008). Adequate sleep is positively associated with healthy lifestyle factors like engaging in physical activity and healthy dietary choices (Peuhkuri, Sihvola, & Korpela, 2012). While, inadequate sleepers consume more calories from fats and refined carbohydrates, report irregular eating patterns, consume more snacks, and eat less fruits, vegetables, and milk (Haghighatdoost, Karimi, Esmaillzadeh, & Azadbakht, 2012; Kant, & Graubard, 2014; Cao, Wittert, Taylor, Adams, & Shi, 2016).

Diet's association with sleep has just started receiving attention, and a few reviews have attempted to elucidate the diet and sleep relationship (Frank, Gonzalez, Lee-Ang, Young, Tamez, & Mattei, 2017; Peunhkuri, Sihvola, & Korpela, 2012; St-Onge, Mikic, & Pietrolungo, 2016). However, the diet-sleep relationship is only partially clear, but diet may affect sleep through nutrients that alter health status and neurological pathways, and sleep may affect dietary intake through behavioral modification, and hormonal influences (Frank, et al., 2017). Some nutrients for example act as precursors for sleep hormones, and play a key role in neurological pathways, such as tryptophan and zinc (Murray, 2009; Turgeon, & Albin, 1992). While poor sleep may influence one's hunger and satiety hormones - leptin and ghrelin - and possibly affect dietary intake (Al-Disi, Al-Daghri, Khanam, Al-Othman, Al Saif, Sabico, & Chrousos, 2010). Thus, a dynamic diet-sleep relationship is proposed to be bidirectional (Frank, et al., 2017).

Research suggests both diet and sleep habits fluctuate during college years (Butler, Black, Blue, & Gretebeck, 2004; Lund, Reider, Whiting, & Prichard, 2010). In academia, college students may go through a number of lifestyle changes that affect their regular sleep patterns. Students may practice unusual dietary patterns, eat more energy dense foods, have fluctuating meal frequency, consume increased alcohol and caffeinated beverages, and have low levels of physical activity (Hicks, Mc Tighe, & Juarez, 1986; Kenny, & Gortmaker, 2017). College students may also struggle with the pressure of exams and homework assignments, noisy roommates and parties disrupting them, and on top of this, work a number of hours each week, amongst other factors preventing restorative sleep.

The dietary factors of these college students are of special concern as previous studies have reported students are not meeting dietary recommendations, and diet is associated with sleep outcomes (Ha, & Caine-Bish, 2011; Grandner, Jackson, Gerstner, & Knutson, 2013). US college students may be getting inadequate milk, whole grains, and fruits and vegetables, all of which are important factors for overall health and positive sleep outcomes (Ha, & Caine-Bish, 2009; Ha, & Caine-Bish, 2011; Willett, 2011; Pérez-Farinós, Villar-Villalba, Sobaler, Saavedra, Aparicio, Sanz, & Anta, 2017). These factors may have negative consequences on college students' academic performance, as their deleterious effects on sleep may bolster hurdles for students' learning and information retention of class materials - adding pressures to educators in effectively instructing their students (Curcio, Ferrara, & De Gennaro, 2006).

Statement of the Problem

Despite the importance sleep plays during academic years, a majority of college students are getting inadequate sleep, and insufficient sleep may lead to lower grade point average (Lund, Reider, Whiting, & Prichard, 2010; Kelly, Kelly, & Clanton, 2001; Sivertsen, Glozier, Harvey, Hysing, 2015; Hysing, Harvey, Linton, Askland, Sivertsen, 2016). US college students also have a number of concerning dietary factors: consuming less than ideal dairy, fruits and vegetables, and whole grain products - all of which are important factors for sufficient, restorative sleep. The association between diet and sleep is therefore an important phenomenon to examine in college student populations, considering that both diet and sleep have been associated with academic performance, and a number of studies have found these factors to have interrelationships in other populations (Hunt, 2017; Lund, Reider, Whiting, & Prichard, 2010). However, the association between diet and sleep has yet to be robustly studied, and research examining the comparison of dietary intake between good and poor sleepers is rare to non-existent using college student samples from the United States.

Statement of Purpose

The purpose of this study is to compare calorie and macronutrient intake in individuals with good and poor sleep quality.

Hypotheses

H1: There will be a difference in calories consumed between individuals with good and poor sleep quality.

H2: There will be a difference in macronutrients (carbohydrates, fat, and protein) consumed between individuals with good and poor sleep quality.

Operational Definitions

Sleep quality – refers to sleep quality defined by the Pittsburgh Sleep Quality Index (Buysse, et al., 1988). Sleep quality is a global score calculated by considering: usual bed time, sleep latency, usual wake time, average sleep duration, difficulty falling asleep or waking, sleeping breathe, coughing and snoring, sleeping temperature, dreaming, any pain, subjective sleep quality score, sleep medication use, wakefulness, mood, and roommate/bed partner disruption. The scores are then dichotomously split into good (≤ 5) and poor sleep (> 5) quality (Buysse, et al., 1988).

Macronutrients – refers to carbohydrates, fats, and proteins, with the exception of water.

CHAPTER 2

REVIEW OF LITERATURE

The Purpose & Importance of Sleep

Sleep is a phenomenon that is essential for physical and mental health (Knowlden, Hackman, & Sharma, 2016). It has been proposed that sleep is key for bodily and cellular repair, and sufficient sleep is associated with emotional regulation, brain recuperation, memory consolidation, and overall mental health (Knowlden, et al., 2016; Hsu, Chen, Lee, Shih, & Lin, 2014; Curicio, Ferrara, & Gennaro, 2006). Conversely, inadequate sleep is associated with a number of health problems, including: obesity, hypertension, inflammation, diabetes, cardiovascular disease, and early mortality (Knowlden, et al., 2016; Cappuccio, D'elia, Strazzullo, & Miller, 2010; Cunningham, & Di Pace, 2015). Sleep is an essential function in humans, and individuals who receive enough time sleeping and quality sleep, are less likely to develop morbidities throughout life, whereas deficiency may result in serious physiological consequences (Cappuccio, et al., 2010; Cunningham, & Pace, 2015; Altevogt, & Colten, 2006).

Sleep Epidemiology

The National Sleep Foundation recommends 7-9 hours of sleep each day for adults (2015). Despite this, over one-third of Americans self-report less than seven hours of sleep each day (CDC, 2011). The CDC reports that the remaining 65% of adults ages 18-60 years old, report a healthy sleep duration of more than seven hours of sleep (Liu, 2016). The prevalence of unhealthy sleep duration is associated with ethnicity. With less than seven hours of sleep more commonly reported among non-Hispanic blacks, Pacific Islanders, Native Americans, and multiracial groups, compared to non-Hispanic Caucasians, Hispanics, and Asians (Liu, 2016). Areas around the Appalachian Mountains and in the southeastern United States have the lowest report of healthy sleep duration. Some of these states report the lowest proportion of healthy sleep duration, and are: Ohio (62%), West Virginia (61%), Kentucky (60%), Indiana (61%), and Hawaii (56%) (Liu, 2016) (Figure 1). Areas in the Great Plain regions have the highest percentages of healthy sleep duration, with South Dakota and Colorado reporting the most (71%) (Liu, 2016). Ohio also has one of the highest proportion of <7 hours/day of sleep (Figure 2).

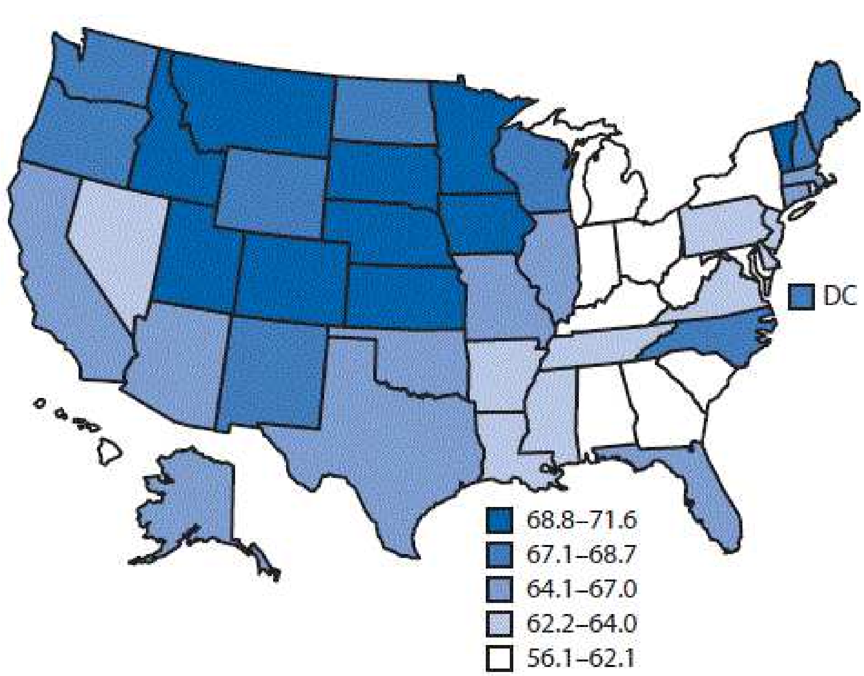

Figure 1. Percentages of Adults Reporting Healthy Sleep Duration by State in 2014 (Liu, 2016)

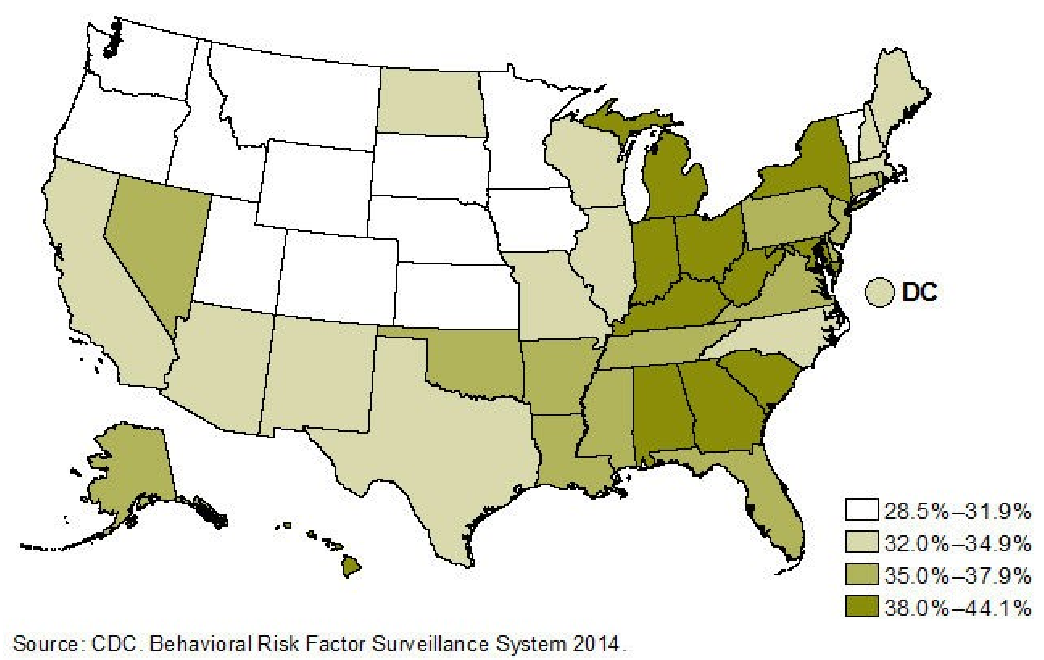

Figure 2. Percentages of Adults Reporting <7 Hours of Sleep a Day by State (Sleep and Sleep Disorders, 2017)

Sleep requirements change across the life-span, with newborns needing around 14-17 hr./day, young adults 7-9 hr./day, and older adults needing around 7-8 hr./day (National Sleep Foundation, 2015) (Figure 3). The sleep recommendations also include outlier ranges that may be more appropriate for some individuals (National Sleep Foundation, 2015) (Figure 3). The amount of sleep a person needs may be unique to the individual, and the National Sleep Foundation recommends assessing one's personal sleep needs by asking the following questions: 1), is x number of hours enough for you to be productive and happy? 2), do you have health issues? 3), are you having sleep problems? 4), do you depend on caffeine? and 5), do you feel sleepy behind the wheel? (National Sleep Foundation, 2015).

Figure 3. Sleep Duration by Age

(National Sleep Foundation, 2015)

Sleep Components - REM & NREM Sleep

The sleep process consists of four cyclic phases, subdivided into two categories: non-rapid eye movement sleep (NREM), and rapid eye movement (REM) sleep (Carskadon & Dement, 2005). Memory is noted to be predominantly enhanced through REM sleep, which, if negatively affected, may decrease one's academic performance (Champlin, Pasch, & Perry, 2016; Diekelmann & Born, 2010). NREM is subdivided into three consecutive stages, which increase progressively in depth by stage (Altevogt, & Colten, 2006). Each of these stages has unique attributes, that may differ by brainwave, muscle tone or eye movement, and were originally discovered using electroencephalographic records (Loomis, Harvey, & Hobart, 1937; Altevogt, & Colten, 2006; Dement, & Kleitman, 1957). Sleep begins with a short duration of NREM Stage 1 sleep, then subsequent stages thereafter (Stage 2, Stage 3&4, and then REM) (Altevogt, & Colten, 2006; Robbins, 2015). Note, that Stage 3 and 4 are now considered a single stage of sleep, and a deep sleep; often referred to as "slow wave" (Robbins, 2015). During the night, individuals cycle between NREM and REM (Figure 4) (Altevogt, & Colten, 2006). Most sleep is spent in NREM sleep, making up approximately 75-80% of total sleep (Altevogt, & Colten, 2006). One complete cycle of REM and NREM sleep, during the first cycle, is around 70-100 minutes, and thereafter approximately 90-120 minutes (Altevogt, & Colten, 2006). With each cycle, REM duration increases (Altevogt, & Colten, 2006) (Figure 4).

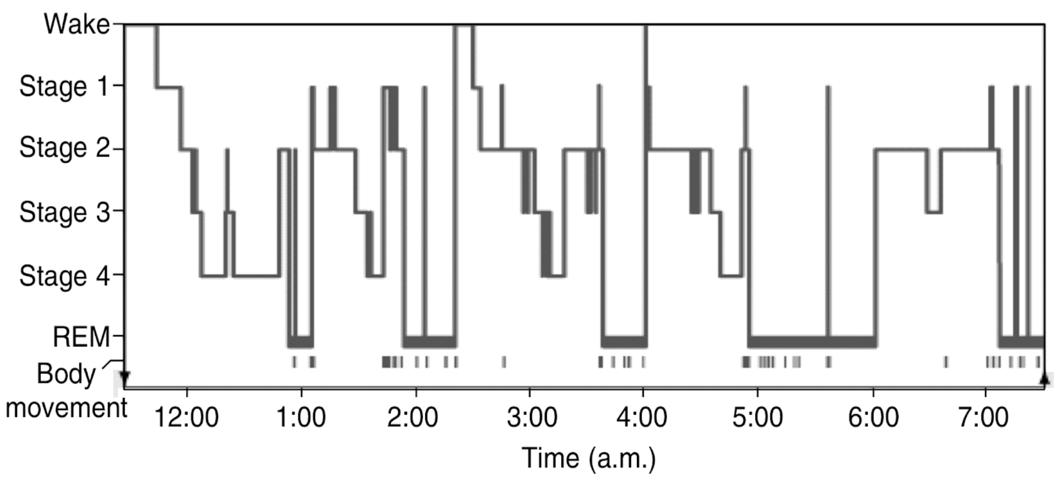

Figure 4. The Stages of Sleep

(Altevogt, & Colten, 2006)

Stage 1 is the first phase of a sleep episode in normal, healthy adults (Altevogt, & Colten, 2006). It usually lasts 1-7 minutes, and is 2-5 percent of total sleep (Altevogt, & Colten, 2006). This stage is noticed through electroencephalographic records by alpha waves (Altevogt, & Colten, 2006). In Stage 2 sleep, a typical duration lasts around 10-25 minutes, and increases in duration throughout the night (Altevogt, & Colten, 2006). This stage makes up around 45-55 percent of total sleep, and more stimuli is required for waking compared to Stage 1 (Altevogt, & Colten, 2006). Stage 2 is characterized by low-voltage waves called sleep spindles and K-complexes, and are hypothesized to assist with memory (Figure 5) (Altevogt, & Colten, 2006). Stage 3 and 4 are collectively known as slow-wave sleep, which is the deepest sleep (Altevogt, & Colten, 2006; Saladin, 2010; Robbins, 2015).

REM sleep is the last step in a usual cycle, and progresses in duration as sleep continues (Andrés, Garzón, & Reinoso-Suárez, 2011). REM sleep is most commonly identified by rapid eye movement, hence the name, and is known as the most restorative sleep, and is important for memory consolidation (Saladin, 2010; Altevogt, & Colten, 2006).

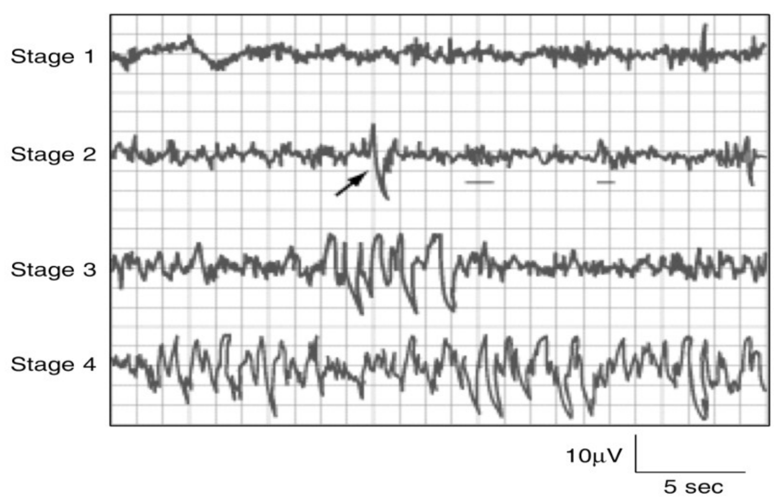

Figure 5. Different Frequencies in Sleep Stages

(Altevogt, & Colten, 2006)

Measuring Adequate Sleep

Sleep may be measured objectively and subjectively. Objective measures include electronic devices that measure specific sleep parameters, depending on the device. Some examples of objective instruments include: electroencephalography, polysomnography, and actigraphy (Mayo Clinic, 2014). Subjective measures are usually self-reported sleep parameters such as duration, time it takes to go to bed (sleep latency), daytime fatigue, and wakes per night - to name a few (Buysse, Reynolds III, Monk, Berman, & Kupfer, 1988). Subjective measures sometimes include sleep logs and diaries, where participants record bedtimes and wake times.

An actual objective measure of an individual's sleep quality has been formally difficult to measure (Buysse, et al., 1988). Though a subjective measure, sleep quality encompasses both quantitative and subject aspects, and may be more comprehensive a measure of sleep, compared to subjectively measuring one component of sleep. Quantitatively, one's total time sleeping (duration), sleep latency, and the number of arousals can be measured. On the other hand, subjective factors may be included, such as the depth or the restfulness of one's sleep (Buysse, et al., 1988). These factors together yield an individual's sleep quality.

Sleep Quality, Polysomnography, & Actigraphy

One of the most popular and globally used tools to measure sleep quality is the Pittsburgh Sleep Quality Index (PSQI) (Buysse, et al., 1988). This instrument was originally created to measure "sleep quality" in a psychiatric population but has also been found a reliable tool for clinical and research purposes (Buysse, et al., 1988). Psychiatric patients commonly report depression, anxiety disorders, and the use of psychoactive substance; all of which may have damaging consequences on sleep quality (Buysse, et al., 1988).

The PSQI was created through a combination of clinical judgment, 18 months of field practice, and also through literary analysis of sleep quality questionnaires (Buysse, et al., 1988). The PSQI is considered a post sleep questionnaire, where many of the questions start with, “in the last month…” and then go on to measure a specific aspect of sleep. Measuring sleep quality within the last month is one of the benefits of the PSQI, as many previous questionnaires only measure smaller segments of sleep (i.e. the past night of sleep), or other questionnaires measure “sleep type,” which according to Buysse et al. (1988) may assess sleep quality for a year or more ago. The PSQI instrument provides a global score, which may be used to produce a dichotomy of either “good” or “poor” sleepers. Ultimately, the PSQI measures seven components of sleep, which are: subjective sleep quality, latency, duration, habitual efficiency, disturbances, sleep medications, and dysfunction during the day (Buysse, et al., 1988). The survey is estimated to take 5-10 minutes for the client to complete. Homogeneity over all seven components of the instrument were found to have a correlation of 0.83, which may mean each component was measuring the same phenomenon, in this case supposed sleep quality (Buysse, et al., 1988).

Sleep may be measured objectively by polysomnography and actigraphy. Polysomnography is often used in clinical settings for diagnosing sleep disorders (Mayo Clinic, 2014). It reads a number of sleep factors such as, brain waves, oxygen levels in the blood, heart rate, breathing, and eye and leg movements (Mayo Clinic, 2014). Polysomnography monitors the different stages of sleep, starting with NREM, it uses electroencephalography to record brain waves (Mayo Clinic, 2014). This measure allows for medical professionals to determine if or when sleep disturbance occur (Mayo Clinic, 2014). Actigraphy is another objective measure of sleep, and is similar to a watch in form (Auger, Varghese, Silber, & Slocumb, 2013). Measuring movement of the wrist, the actigraphy follows the assumption that individuals have more wrist movement during wake times, compared to sleeping (Auger, et al., 2013). The actigraphy can record the total sleep time, sleep duration, arousals, and naps during the day (Auger, et al., 2013). Actigraphy has been shown to be an effective measure compared to subjective measures like sleep logs, which may overestimate (Auger, et al., 2013).

Factors Associated with Sleep

There are a number of factors that can influence sleep and sleep can also lead to metabolic changes that may increase the development of morbidities and early mortality (Peters, Fucito, Novosad, Toll, & O'malley, 2011; Al-Disi, Al-Daghri, Khanam, Al-Othman, Al-Saif, Sabico, & Chrousos, 2010; Doo, & Kim, 2016). Factor that may directly affect sleep are alcohol, nicotine, physical activity, body weight, and screen time. These factors have biological mechanisms that affect sleep in different ways. Sleep conversely may influence biological signals that could lead to decreased of increased appetite (Al-Disi, Al-Daghri, Khanam, Al-Othman, Al-Saif, Sabico, & Chrousos, 2010). The associations of factors with sleep is therefore a bidirectional association in some cases.

Alcohol & Smoking

Studies have found a negative relationship between increased use of nicotine, and alcohol with decreased sleep quality (Zunhammer, et al., 2014; Peters, Fucito, Novosad, Toll, & O'malley, 2011). A number of studies have reported smokers to have difficulty falling asleep compared to non-smokers (Lohsoonthorn, et al., 2012; Wetter, & Young, 1994). This is likely due to nicotine acting as a stimulant, making it difficult for users to fall asleep, especially if smoking episodes increase with the progression of the day, up to bedtime (Diaz, 2016; Wetter & Young, 1994; Peters, et al., 2011).

Alcohol is commonly thought of as a sedative, and some users suggest it helps them fall asleep, however, alcohol may disrupt normal sleep rhythms and decrease sleep quality. During college years, students often explore the use of alcoholic beverages with nearly two thirds consuming the substance (Bulmer, Irfan, Mugno, Barton, & Ackerman, 2010). Additionally, one third of students may participate in binge drinking consuming around 4-5 drinks in a single sitting (Bulmer, et al., 2010). The use of alcohol has been found to have a positive relationship with sleep duration, where higher intakes of the substance is associated with longer periods of sleep (Grandner, 2013; Lund, Reider, Whiting, & Prichard, 2010). Both smoking and alcohol may disrupt normal sleep cycles, sometimes in opposite (stimulant vs. sedative) ways, but having the same negative effect on one’s overall sleep quality.

Screen Time & Digital Devices

Another factor that may influence sleep is screen time. Screen time includes a number of electronic devices (e.g. television, computers, video games, smartphones, and tablets). Screen time use has steadily increased over the years, and spiked with the availability of personal smartphones (Perez-Farinos, 2017). Screen devices can produce rays that may affect normal circadian rhythms, and decrease sleep quality and duration (Perez-Farinos, 2017; De Jong, Visscher, HiraSing, Heymans, Seidell, & Renders, 2013). Forms of screen time, like television and computers may reduce the total amount of sleep per/day (Perez-Farinos, 2017; De Jong, et al., 2013). Screen time may also cause a distracting environment, where individuals think less about food choices, while also increasing exposure to "unhealthy" food advertisements, that may promote poor dietary choices (Coon, Goldberg, Rogers, & Tucker, 2001).

Increased screen time may be associated with the changing family dynamic, and the affordability and accessibility to electronic devices for children. For example, in 2011, approximately 30% of children had a screen device in their bedroom, and this percentage significantly increased to 35% in 2013 (Perez-Farinos, et al., 2017). Also, the amount of screen time increased over the years, where, in 2011, 1.8 hours/day was usual, and this amount increased to 2.5 hours/day in 2013 (Perez-Farinos, et al., 2017). Among these, males on average report 12-17% more time in front of a screen (Perez-Farinos, et al., 2017; Tajeu, & Sen, 2017).

Children who are overweight are more likely to have a screen device in their bedroom, and most children with screen devices in their bedroom come from parents of lower socioeconomic status (Perez-Farinos, et al., 2017). Children with higher screen time also reported higher frequencies of consuming "unhealthy foods" like, potato chips, chocolate, cakes, pizza, French fries, hamburgers, milkshakes, and soft drinks (Perez-

Farinos, et al., 2017). With an increase in only one hour of screen time, children may eat significantly more of all of these foods (Perez-Farinos, et al., 2017). On the other hand, low screen time users may eat more "healthy foods" like, fresh fruit, vegetables, 100% fruit juice, cereals, fish, and whole-grain bread (Perez-Farinos, et al., 2017).

Body Weight & Physical Activity

The prevalence of obesity has significantly increased in the last few decades all around the world, and the World Health Organization now refers to obesity as a global epidemic (World Health Organization, 2000; Cappuccio, Taggart, Kandala, Currie, Peile, Stranges, & Miller, 2008). Childhood obesity is also increasing, and Ogden et al. found a significant increase in the prevalence of obesity over a span of 12-years (Al-Disi, Al-Daghri, Khanam, Al-Othman, Al Saif, Sabico, & Chrousos, 2010; Ogden, et al., 2012). At the same time, sleep duration has decreased by approximately 1.5-2 hours in the past 50 years, and meta-analysis shows a significant association between short sleep duration and obesity (Cappuccio, et al., 2008; Taheri, et al., 2004; Nam, Han, Kim, Lee, & Seo, 2017). Typical measures of weight status and obesity are body mass index (BMI), waist circumference, waist-to-hip ratio, and body fat percentage. Weight status is one of the strongest associations with sleep parameters, hence, it is often adjusted for in sleep studies. One diet and sleep study found BMI was five times stronger in effect with sleep compared to fat intake, and also accounted for approximately 30% of a sleep index, using objective measures (Cao, Wittert, Taylor, Adams, & Shi, 2016).

Nam et al. used the Korean National Health and Nutrition Examination Surveys (KNHANES) and found obesity measures were inversely associated with sleep duration

(Nam, Han, Kim, Lee, & Seo, 2017). One study examined how sleep may influence the development of obesity in children and adults around the world, through meta-analysis (Cappuccio, Taggort, Kandala, Currie, Peile, Stranges, & Miller, 2008). Children with shorter sleep duration were 89% more likely to be obese, and adults were 55% more likely to be obese (Cappuccio, et al., 2008). Similarly, Rosi et al. found a higher BMI in children was associated with decreased sleep time (2017). It is surmised that short sleep duration may increase the risk of obesity in both children and adults, and is of great concern, considering obesity in children is steadily increasing (Rosi, et al., 2017; Al-Disi, et al., 2010).

Another study found fat mass increases and lean mass decreases in association with less sleep (Kim, Shin, Jung, Lee, & Park, 2017). Sleep deprivation (less than 5 hours per day) shows a 22% increase in the odds of general obesity, and 32% increase in abdominal obesity (Kim, et al., 2017). Ryu et al. found that even when accounting for metabolic normality vs. abnormality, obesity is still significantly associated with less than six hours of sleep each day, and non-obese individuals have longer sleep duration (Ryu, Lee, Hong, Choi, Yoo, Seo, & Choi, 2015).

Poor sleep efficiency is also associated with inactivity (Kahlhöfer, et al., 2016). This could be interlinked with weight status, as higher fat mass has been found to be significantly associated with inactivity in women (Kahlhöfer, et al., 2016). Physical activity though, was found to have non-significant effects on sleep which is contrary to other studies (Kahlhöfer, et al., 2016; Rosi, Calestani, Parrino, Milioli, Palla, Volta, & Scazzina, 2017). In children, physical activity may be positively associated with sleep duration, while BMI leads to negative associations with sleep duration (Rosi, et al., 2017). In an experimental study, sleep quality scores were shown to improve with moderate exercise for a succession of weeks, compared to controls (King, Oman, Brassington, Bliwise, & Haskell, 1997).

Hormones, weight gain, & sleep. The fat cells of the human body are called adipocytes, and release hormones called adipokines. Adipokines have an important role in metabolic regulation and may affect feelings of hunger or satiety, and have received growing attention in research considering the obesity epidemic (Al-Disi, Al-Daghri, Khanam, Al-Othman, Al-Saif, Sabico, & Chrousos, 2010; Taheri, Lin, Austin, Young, & Mignot, 2004). Energy and macronutrient intake have been associated with hormonal changes, along with sleep (Al-Disi, et al., 2010). Most common hormones under investigation are leptin, adiponectin, resistin and ghrelin; each playing a unique role in metabolism and adipocyte regulation. Some research aims to understand how sleep, obesity, and weight status are interlinked (Al-Disi, Al-Daghri, Khanam, Al-Othman, Al-Saif, Sabico, & Chrousos, 2010; Taheri, Lin, Austin, Young, & Mignot, 2004).

Hormones may fluctuate depending on body weight and total sleep (Al-Disi, et al., 2010). Ghrelin - a satiety hormone - has been inversely associated with sleep duration and waist-hip ratio (Al-Disi, et al., 2010; Taheri, et al., 2004). Resistin may be inversely related to ghrelin levels, and increases with higher BMI (Al-Disi, et al., 2010). When sleep is interrupted, ghrelin levels may spike (Al-Disi, et al., 2010). Leptin - a hunger stimulant - shows a strong positive correlation with BMI. Unlike ghrelin, leptin may increase with larger waist-hip ratios, BMI, and insulin resistance (Al-Disi, et al., 2010). Low levels may be associated with shorter sleep duration (Taheri, et al., 2004). Increased adiponectin shows a significant association with lower BMI, leptin, waist-hip ratio, and serum triglycerides (Taheri, et al., 2004). On the other hand, adiponectin is higher in lean members, and positively associated with high density lipoproteins, and an increase in sleep duration (Taheri, et al., 2004).

Understanding how these hormones may fluctuate with sleep and weight status is still under investigation. However, the following theory is proposed in a number of studies, suggesting that inadequate sleep may lead to more hunger hormones, thus leading to subsequent weight gain and obesity. This is the common theory suggested in diet and sleep literature, and the purpose of studying diet and sleep often seeks to better understand the increasing rate of obesity. On the other hand, weight status is commonly associated with physiological problems that may lead to sleep disorders like sleep apnea. So, the directionality of poor sleep leads to weight gain, vs. weight gain leads to poor sleep, is still not clearly understood. Additionally, studies suggest other theories, proposing less sleep allows for more eating opportunities during the day.

Mortality & Morbidity

Inadequate sleep is associated with a number of morbidities and early mortality. The association between health problems and sleep may be bidirectional, where health problems may promote inadequate sleep, and inadequate sleep may lead to poor health outcomes. This may lead to a poor-health, poor-sleep cycle, which may decrease quality of life and lead to further poor health outcomes. Less than ideal amount of sleep is also associated with a number of disease risk factors including: elevated systolic blood pressure, diastolic blood pressures, and hypertension (Doo, & Kim, 2016). A number of studies have found diseases, such as coronary heart disease, type-2 diabetes, and osteoporosis risk increases with shorter sleep duration (Cappuccio, D'Elia, Strazzullo, & Miller, 2010; Cunningham, Brian, & Pace, 2015; Doo, & Kim, 2016).

It has been found that short sleep duration is significantly associated with elevated cardiovascular risk through a ten-year cardiovascular risk assessment (Doo, & Kim, 2016). Another study found increased odds of stroke, heart failure, and coronary heart disease when a person has sleep disorders (Shahar, Whitney, REdline, Lee, Newman, Javier Nieto, & Samet, 2001). Cappuccio et al. conducted a meta-analysis and found that individuals with short sleep duration were 28% more likely to develop type-2 diabetes (2010). Long sleep may also increase the incidence of diabetes by 48%, and there is an 84% more chance of having sleep disturbances (Cappuccio, et al., 2010). In the elderly, short sleep duration (<6 hours/day) may be associated with 59% increased risk of osteoporosis (Cunningham, Brian, & Pace, 2015).

There are a number of proposed mechanisms linking sleep, stress, and disease. For type-2 diabetes, sleep deprivation may lead to insulin resistance, and mediate weight gain (Wellen, & Hotamisligil, 2005). Decreased sleep may also affect satiety and hunger hormones, (leptin and ghrelin) leading to weight gain and subsequent type-2 diabetes (Wellen, & Hotamisligil, 2005). Inadequate sleep may also promote the development of atherogenesis factors - promoting the accumulation of plaque and cholesterol esters - and have negative effects on circulation rates, that collectively lead to an increased risk of cardiovascular disease (Shahar, Whitney, REdline, Lee, Newman, Javier Nieto, & Samet, 2001; Klingelhöfer, Hajak, Sander, Schulz-Varszegi, Rüther, & Conrad, 1992). Regarding the development of osteoporosis, there are a few proposed mechanisms: 1), sleep deprivation may increase circulating corticoids; possibly decreasing bone mineral density, 2), those who have poor sleep may have other characteristics that may lead to osteoporosis like smoking, reduced sun exposure, and low BMI, and, 3), dietary and other factors may simultaneously disrupt both sleep quality/duration and bone mineralization (Cunningham, Brian, & Pace, 2015).

Sleep Treatments

Pharmaceutical and non-pharmaceutical regimens may be used to initiate or maintain sleep quality and duration (Chong, Fryar, & Gu, 2013; Edinger, Wohlgemuth, Radtke, Marsh, & Quillian, 2001). The Center for Disease Control and Prevention estimates that 4% of the population is using a type of sleeping pharmaceutical (Chong, Fryer, & Gu, 2013). However, a study suggested similar medications might increase risk for mortality, with increased ingestion being related to increased mortality risk (Kripke, Langer, Kline, 2017). Non-pharmaceutical interventions may include a number of regimens, including, cognitive-behavioral therapy, hygiene education, herbal extracts, physical activity, and mindfulness techniques (Knowlden, et al. 2016). Furthermore, nutrition interventions may improve sleep, as another form of complementary treatment (St-Onge, Mikic, & Pietrolungo, 2016; Peuhkuri, Sihvola, & Korpela, 2012).

Dietary Nutrients & Sleep

Diet's effect on sleep has just started receiving attention, and a few reviews have attempted to elucidate the diet and sleep relationship (Frank, Gonzalez, Lee-Ang, Young, Tamez, & Mattei, 2017; Peunhkuri, Sihvola, & Korpela, 2012; St-Onge, Mikic, & Pietrolungo, 2016). However, how diet affects sleep is only partially clear, but may affect sleep through nutrients that alter health status and neurological pathways, and sleep may affect dietary intake through behavioral modification, and hormonal influences (Frank, et al., 2017). Thus, a dynamic diet-sleep relationship is proposed to be bidirectional (Frank, et al., 2017).

Calories

Calories are sometimes referred to as the energy currency of the cell. Calories are sourced from three essential nutrients and one nonessential, in humans. Collectively they are protein, fat, carbohydrates, and non-essential alcohol (Nelms, & Sucher, 2015). The amount of calories individuals consume increases over the years, where, in the 70s men consumed around 2450 calories a day, and in the 21st century around 2600 calories a day (Centers for Disease Control and Prevention, 2004). This pattern is similar in women, who consumed around 1500 calories in the 70s, and 1800 calories in the 21st century (Centers for Disease Control and Prevention, 2004). Total calories in association with sleep has shown a general pattern across studies. It appears that, higher intake of calories are generally associated with shorter duration, and lower intakes with longer duration of sleep (Leenaars, Klinkenberg, Aussems, Borger, Faatz, Hak, & Kalsbeek, 2015;

Grandner, Jackson, Gerstner, & Knutson, 2013; Haghighatdoost, Karimi, Esmaillzadeh, & Azadbakht, 2012).

This is similar for college student populations, who consume around 1800-2100 calories a day, and Leenaars et al. examined calories and sleep, finding that there was an association between less calories throughout the day and longer sleep duration (Leenaars, et al., 2015; Ha, & Caine-Bish, 2011). Furthermore, higher calorie intake at night may increase sleep latency, and decrease sleep efficiency (Crispim, Zimberg, Reis, Diniz, Tufik, & Mello, 2011). In contrast to the usual findings, that less calories leads to longer sleep, Grandner et al. found fewer calories has a polar opposite association, with both long sleep duration, and short sleep duration (2013).

Overall, calorie amount seems to have a negative association with sleep duration, and quality measures, where more calories are associated with shorter sleep duration, and less calories are associated with longer duration (Leenaars, et al., 2015; Haghighatdoost, et al., 2012). This may be due to longer sleep duration reducing wake time, and therefore the amount of time available for eating, compared to short sleepers (Baron, Reid, Kern, & Zee, 2011).

Macronutrients

The sources of macronutrients are: carbohydrates, fats, and proteins. Each macronutrient encompasses large pools of nutrients that have similar attributes. For instance, fats may be categorized as saturated, unsaturated and trans fatty acids. Carbohydrates may range from simple sugars, to more complex sugar structures, and proteins are comprised of 20 amino acids; forming different structures. There have been a number of studies examining how macronutrients associate with sleep, but results are conflicting, and the association seems to be dynamic (Cao, Wittert, Taylor, Adams, & Shi, 2016; Frank, et al., 2017).

Carbohydrates. A number of studies have found an association between carbohydrates and sleep parameters. Philips et al. found significantly less slow wave sleep when a high-carbohydrate/low-fat diet was eaten after a normal balanced diet or a low-carb/high fat diet (1975). Whereas both a diet high in carbohydrates and lower in fat, and a low in carbohydrate and high in fat diet were associated with more REM sleep, but this may have been attributed to adaptation effects in the laboratory (Philips, et al., 1975). Similarly, Yajima et al., found in an experimental study, that 80% carbohydrate dinners were associated with less slow wave sleep in the first cycle, using polysomnography (2014). A reduction in slow wave sleep during the first sleep cycle may be due to higher rates of oxidative metabolism, which has been found to be higher after carbohydrate rich meals (Yajima, Seya, Iwayama, Hibi, Hari, Nakashima, & Tokuyama, 2014). Additionally, another study found that high carbohydrate snacks 45 minutes before bed were associated with more REM and specifically Stage 3 sleep, and less overall NREM sleep (1981). High carbohydrate foods before bedtime may also reduce sleep latency time compared to lower carbohydrate foods, in experimental studies (Afaghi, O'Connor, & Chow, 2008; Lindseth, & Murray, 2016). Other studies report that a higher percentage of carbohydrates and higher intake of simple sugars are associated with short sleep duration, and more arousals throughout the night (Al-Disi, Al-Daghri, Khanam, Al-Othman, Al-Saif, Sabico, & Chrousos, 2010; St-Onge, Mikic, &

Pietrolungo, 2016). This could have to do with the quick absorption of simple sugars, as higher serum glucose levels may be related to worse sleep efficiency (Lindseth, et al., 2013).

Low carbohydrates may also pose effects on sleep. In female youth low carbohydrates diets have been associated with a reduction in the total sleep duration (Haghighatdoost, et al., 2012). Very low carbohydrate diets have been shown to increase slow wave sleep, while reducing REM sleep (Afaghi, et al., 2008). Lower carbohydrate diets may also increase the number of arousals each night and has been associated with poor sleep efficiency, which is the ratio of sleep time over the total time in bed (Afaghi, et al., 2008; Kahlhöfer, Karschin, Breusing, & Bosy-Westphal, 2016).

Fiber. Fiber, in humans, is an edible but indigestible substance that is passively excreted - remaining unabsorbed. There are two types of fiber: soluble and insoluble. Soluble fiber is able to adsorb fluids and cholesterol in the form of bile, whereas insoluble fiber is unable. Soluble fiber is important for stool formation, may slow down digestion, and may help treat forms of diarrhea, and prevent cardiovascular disease. On the other hand, insoluble fiber may speed up digestion, and the elimination of stool, and has been shown to play an important role in decreasing risk of gastrointestinal problems (Nelms, & Sucher, 2015). In association with sleep, lower fiber intake is associated with abnormal sleep duration in adults and youth (<6 hr./day & >9 hr./day), and more arousals throughout the night (Grandner, et al., 2013; Haghighatdoost, et al., 2012). On the other hand, higher fiber may predict less Stage 1 sleep, and more slow wave sleep each night (St-Onge, et al., 2016). Fiber also plays a role in slowing down the absorption of carbohydrates, sometimes in the form of simple sugars. Fiber may influence sleep through mediation effects, on slowing down sugar absorption around bed time, but this proposed mechanism is speculative (Lindseth, et al., 2013).

Protein. Proteins are the building blocks of the body, and are important for tissue repair, and the structure, functions and maintenance of cells. Proteins are made up of one or more polypeptides - long chains of amino acids - that come together forming structures. Some amino acids are synthesized in the body, while others are essential and require consumption. Most animal products contain "complete" proteins, meaning they contain a balance of amino acids that are needed for normal bodily function. Conversely, most plant products are high in a limited number of amino acids, and are considered incomplete protein sources. Although there are exceptions to this rule with a few plant based products being considered complete protein sources like: edamame, quinoa, soy, and Ezekiel bread. Incomplete sources of protein may often be combined with complementary sources to yield a complete protein meal or snack. For example, beans and rice are mutually exclusive incomplete, but complete when consumed together.

Total protein intake may differ by age, with young children consuming around 55 grams per day, and adults 91 grams a day (Fulgoni, 2008). In older adults however, intake of protein may decrease, as a nationally representative sample indicates ages 71 and above may consume around 66 grams of protein per day (Fulgoni, 2008). Males tend to consume more grams of protein than women, and most ages consume more protein than the DRI which is 0.8 grams/kg (Fulgoni, 2008). Children, adolescents, adults and the elderly may consume, 300-500%, 187-210%, 162%, and 125%, of the protein recommendation, respectfully (Fulgoni, 2008).

A majority of studies seem to indicate higher protein diets are associated with better overall sleep. Higher protein intakes are associated with decreased sleep disruption throughout the night, and good sleep quality, while lower levels of protein are associated with short sleep duration (<5 hr./day) (Lindseth, et al., 2013; Komada, et al., 2017; Grandner, et al., 2013). Even during weight loss interventions in overweight individuals, a higher protein intake leads to improved sleep compared to controls (Zhou, Kim, Armstrong, Chen, & Campbell, 2016). Although, a large cross-sectional study in contrast with usual findings, found no association between protein intake and sleep duration (Shi, McEvoy, Luu, & Attia, 2008). This could be due in part to ethnicity, since participants were Chinese, and may have metabolic and genetic differences (Shi, et al., 2008). Sources of protein may vary results, as in one study greater intake of plant protein, was significantly associated with longer sleep duration, compared to higher animal protein intake (Kocevska, Voortman, Dashti, Hooven, Ghassabian, Rijlaarsdam, Schneider, Feskens, Jaddoe, Tiemeier, & Franco, 2016). Another study found beans - a high protein legume - to be reported low in females reporting less sleep (Haghighatdoost, et al., 2012). However, in three-year olds, plant vs. animal sources of protein are non-significantly associated with different sleep outcomes (Kocevska, Voortman, Dashti, Hooven, Ghassabian, Rijlaarsdam, Schneider, Feskens, Jaddoe, Tiemeier, & Franco, 2016).

Interestingly, an amino acid called theanine found in tea may also have association with sleep. Theanine is found in green tea, and low-caffeine green tea may allow for more bioavailability of theanine (Unno, Noda, Kawasaki, Yamada, Morita, Iguchi, & Nakamura, 2017). In an experimental study, individuals who consumed theanine in low-caffeine green tea, were found to have lowering markers of stress compared to controls, and good sleep quality, measured using electroencephalogram. Caffeine reduction was suggested to be the main reason for decreased stress and increased sleep quality, as this allowed the bioavailability of theanine to increase (Unno, et al., 2017).

Tryptophan. There are slight deviations regarding the result protein has on sleep, however, a majority of studies seem to suggest, higher protein intake leads to less sleep disruptions, and better sleep quality/duration. A largely proposed mechanism for this association is a component of protein, an amino acid called tryptophan. Tryptophan is a precursor to two neurological hormones, serotonin and melatonin, which may improve mood and sleep, respectfully (Murray, 2009). After absorption into the body as an amino acid, tryptophan is transported to the liver, where it undergoes hydroxylation and decarboxylation into 5-hydroxytryptophan and then 5-hydroxytryptamine, otherwise called serotonin (the happy, mood-altering hormone) (Murray, 2009). Serotonin can then be metabolized into melatonin; a hormone associated with sleep and feeling calm (Murray, 2009). More serotonin metabolites during states of improved sleep may indicated turnover of serotonin into melatonin (Aparicio, et al., 2007). Tryptophan is a large neutral amino acid that can travel across the blood-brain barrier but competes with other neutral amino acids in the process (Lieberman, Agarwal, & Fulgoni III, 2016). Another key feature of tryptophan is the conversion to niacin, which plays a role in a number of metabolic reactions throughout the body in the form of NAD and NADH.

The average US citizen has a high intake of tryptophan. In the National Health and Nutrition Examination Survey (NHANES), 2001-2012, the average US adult consumed, 826 mg/day or 295% of the daily tryptophan recommendation, while men consuming 43.8% more than women (men intake: 977 mg/day; recommendation: 280 mg/day for 70 kg person) (Lieberman, et al., 2016). Even the 10th percentile consumed 79% more than the recommendation, while the 99th percentile far exceeded it, consuming 500% the recommendation (1410 mg/day). Age was found with decreased intake, with 51-70 and 71+ year olds reporting, respectfully, 9% and 22% lower intakes compared to younger adults (Lieberman, et al., 2016). This is of further concern, since hormonal levels of serotonin and melatonin may also decrease with age, and sleep duration also decreases (Altevogt, & Colten, 2006). Serotonin and melatonin's effect on sleep therefore may attenuate with age.

Bravo et al. sought to test tryptophan enriched cereal, eaten for breakfast and dinner, in an experimental design of the elderly (2013). The cereal groups had better sleep efficiency, an increase in sleep duration, more immobility time, and decrease in nocturnal activity and sleep latency time, compared to controls (Bravo, Matito, Cubero, Paredes, Franco, Rivero, & Barriga, 2013). In another experimental study 3g/day of tryptophan for seven days, was associated with better sleep quality, in 5-HTTLPR genotypes, compared to controls (Van Dalfsen, & Markus, 2015). Tryptophan may also be an appropriate nutrient used for chrononutrition - a nutrition method that seeks to understand the relationship between diet, sleep, and eating timing (Bravo, et al., 2013). In an infant population, Aparicio et al., looked at how tryptophan in baby formula may affect sleep (2007). Using a double-blind experimental design, infants that received higher tryptophan formula slept more during the night, had better sleep efficiency, less night movements and waking episodes (Aparicio, Garau, Esteban, Nicolau, Rivero, & Rial, 2007). Urinary metabolites of serotonin increased in the tryptophan groups suggesting that the improvement in sleep parameters may be associated to tryptophan acting as a precursor to melatonin (Aparicio, et al., 2007).

Fernstrom & Wurtman, examined the possible mechanism between tryptophan and serotonin in a review article (Fernstrom, & Wurtman, 1972). Tryptophan in and of itself does not appear to have a direct effect on serotonin, but rather a larger tryptophan to amino acids ratio (TRP:ELNAA) (Fernstrom, & Wurtman, 1972). This mechanism is arguably due to tryptophan competing with other neutral amino acids in crossing the blood-brain barrier (Fernstrom, & Wurtman, 1972). However, a more recent investigation suggests that the ratio alone may not reflect the actual amount of tryptophan that is available for uptake to the brain (Van Donkelaar, Blokland, Ferrington, Kelly, Steinbusch, & Prickaerts, 2011). Tryptophan is largely attached to albumin or free-floating in the plasma, and the combination of these two are used to calculate the tryptophan to neutral amino acid ratio (Van Donkelaar, et al., 2011). But tryptophan may dissociate faster near the blood-brain barrier, therefore allowing for more uptake, and effects of other hormones, exercise, stimulants, and stressors may further alter dissociation from albumin (Van Donkelaar, et al., 2011).

Fat. Most studies suggest a higher fat intake leads to abnormal sleep duration, less restorative sleep, and abnormal effects on other sleep parameters (Khan, Faught, Chu, Ekwaru, Storey, & Veugelers, 2017; Grandner, et al., 2013; Kahlhöfer, et al., 2016; Crispim, Zimberg, Reis, Diniz, Tufik, & Mello, 2011). Timing of fat intake, and the types of fat consumed may also alter sleep (Crispim, et al., 2011; Grandner, Jackson, Gerstner, & Knutson, 2014). Higher saturated fat intakes, for example, may be associated with poor sleep outcomes, compared to unsaturated fat intakes (Kocevska, Voortman, Dashti, Hooven, Ghassabian, Rijlaarsdam, Schneider, Feskens, Jaddoe, Tiemeier, & Franco, 2016).

In Chinese participants, higher total fat intake is associated with less than seven hours of sleep (Shi, et al., 2008). This association was similarly found in a large cross-sectional study of Americans, where short sleep duration was associated with a higher fat intake (Grandner, et al., 2013). On the other hand, less fat intake has also been associated with short sleep duration (Al-Disi, et al., 2010). Furthermore, Kahlhöfer et al. found men who had a higher intake of fat self-reported poor sleep efficiency, but this study also found no association with objective sleep measures (Kahlhöfer, et al., 2016).

Fat intake at night may also affect sleep. Crispim, et al., noticed higher fat intake at night in men was positively associated with longer sleep latency, decreased efficiency, and shorter REM sleep using polysomnography and 24-hour records (Crispim, Zimberg, Reis, Diniz, Tufik, & Mello, 2011). Although, in women, a high fat diet leads to a significant decrease in Stage 2 sleep, sleep efficiency, REM sleep, REM latency, and greater total waking time after sleep onset (Crispim, et al., 2011). In a study by Cao et al., found the highest quartile of fat intake had an increase in the prevalence of daytime sleepiness by 78%, and individuals were 198% more at risk for developing sleep apnea, using polysomnography (Cao, Wittert, Taylor, Adams, & Shi, 2016). Additionally, in the highest and lowest quartiles of fat intake there was a high prevalence of sleepiness (Cao, et al., 2016).

Types of fat may also alter a number of sleep symptoms. A large cross-sectional study found lower intake of dodecanoic acid was associated with 9% less likelihood of having difficulty falling asleep, and more hexadecanoic acid was associated with 10% more likelihood of difficulty falling asleep (Grandner, Jackson, Gerstner, & Knutson, 2014). This association is interesting since dodecanoic acid is a plant-based fat (monounsaturated) and hexadecanoic acid is largely animal-based, and is found in butter, cheese, milk and meat (Grandner, et al., 2014). Additionally, difficulty maintaining sleep was 19% more likely with decreased butanoic acid intake, and 25% more likely with increased amounts of hexanoic acid (Grandner, et al., 2014). Non-restorative sleep was 9% and 10% more likely for butanoic acid and cholesterol intake, respectfully (Grandner, et al., 2014). Another study found that greater amounts of energy from saturated fat was associated with less slow wave sleep (St-Onge, et al., 2016). In a similar study, lower cholesterol intake was associated with very short sleepers (< 5 hours/day), and long sleepers (>9 hours/day) (Grandner, et al., 2013). However, higher serum cholesterol levels have been correlated with decreased sleep efficiency (Lindseth, et al., 2013).

In neonates consuming formulas with medium-chain fatty acids compared to long-chain fatty acids have longer sleep durations (Telliez, Bach, Leke, Chardon, & Libert, 2002). The medium-chain triacylglycerols group reported on average 52 minutes more of sleep each day compared to the long-chain triacylglycerol group (Telliez, et al., 2002). Another study looked at how polyunsaturated fatty acid levels during pregnancy may affect sleep quality (Christian, Blair, Porter, Lower, Cole, & Belury, 2016). Omega-3 (DHA; anti-inflammatory) and omega-6 (AA; proinflammatory) ratios were observed in 135 women, 20-27 weeks gestation. Poor sleep was associated with a lower DHA:AA ratio. A mediation model was also proposed and found significant, with DHA:AA mediating sleep (DHA:AA ratio -> sleep -> IL-8 -> length of gestation) (Christian, et al., 2016). Higher DHA levels and DHA:AA ratio were associated with better overall sleep quality, longer sleep duration, decreased latency, and better sleep efficiency (Christian, et al., 2016).

In a study in the Netherlands, Kocevska et al., looked at the macronutrients in infancy and early childhood, and how they may affect sleep (Kocevska, et al., 2016). When fat was substituted with 5% more carbohydrates or protein sleep was respectfully 4-6 minutes longer, for 2-year olds. But at three years of age associations were non-significant. In 3-year olds, more energy from saturated fat was associated with seven minutes less of sleep, but more unsaturated fat with five minutes more (Kocevska, et al., 2016). Similarly, Khan et al., looked at children, finding higher fat intake were associated with poorer sleep quality (2017). After adjustment, results were non-significance (Khan, Faught, Chu, Ekwaru, Storey, & Veugelers, 2017).

Micronutrients

Micronutrients may also foster effects on sleep, whether through biological benefits, or through altering the deleterious effects of deficiencies. Nationally representative samples revealed a number of micronutrients are associated with sleep (Grandner, et al., 2013). In short sleepers, very short sleepers have significantly less intake of: lycopene, thiamin, and folate DFE, (Grandner, et al., 2013). Furthermore, every mineral of lower intake may be associated with either long or very short sleep duration, with the exception of copper (Grandner, et al., 2013). This may change though, since after adjusting for diet, phosphorus, magnesium, iron, zinc, and selenium were associated with very short sleep, while phosphorus was still associated with long sleep (Grandner, et al., 2013).

Using a similar study design, Grandner et al. examined how nutrients may affect sleep disorder symptoms (Grandner, Jackson, Gerstner, & Knutson, 2014). Individuals with low nutrient levels had difficulty falling asleep as follows: selenium (20% increased odds), alpha-carotene (4% increased odds), and calcium (17% increased odds). Sleep maintenance problems were associated with increased salt (19% increased odds) (Grandner, et al., 2014). Vitamin C, and calcium were associated with 19% and 8% increased odds of non-restorative sleep (Grandner, et al., 2014). Low potassium was associated with 30% increased odds of sleepiness (Grandner, et al., 2014). In another study, Komada et al. investigated nutrients and sleep in Japanese adults finding low levels of vitamin B12, and sodium intake were found to significantly alter sleep duration in men, before and after adjustment (Komada, et al., 2017). In a cross-sectional analysis of adolescents, sufficient zinc concentration was associated with individuals who were 57% less likely to have insufficient sleep, 55% less likely to have sleep disturbances, and 44% less likely to have poor sleep quality (Ji, & Liu, 2015). On the other hand, low zinc concentration predicted poor sleep efficiency (Ji, & Liu, 2015).

How micronutrients are related to sleep is still being investigated. Generally, B vitamins effects are based on their influence on melatonin secretions (Peuhkuri, et al., 2012). Specifically, for B vitamin, niacin, higher intakes may reduce the amount of tryptophan needed to convert to niacin, thus allowing more tryptophan to form serotonin and melatonin. Additionally, pyridoxine, vitamin B6, may also mitigate a role with tryptophan by converting it to 5-Hydroxytryptophan which is an intermediate of serotonin (Peuhkuri, et al., 2012). One review article suggests that there may also be disease-nutrient interactions that are the main factor(s) for sleep deprivations. Suggesting that vitamin C, vitamin D, and sodium, may affect blood pressure, which then may affect sleep (Frank, et al., 2017).

Vitamin D Deficiency. Low vitamin D levels, have commonly been associated with worse sleep. Serum vitamin D deficiency may be associated with obstructive sleep apnea, and abnormal sleep duration (Piovezan, Hirotsu, Feres, Cintra, Andersen, Tufik, & Poyares, 2017). In pregnant women, low serum vitamin D may also be associated with less sleep per night, and is associated with abnormal eating, later bedtimes, longer sleep latency, more disturbances during sleep, and daytime dysfunction (Cheng, Loy, Cheung, Cai, Colega, Godfrey, Chong, Tan, Shek, Lee, Lek, Chan, Chong, & Yap, 2017). Furthermore, in male hemodialysis patients - who are typically older - have poor sleep when vitamin D levels are low (Han, Zhu, Shi, Wu, & Gu, 2017). Komada et al., found vitamin D was significantly correlated with sleep duration in men (2017). In consideration of the aforementioned studies, lower vitamin D levels seem to be associated with negative sleep outcomes (Han, & Gu, 2017; Cheng, & Yap, 2017; Piovezan, & Poyares, 2017). Although vitamin deficiency seems to have a negative effect on sleep parameters in individuals, it is hard to discern if deficiency is due to dietary, lifestyle or other factors.

Supplements

Little research has focused on diet and sleep, and even less has examined supplements and sleep. Kunces et al. compared multivitamins with Relora to multivitamins or a placebo in cyclists the night before an event (Kunces, Keenan, Munoz, Luk, Vingren, & Carlson-Phillips, 2016). Relora is blend of Magnolia officinalis and Phellodendron amurense - both bark extracts that have anti-anxiety effects (Kunces, 2016). Before a cycling event, athletes reported their habitual and previous night's bedtime, latency and sleep quality. Participants were then randomly assigned into a supplement group. One serving of the supplement was consumed the night before the event. The multivitamin with Relora group fell asleep 28 minutes faster than the placebo group. The multivitamin and the placebo group reported sleep quality worse the night before the event, while the multivitamin with Relora group reported sleep quality similar to habitual sleep. These findings may suggest multivitamins with Relora, improve sleep before athletic events (Kunces, 2016). Another study looked at supplement vs. non-supplement users of multivitamins, finding non-users to have poorer sleep outcomes compared to users, reporting more waking episodes, and longer sleep latency (Lichstein, Payne, Soeffing, Durrence, Taylor, Riedel, & Bush, 2007). In vitamin D deficient males, vitamin D supplementation has been shown to improve sleep quality and duration (Huang, Shah, Long, Crankshaw, & Tangpricha, 2013). Sleep duration increased by 45 minutes, and vitamin D users fell asleep around 8 minutes faster (Huang, et al., 2013).

Whole Foods

There have been a number of studies that have examined how foods may affect sleep. Although mechanisms are poorly understood and examined, some suggested that specific nutrients, such as, zinc, calcium, protein, tryptophan, etc., may be the primary factors influencing sleep. One of these foods is milk, which is high in melatonin, and typically has beneficial effects with sleep (Komada, et al., 2017). In addition, cow's milk has even higher levels of melatonin when collected at night and drinking this milk may have stronger effects on improving sleep (Valtonen, Niskanen, Kangas, & Koskinen, 2005). Similarly, drinking Horlicks - a malted milk beverage - may reduce sleep disturbances and improve sleep duration (Southwell, Evans, & Hunt, 1972; Březinová, & Oswald,1972; Adam, 1980). In the elderly, 100g of fermented milk may also lead to better sleep efficiency (Yamamura, Morishima, Kumano-Go, Suganuma, Matsumoto, Adachi, & Takano, 2009). Cherries and cherry juice intake can also improve sleep, with consumers reporting longer sleep durations and greater sleep efficiency (Garrido, Paredes, Cubero, Lozano, Toribio-Delgado, Muñoz, & Rodríguez, 2010; Howatson, Bell, Tallent, Middleton, McHugh, & Ellis, 2012). The relationship is hypothesized to be associated with the high concentration of tryptophan, and antioxidant benefits of cherries

(Garrido, et al., 2010; Howatson, et al., 2012). Consumers of cherry products, may have higher serum melatonin levels, and total antioxidant capacity, which may be the primary mechanisms for improving sleep (Garrido, et al., 2010; Howatson, et al., 2012).

Another food that may influence sleep are oysters, which have a high zinc content. An experimental study found that participants who consumed oysters had decreased sleep latency and improved sleep quality compared to placebo (Saito, Cherasse, Suzuki, Mitarai, Ueda, & Urade, 2017). Other high zinc containing foods like, zinc-enriched yeast and astaxanthin oil may also improve sleep latency and quality (Saito, et al., 2017). These findings seem to suggest zinc to be the primary influence on sleep outcomes. Longer sleep duration has also been positively associated with greater consumption of bread, pulses, fish, and shellfish (Komada, et al., 2017). Possibly suggesting that higher protein, unsaturated fats, and grain products may have positive effects on sleep. Children have better sleep when reporting more “healthy,” nutrient-dense foods (Pérez-Farinós, Villar-Villalba, Sobaler, Saavedra, Aparicio, Sanz, & Anta, 2017). Children who report more fresh fruits, vegetables, whole-fat milk, yoghurt, whole-grain bread, meat, and fish have longer sleep duration/day (Pérez-Farinós, et al., 2017). Conversely, lower whole-grain intake may be associated with less sleep/day (Haghighatdoost, et al., 2012). Unlike Perez-Farinos et al., Khan et al., found meat to be negatively associated with sleep in children (2017). Fruit and vegetable intake may also be associated with better sleep quality, and low levels are associated with short sleep duration (Khan, et al., 2017; Haghighatdoost, Karimi, Esmaillzadeh, & Azadbakht, 2012). Generally, children who sleep less, report more "unhealthy" foods, like: potato chips, chocolates, biscuits, milkshakes, and soft drinks (Pérez-Farinós, et al., 2017).

A higher intake of fruits, vegetables, milk, milk products, seafoods, whole-grains, meat products, may lead to better sleep quality and/or duration (Komada, et al., 2017; Khan, et al., 2017; Haghighatdoost, et al., 2012; Pérez-Farinós, et al., 2017). Low intake of these foods may lead to sleep problems, and high intake of unhealthy foods such as, chips, candies, and soft drinks may have negative effects on sleep. Whole foods that are nutrient dense, and contain certain nutrients, that may positively influence sleep, may lead to better sleep quality and duration. Many of these foods are also recommended as a preventative measure to decrease future health problems, and used in medical nutrition therapy (Nelms, & Sucher, 2015).

Water

Water amount and sources are association with sleep. Moisture and plain water is reported highest in very short sleepers (<5 hr./day), followed by normal (7-8 hr./day), and then long sleepers (>9 hr./day), but lowest in short sleepers (<7 hr./day) (Grandner, et al., 2013). Normal sleepers report the highest consumption of tap water have normal sleep (7-8 hr./day). Tap water was lowest in very short sleepers and short sleepers (Grandner et al., 2013). Long sleeping was associated with decreased overall moisture (Grandner et al., 2013).

Caffeine & Theobromine

Caffeine is the most commonly consumed psychoactive substance in the world, with approximately 80% of individuals ingesting it daily (Chambers, 2009). Most common sources include beverages such as coffee, tea and soda. A typical 8-fluid ounce cup of coffee contains approximately 100mg of caffeine - twice the amount of a cup of tea or a 12-fluid ounce soda (Chambers, 2009). Chocolate is amongst the highest caffeine containing whole foods, with a 30-gram chocolate bar being equivalent to half a cup of tea (Chambers, 2009). Around 99% of orally ingested caffeine is absorbed, with a peak plasma level reached between 15-45 minutes (Chambers, 2009).

Caffeine has been heavily researched metabolically when it comes to sleep deprivation. The common mechanism caffeine facilitates is its ability to cross the blood-brain barrier and bind with A1 and A2A adenosine receptors (Chambers, 2009). These receptors are associated with the regulation of sleep, arousal and cognition (Chambers, 2009). Therefore, caffeine's ability to bind these receptors may alter and modulated physiological and mental states. In a study where participants were required to stay awake for 77 hours, caffeine was able to inhibit the effects of fatigue (Snel, & Lorist, 2011). Fatigue, daytime dysfunction, wakefulness, and deteriorations in task performance all have a negative correlation with increased caffeine consumption. However, sleep's temporary effects on decreasing "tiredness" characteristics, may also lead to subsequent sleep detriment, in which sleep is decreased due to the antagonistic effects of caffeine. This in turn, may lead to "tiredness" characteristics, which are associated with decreased quality of sleep. So, caffeine may decrease tiredness characteristics when ingested, but this may decrease the quality of sleep, ultimately leading to future tiredness during the day. Caffeine's effect is dependent on an individual's unique sensitivity to the substance and may increase a person's heart and respiratory rate. Overall, caffeine is a unique substance, considering its psychoactive properties, while also being legal and even available for consumption to young children, sometimes in questionable amounts (e.g. energy drinks). This additionally, has brought way to controversial views regarding caffeine, especially considering the substance is under little to no regulation, and toxicity levels are currently unestablished (Chambers, 2009).

Through stepwise analysis, theobromine was found to have the largest effect on the variance of sleep (Grandner, et al., 2013). Watson et al., in a cross-sectional study of 80 adults, found that an increased intake of caffeine was associated with a decrease in sleep duration (2016). Additionally, poor sleep has been reported with an intake of ~192.1 mg of caffeine, whereas, good sleepers reported less (125.2 mg) (Watson, et al., 2016). In an experimental study, using a fixed dose pill of 400 mg of caffeine, administered 0, 3, and 6 hours before usually bedtime, caffeine given at bedtime, and 3 hours before bedtime reduced total sleep by ~41 minutes (Drake, Roehrs, Shambroom, & Roth, 2013). Latency was enlarged the greatest 3 hours before bedtime, and caffeine administered 6 hours before bedtime had two times the usual latency period (Drake, et al., 2013). Additionally, an experimental study found high levels of caffeine reduces sleepiness in Navy SEALS during a period of intense sleep deprivation, but lower amounts of caffeine users reported tiredness (Liberman, Tharion, Shukitt-Hale, Speckman, & Tulley, 2002). In another study, through diary record, it was recorded that participants who consumed caffeine went to bed 57 minutes later on average (Aepli, et al., 2015). Also, caffeine-consuming subjects had reduced slow wave and alpha activity in the prefrontal, central and occipital regions (Aepli, et al., 2015). Cole examined 25,200 first year students and found students who woke up earlier (morning types) were more likely to consume no caffeine (2015). Whereas, evening type students were 250% more likely to consume greater than or equal to 3 servings of caffeine per day (Cole, 2015). Furthermore, morning types, without caffeine report the highest grades with nearly 64% reporting A grades (Cole, 2015). In a study of college medical students at a university in Pakistan, the frequency of energy drinks and an evaluation of knowledge of perception of drink ingredients was examined. The study found that 51.9% consumed energy drinks (Usman, Bhombal, Jawaid, & Zaki, 2015). Amongst the products consumed, Red Bull is the most popular source, representing approximately 43% of energy drinks consumed (Usman et al., 2015). This population of medical students claimed to ingest the energy drinks to increase energy and for exam preparation. Both television and friends were reported to be the major sources of energy drink information, 153 (66%) and 113(48%), respectfully.

Caffeine Epidemiology. Caffeine and beverage trends are a constantly changing phenomenon. Caffeine focused studies have examined sugar-sweetened beverages, since beverages such as sodas, energy drinks, flavored coffees and others, seem to be high in caffeine content (Drewnowski, & Rehm, 2016). Drewnowski & Rehm, looked at 2011-2012 National Health and Nutrition Examination Survey (NHANES) data, to examine the most recent caffeine sources and also to examine the changing trends of caffeine sources from 2003-2012 (2016). Overall, children and adolescents consume roughly 35 mg of caffeine per day, and adults consumed on average around 173 mg/day, with men consuming around 196 mg, and females 151 mg (Drewnowski, & Rehm, 2016). For children the main sources of caffeine were tea, soda, foods and flavored milks, and for adults coffee and tea were the main sources (Drewnowski, & Rehm, 2016). Caucasians were found to have the highest consumption rate with African Americans consuming the least amounts (Drewnowski, & Rehm, 2016). Those who were employed consumed significantly more than the unemployed (Drewnowski, & Rehm, 2016). Caffeine consumption for children and adults from 1999 to 2012 dropped by 33 mg/day (Drewnowski, & Rehm, 2016).

Caffeine Medication. Although, the prevalence of caffeinated medication in an elderly population is around 5.4%, there may be 79% increased risk in trouble falling asleep for users (Drake, et al., 2013). However, caffeinated medication were unassociated with other nighttime or daytime sleep problems (Drake, et al., 2013). The caffeine effects of these medications is further confirmed, since analogue medications without caffeine have non-significant association with trouble falling asleep (Drake, et al., 2013). Although many studies show deleterious effects of caffeine on sleep, in athletes, effects may differ. In a double blind, placebo-controlled, crossover study, caffeine capsules were given 60 minutes before afternoon training (Gardiner, Toohey, Duncan, Dascombe, 2016). Caffeine supplementation at low dosage (3 mg per kg) did not affect sleep quality, however, moderate doses had effect (6 mg per kg) (Gardiner et al, 2016). Low caffeine supplementation, is proposed to have quicker metabolism in athletes post workout, which may explain the phenomenon (Gardiner, et al., 2016).

Eating Patterns & Behavior

‘Unhealthy eating habits and environments’ encompasses a variety of settings including: eating outside of the home, eating dinner alone, eating in front of the television, and eating fast food. A study of children found ‘unhealthy eating habits and environments’ and ‘snacking between meals’ associated with poor sleep quality (Khan, et al., 2017). As ‘unhealthy eating habits and environments’ increases (1 SD) children may be 12% less likely to report good quality of sleep (Khan, et al., 2017). Similarly, as ‘snacking between meals’ increases (1 SD) there may be a 7% decrease in the likelihood of good quality sleep (Khan, et al., 2017). Choices children have or make, may due in part to parental relationships. Children's diets may be affected by their parent’s socioeconomic status, which may be accompanied with food insecurities (Pérez-Farinós, et al., 2017). Additionally, children with parents without formal education generally, eat more “unhealthfully.” For example, they report eating more soft drinks, milkshakes, salty snacks, and less of fruits, vegetables, and cheeses (Pérez-Farinós, et al., 2017).

Kant & Graubard examined eating behaviors association with sleep duration using a large nationally represented cross-sectional study in a US population (2014). Short-duration sleepers report less breakfast, lunch, and dinner (Kant, & Graubard, 2014). Short-duration sleepers also had higher reported calories from snacks and less calories from main meals (Kant, & Graubard, 2014). In addition, short sleep duration was associated with a larger eating period throughout the day, with eating episodes after waking beginning earlier along with the last eating episode before bed, ending later (Kant, & Graubard, 2014). In women, shorter sleep duration was also associated with absolute sugar, caffeine, and beverage energy percentage (Kant, & Graubard, 2014). Normal sleepers report eating the greatest food variety, whereas very short and long sleepers report the least variety (Grandner, et al., 2013). Very short sleepers have greater deviation regarding variety of food items, and more likely to be on a special diet (Grandner, et al., 2013). This association may be due in part to the fact that special dieters are more likely to be on a low sodium diet (Grandner, et al., 2013). Dieting has also been association with shorter sleep latency, longer sleep duration, improved sleep efficiency, and lower nocturnal awakenings in overweight individuals consuming 300-500 less kcal/day and losing 3kg (Tan, Alén, Wang, Tenhunen, Wiklund, Partinen, & Cheng, 2016).

Mediterranean Diet. The Mediterranean diet has received attention in recent years for having some of the lowest rates of comorbidities, including coronary heart disease, stroke and diabetes. Mediterranean diets have been associated with increased health factors, including, eating more home cooked meals, normal BMIs, higher fruit and vegetable consumption, and higher serum vitamin C levels (Mills, Brown, Wrieden, White, & Adams, 2017). The Mediterranean diet may also be an effective way to improve sleep parameters, including, sleep quality and decrease the risk of abnormal sleep duration (Campanini, Guallar-Castillón, Rodríguez-Artalejo, & Lopez-Garcia, 2017). Cohort, cross-sectional, and experimental studies suggest positive effects of the Mediterranean diet on sleep parameters.

In a cohort study of adults, the Mediterranean diet effectively improved sleep (Campanini, et al., 2017). Over time individuals in the highest tertile of Mediterranean diet compliance were less likely to have a reduction in total sleep per day and more likely to have more sleep each day (Campanini, et al., 2017). Similarly, individuals in the highest tertile of the mediterranean compliance were more likely to have good sleep quality. In another study of children, Rosi et al, found lower mediterranean compliance was associated with shorter sleep duration. Sleep benefits have also been found in children populations (2017). Compliance to the Mediterranean diet, therefore, may affect dietary intervention to improve sleep patterns. With studies showing, improved sleep duration and quality with better compliance.

Sleep During College

In academia, the central goal is to increase one's knowledge and skills (Champlin, Pasch, & Perry, 2017), and a specific university states that this will help students "transform lives and communities" (Kent State University, 2017). It is therefore important for students to have the mental functioning necessary to develop their knowledge and skills in an academic setting, so they may display competencies in their future. Sleep is an important factor that can either encourage or discourage these goals. Sleep plays a key role in academic performance, reestablishing alertness, stress management, learning, and the consolidation of memories (Killgore, 2010). However, adequate sleep may be compromised through students' lifestyle, environmental, and dietary factors, which could compromise the central goal of academia (Champlin, et al., 2016).

Although the national recommendation of sleep duration for adults is 7-9 hours of sleep per day, and epidemiological studies report similar recommendations, many college students report less than ideal amounts of sleep (National Sleep Foundation, 2015; Knowlden, et al., 2016; Bixler, 2009; Champlin, 2016). Sixty percent of college students report poor sleep quality, and 28% report sleep duration outside of the recommended range (Lund, Reider, Whiting, & Prichard, 2010; Kelly, Kelly, & Clanton, 2001; Sivertsen, Glozier, Harvey, & Hysing, 2015; Hysing, Harvey, Linton, Askland, & Sivertsen, 2016). This is concerning as inadequate sleep has been associated with lower GPA (Sivertsen, Glozier, Harvey, & Hysing, 2015). Furthermore, inadequate sleep is associated with decreased work function, less academic achievement, and fatigue - which may negatively impact a student's learning and overall health (Lohsoonthorn, Khidir, Casillas, Lertmaharit, Tadesse, Pensuksan, Rattananupong, Gelaye, & Williams, 2013); Cappuccio, Taggart, Kandala, Currie, Peile, Stranges, & Miller, 2008). These outcomes could potentially dampen a student's future potential to 'transforming lives and communities" and finding a better or more fitting career (Kent State University, 2017).

Students may also begin using a number of substances that affect sleep, including, alcohol, nicotine, medications, illicit drugs, and have higher intake of caffeine (Wetter, Kenford, Welsch, Smith, Fouladi, Fiore, & Baker, 2004; Zunhammer, Eichhammer, & Busch, 2014; Rozenbroek, & Rothstein, 2011). These substances may act as stimulants or sedatives, and modulate abnormal sleep rhythms. Additionally, fluctuating lifestyle patterns in college students, juggling between school, work, sports, and social life, and emotional and academic stressors are more obstacles to adequate sleep (Lund, et al., 2010). Students may also practice abnormal eating patterns, eat at different places, skip meals, and have food insecurity (Hicks, McTighe, & Juarez, 1986). This may lead to poor dietary quality, including, more intake of sugar-sweetened beverages, caffeine, and calorie dense foods, and lower intake of whole grains, milk, and fruits and vegetables (Kenny, & Gortmaker, 2017; Ha, & Caine-Bish, 2009; Ha, & Caine-Bish, 2011). Despite, dietary changes in college students, the comparison of dietary intakes between good and poor sleepers has yet to be examined in samples of college students from the United States.

CHAPTER 3

METHODOLOGY

Background

This study was part of a larger dietary and lifestyle investigation of college students at a Midwestern university. Approximately 1000 students who enrolled in a sophomore level general education course called Science of Human Nutrition completed 4-day dietary records and anthropometric measurements as part of class projects. In addition, students were required to fill out ten different surveys as either homework assignments or class activities. Among those ten questionnaires, this investigation has used demographic and sleep quality survey.

Study Design

This cross-sectional study design used pre-existing data collected between January 2017 and March 2017. Original data were collected as part of class activities and homework assignments and included demographic, 4-day dietary intake, sleep quality, and lifestyle information. Independent and dependent variables for analysis purposes were sleep quality, and calories and macronutrients: carbohydrates, fat, and protein, respectfully. Institutional Review Board approved the use of the collected data for research purposes

Study Sample

Data from 232 students were used for assessing sleep quality and dietary intake from 3 sections of Science of Human Nutrition. Enrolled students were from a variety of majors including: Nutrition, Human Development, Hospitality Management, other, and undeclared.

Dietary Record

Dietary intake data was obtained using a 4-day dietary record, encompassing 24-hour periods. Students were instructed to record the intake from Wednesday to Saturday, while adhering to usual eating patterns. A number of tools were used to aid with accurate recording, including: 1), a presentation and instructions on using a dietary record were given, 2), portion size guides were provided, 3), food labels were collected for foods consumed, 4), students attended a dietary interview to cross-check recorded food items with a trained researcher, and, 5), researchers used cups, utensils and food models to adjust recorded portion sizes during the interview. During the meeting with the researcher, participants were asked in depth about their intake, including, “what did you have to drink... (with this meal)?,” “what type of oil did you use... (with your egg)?,” and, “how much salt did you add?.”

Dietary Analysis

One trained researcher entered dietary records into ESHA Food Processor (version 11.4, 2017), while consulting food labels and a standardized food item list. ESHA Food Processor is a dietary software that accesses the Master Food and Nutrition Database that includes over 72,000 food items, and data from over 1,800 reputable sources. The software's data sources are from USDA Standard Reference Data, manufacturers' data, restaurant data, and data from literature sources, and each food item contains up to 173 individually sourced nutrient components.

The Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI) was used to measure sleep quality in the past 30 days (Buysee, et al., 1989). PSQI is a self-rated questionnaire that measures seven components of sleep including: subjective sleep quality, latency, duration, habitual sleep efficiency, sleep disturbances, medication use, and tiredness during the day (Buysee, et al., 1989). Sleep components are then used to generate a global score of sleep quality, splitting global scores into good (≤5) or poor sleepers (>5) (Buysee, et al., 1989).

Procedure of Original Data Collection

Before original data collection, a research team was formed of select nutrition graduate students one week prior to the start of the semester. Researchers were trained by registered dietitians through lectures, hands-on practice with anthropometric measurements, and simulation rounds. Students enrolled in Science of Human Nutrition completed the demographic and Pittsburgh Sleep Quality Index the first day of class. Students were then instructed how to complete a 4-day dietary record, and provided with food logs to record their intakes, given portion size guides and past examples of completed dietary records. Students then scheduled an appointment with a trained researcher to cross-check the dietary record during a 30-minute interview. After dietary records were turned in and completed, dietary records were entered into ESHA Food Processor (version 11.4, 2017).

Statistical Analysis

Statistical analysis was conducted on a final sample of 230 college students, after exclusion of two participants due to incomplete dietary records. The independent variable for this study was the PSQI. The PSQI global scores were calculated and the sample was split into good (score ≤ 5) and poor (score > 5) sleep quality groups, according to the PSQI instructions (Buysee, et al., 1989). Nutrients under analysis as dependent variables were: calories, carbohydrates, fat and protein. Independent t-tests were used to show the difference between good and poor sleepers for dependent nutrient variables. Bonferroni correction was used to adjust for testing hypothesis 2, that is, that macronutrient variables will be different between sleep quality groups. Homogeneity of variance was tested by Levene's test at an alpha level of <0.05. If variances were significantly different, then the Satterthwaite p-value was used. Descriptive statistics were recorded as means and standard deviations (SD) for calories, carbohydrates, fat, and protein. Descriptive statistics were then presented for the total sample, and for good and poor sleepers. All statistics were calculated using SPSS (version 24) (IBM Corp, 2016), and a p-value of <0.05 was considered significant for hypothesis 1 and a p-value of <0.017 for hypothesis 2 after Bonferroni correction (alpha 0.05/3 t-tests).

CHAPTER 4

JOURNAL ARTICLE

Introduction

Sufficient sleep is important for memory consolidation, bodily repair, hormonal regulation, and learning (Hsu, et al., 2014; Curcio, et al., 2006). Sufficient levels of sleep vary from person to person, with age being a key factor. A typical adult requires 7-9 hours of sleep each day, whereas infants, children, and teens require more (Johnson, et al., 2014). Sleep may also be defined by quality; with less arousals, restfulness, and shorter sleep latency indicating better sleep quality (Buysse, et al., 1989).

Insufficient sleep quality and duration may increase the risk of developing morbidities such as cardiovascular disease, type-2 diabetes, and obesity (Cappuccio, et al., 2010; Cunningham, et al., 2015; Doo, et al., 2016; Al-Disi, et al., 2010). Less restorative sleep has been robustly studied in association with weight gain, with proposed mechanisms looking at sleep's effect on hunger hormones, ghrelin and leptin (Al-Disi, et al., 2010). A number of factors may lead to inadequate sleep, with weight status, smoking, alcohol, caffeine, and physiological problems, all having deleterious effects on sleep (Peters, et al., 2011; Hunsberger, et al., 2015; Rosi, et al., 2017; Vgontzas, et al., 2008). Adequate sleep is positively associated with healthy dietary choices (Peuhkuri, et al., 2012). While, inadequate sleepers tend to consume more calories from fats, refined carbohydrates, consume less fruits, vegetables and milk, report more irregular dietary patterns, and consume more snacks throughout the day (Haghighatdoost, et al., 2012; Kant, et al., 2014; Cao, et al., 2016).

Students undergo many lifestyle changes during college, and research suggests that both diet and sleep habits fluctuate during these years (Butler, et al., 2004; Lund, et al., 2010). The dietary intake of college students are of special concern as students are not meeting dietary recommendations, and diet is associated with sleep (Ha, et al., 2011; Grandner, et al., 2013). However, the association between diet and sleep has yet to be robustly studied, and research examining the comparison of dietary intake between good and poor sleeping US college students are few to non-existent. The purpose of this study is to compare calorie and macronutrient intake in individuals with good and poor sleep quality. It is hypothesized that 1) calorie intake will be different between good and poor sleepers, and 2), good and poor sleepers will have different intakes of carbohydrate, fat and protein.

Methodology

The following method section contains details over the study design, study sample, dietary record, dietary analysis, the Pittsburgh Sleep Quality Index, data procedure, and statistical analysis.

Study Design

This cross-sectional study design used pre-existing data collected between January 2017 and March 2017. Original data were collected as part of class activities and homework assignments and included demographic, 4-day dietary intake, sleep quality, and lifestyle information. Independent and dependent variables for analysis purposes were sleep quality, and calories and macronutrients: carbohydrates, fat, and protein, respectfully. Institutional Review Board approved the use of the collected data for research purposes.

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Statistical Analysis

Statistical analysis was conducted on a final sample of 230 college students, after exclusion of two participants due to incomplete dietary records. The independent variable for this study was the PSQI. The PSQI global scores were calculated and the sample was split into good (score ≤ 5) and poor (score > 5) sleep quality groups, according to the PSQI instructions (Buysee, et al., 1989). Nutrients under analysis as dependent variables were: calories, carbohydrates, fat and protein. Independent t-tests were used to show the difference between good and poor sleepers for dependent nutrient variables. Bonferroni correction was used to adjust for testing hypothesis 2, that is, that macronutrient variables will be different between sleep quality groups. Homogeneity of variance was tested by Levene's test at an alpha level of <0.05. If variances were significantly different, then the Satterthwaite p-value was used. Descriptive statistics were recorded as means and standard deviations (SD) for calories, carbohydrates, fat, and protein. Descriptive statistics were then presented for the total sample, and for good and poor sleepers. All statistics were calculated using SPSS (version 24) (IBM Corp, 2016), and a p-value of <0.05 was considered significant for hypothesis 1 and a p-value of <0.017 for hypothesis 2 after Bonferroni correction (alpha 0.05/3 t-tests).

Results

The following results section shows the calorie and macronutrient distribution for the overall population and between good and poor sleepers.

Descriptive Statistics for Overall Calorie and Macronutrient Intake in Total Sample

Of the 230 college students, approximately 28 percent were males and approximately 72 percent females, and the average age was 19.5 years (SD 1.90). Regarding ethnicity around 77.5% were White non-Hispanic, around 11.5% Black non-Hispanic, 3% Hispanic, 2% Middle Eastern, 2% Asian/Pacific Islander and 4% of another ethnicity. The average consumption of calories for the total sample of college students were 2004.15 calories (SD 686.08). College students also consumed 217.51 grams of carbohydrate (SD 84.75), 86.96 grams of fat (SD 33.89), and 87.93 grams of protein (SD 50.52).

Table 1

The Comparison of Calorie and Macronutrient Intake Between Good and Poor Sleeping College Students Enrolled in Nutrition Science Classes.

	Total Sample		**Good Sleep (n=99)**		**Poor Sleep (n=131)**		
	Mean	SD	Mean	SD	Mean	SD	p-value
Diet							
Calories (kcal)	2004.16	686.08	2122.06	785.44	1914.37	586.94	0.028*
Macronutrients							
Carbohydrates[a] (g)	217.51	84.75	227.41	100.05	209.98	70.42	0.137
Fat[a] (g)	86.96	33.89	92.54	33.89	82.71	33.4	0.03
Protein[a] (g)	87.93	50.52	96.5	66.37	81.4	32.64	0.038

a - p-value based on Bonferroni correction (alpha < 0.017)

*p-value <0.05 and calculated using independent t-test

Comparison of Calorie and Macronutrient Intake Between Good and Poor Sleepers

Table 1 illustrates intake of calories and macronutrients in good and poor sleepers. Calorie intake was found to be significantly higher for good sleepers compared to poor sleepers, with good sleepers consuming on average around 208 more calories compared to poor sleepers (p=0.028). Carbohydrate intake of good sleepers was 227.41 grams and poor sleepers consumed 209.98 grams of carbohydrate (17.43 Δ). For good sleepers, protein intake was 96.5 grams while poor sleepers consumed 81.4 grams of protein (15.1 Δ). Fat intake in good sleepers was 92.54 grams and 82.71 grams of fat was consumed by poor sleepers (9.83 Δ). After Bonferroni correction (critical value of 0.017) carbohydrates, fat and protein were all found to be non-significantly different between good and poor sleepers (p = 0.137, 0.03, 0.038, respectfully).

Discussion

This study examined the different dietary intakes of college students with good and poor sleep quality. The investigation found, when testing hypothesis 1, that calorie intake was significantly higher for good sleepers compared to poor sleepers, at around a 208 higher calorie intake, accepting hypothesis 1 (p = 0.028). However, testing hypothesis 2, that is, if there was a difference between good and poor sleepers' intake of macronutrients: carbohydrates, fat, and protein, the results were non-significant, and hypothesis 2 was rejected.

Total calorie intake of college students in this study was similar to other studies with college student samples, which found caloric intakes to range between 1800-2100 calories (Leenaars, et al., 2015; Ha, & Caine-Bish, 2011). In terms of calorie intake in two different groups, somewhat contrary to this studies' finding, past literature found higher calorie consumption to be associated with insufficient sleep measures (that is, abnormally short sleep duration) and lower calorie intake with better sleep (longer sleep duration) (Grandner, et al., 2013). It is unclear why higher calorie intake was found to be in good sleepers compared to poor sleepers in this study. However, it could be due in part to unexamined lifestyle related variables that may affect sleep quality (Hicks, McTighe, & Juarez, 1986). College students may be juggling between school, work, sports, and social life, and emotional and academic stressors may lead to more obstacles for adequate sleep (Lund, et al., 2010). Research shows that college students may begin using a number of substances that affect sleep, including, nicotine, medications, illicit drugs, and have higher intake of caffeine to cope with those stressors (Wetter, Kenford, Welsch, Smith, Fouladi, Fiore, & Baker, 2004; Zunhammer, Eichhammer, & Busch, 2014; Rozenbroek, & Rothstein, 2011). For example, smoking can be one possible factor affecting sleep quality, which was not examined in the current study. Past studies have found smoking to be associated with poor sleep, and smoking is also an appetite suppressant, which may work to explain less calories with poor sleep quality, although this was out of the current scope of this study (Diaz, 2016; Wetter & Young, 1994; Peters, et al., 2011). Other possibilities that may contribute to this discrepancy are physical activity, academic load and work hours all of which were unexamined in this study. Physical activity levels may also have an influence in explaining why good sleepers consumed more calories, since more physical activity requires more calories for bodily function and may also stimulate appetite (Rosi, et al., 2017). Physical activity is also associated with better sleep outcomes, and higher intakes of protein, which may improve sleep (King, et al., 1997). On the other hand, work hours may be another underlying factor, as work hours may influence dietary intake, and disrupt healthy sleep behaviors depending on the number of hours worked, and time of the shifts. In comparison, good sleepers could be more organized, have better lifestyle habits, and more structure of dietary intake compared to poor sleepers.

Intake of all macronutrients including carbohydrates, fat, and protein was found non-significantly different between good and poor sleepers. This finding is not in line with past research, which has found significant differences between these macronutrients and sleep measures. This non-significant finding may be due to the Bonferroni correction, which may be an over conservative approach in consideration of the magnitude of the difference, and the small sample size of 230. Carbohydrate intake in epidemiological and experimental studies show higher intakes leading to better sleep outcomes, including, shorter sleep latency, less slow wave sleep, and more REM sleep (Afaghi, et al., 2008; Lindseth, et al., 2016; Phillips, et al., 1975). It is posited that higher carbohydrate intake, especially around bedtime may lead to more REM sleep, and less slow wave sleep, due to a higher rate of oxidative metabolism (Yajima, et al., 2014). Although, other studies have found more simple carbohydrate intake, such as sugar, to be associated with short sleep duration, and more arousals throughout the night, ultimately leading to worse sleep (Al-Disi, et al., 2016). This could be due in part to the quick absorption of simple sugars, which if serum glucose levels increase, sleep efficiency may worsen (Lindseth, et al., 2013).

Studies by other researchers examining the effect of fat intake on sleep seem to contradict this study's non-significant finding as well. Studies have found higher fat intake in association with either too much or not enough sleep, less restorative sleep, and other disturbances with sleep measures (Khan, et al., 2017; Kahlhöfer, et al., 2016; Crispim, et al., 2011). However, the mechanism of how fat is associated with sleep is unclear, and some speculate that higher fat intake may lead to a decrease in consumption of carbohydrates, and protein that have positive effects on sleep quality (Peuhkuri, et al., 2012). Types of fat may also vary the association with sleep, with plant-based fats being associated with better sleep, and animal sourced fats with worsened sleep (Grandner, et al., 2014). This may be due to animal products containing more saturated and omega-6 fatty acids, whereas plant-based sources may contain more unsaturated and omega-3 fatty acids, that have anti-inflammatory benefits (Grandner, et al., 2014). Higher fat intake before bed may also lead to longer sleep latency, less REM sleep, and less sleep efficiency (Crispim, et al., 2011). Although this study did not find a significant difference between the fat intakes of good and poor sleepers, a larger sample size may have shown a different result.

Regarding protein intake, literature conflicts with this studies' non-significant finding. Protein intake has been found to play a metabolic role in the production of mood and sleep hormones. Research has shown higher protein intake to be associated with less sleep disruptions, good sleep quality, and conversely, lower protein intakes with short sleep duration (Grandner, et al., 2013; Lindseth, et al., 2013; Komada, et al., 2017). This positive effect of protein on sleep quality may be explained by the role of tryptophan, an amino acid. Tryptophan acts as a precursor to a neurotransmitter serotonin that improves mood, and then can subsequently metabolize into a sleep hormone known as melatonin which may improve sleep (Murray, et al., 2009; Bravo, et al., 2013). The mean protein intake was around 96 grams for good sleepers, which is slightly more than has been recorded for adults, and studies have shown higher protein diets to be associated with less sleep disruption and better sleep quality (Fulgoni, 2008; Lindseth, et al., 2013; Komada, et al., 2017; Grandner, et al., 2013). Although the difference between groups was non-significant, a larger sample size may find different results between good and poor sleepers in future studies.

Limitations

There are a number of limitations in this study. First, due to the cross-sectional design, directionality or causality cannot be determined. Second, the sleep quality groups measured by the PSQI, were subjectively self-reported, compared to more objective measures such as polysomnography or actigraphy. Third, 4-day dietary records were self-reported which can lead to under or overestimation of actual intake. Although, to minimize errors, it was employed that dietary records were cross-checked during interviews between a trained researcher and the students. Fourth, the sample size of 230 students limits the power of study, and generalizability of the findings to college students may require larger, more diverse samples. The sample size also limits the accuracy of the t-test, in that with a larger sample the Bonferroni correction for macronutrients may have found significant differences. Lastly, the statistical procedure used did not allow for analysis while adjusting for possible covariates or confounders.

Future research investigating sleep quality using college students should use larger and more representative samples to allow for generalizability of findings to college students. Studies with larger samples should also reassess macronutrients in association with sleep quality and investigate statistical models that will allow for adjustment of confounders: BMI, education, smoking, alcohol consumption, age, caffeine, physical activity, overall diet, ethnicity, etc. (Grandner, et al., 2013). Future research should also consider measuring dietary intake prior to measuring sleep quality, or vice versa, as this would allow some directionality of association to be examined. Although this study used Bonferroni correction for multiple t-tests, and this correction may be over conservative. More investigation into the diet-sleep relationship is needed to help elucidate this phenomenon in US college students while also considering the interplay of students' lifestyle and behavioral characteristics.

Conclusion

It seems this was the first study to compare calorie and macronutrient intakes between individuals with good and poor sleep quality using US college students. This study found that good sleepers consumed significantly more calories compared to poor sleepers, which seems contrary to usual diet-sleep studies. This suggests college students have their own unique characteristics in dietary and sleeping patterns not following that of the general population.

APPENDICES

APPENDIX A

FOOD LOG

APPENDIX A

FOOD LOG

Food & Beverage Log (Part 1)

Name ________________________________

Date/Day of the week __________/_________

Time (Time you began eating)	**Meal/ Snack** (M/S)	**Food Item** ("Official Name", i.e. Cobb salad)	**Ingredient** (1 ingredient per row, i.e. lettuce, egg, dressing)	**Amount** (How much you actually ate, i.e. 2 cups, 1 large egg, 1 tbsp.)	**Cooking Method** (Fried, grilled, baked, etc.)	**Brand Name** (Found on packaged foods, i.e. Pepsi)	**Where Food is Prepared (Home/Dorm, Packed, Restaurant)** (i.e. Chipotle, Eastway, etc.)	**Food Label (✓)** (Only those collected)

How does this intake compare to your usual intake? (Check 1 box) ☐ About the same ☐ More ☐ Less

APPENDIX B

PITTSBURGH SLEEP QUALITY INDEX

APPENDIX B

PITTSBURGH SLEEP QUALITY INDEX

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_____

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APPENDIX C

PSQI SCORING

APPENDIX C

PSQI Scoring

PSQIDURAT **DURATION OF SLEEP**

IF Q4 $\geq$ 7, THEN set value to 0
IF Q4 < 7 and $\geq$ 6, THEN set value to 1
IF Q4 < 6 and $\geq$ 5, THEN set value to 2
IF Q4 < 5, THEN set value to 3
Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQIDISTB **SLEEP DISTURBANCE**

IF Q5b + Q5c + Q5d + Q5e + Q5f + Q5g + Q5h + Q5i + Q5j (IF Q5JCOM is null or Q5j is null, set the value of Q5j to 0) = 0, THEN set value to 0

IF Q5b + Q5c + Q5d + Q5e + Q5f + Q5g + Q5h + Q5i + Q5j (IF Q5JCOM is null or Q5j is null, set the value of Q5j to 0) $\geq$ 1 and $\leq$ 9, THEN set value to 1

IF Q5b + Q5c + Q5d + Q5e + Q5f + Q5g + Q5h + Q5i + Q5j (IF Q5JCOM is null or Q5j is null, set the value of Q5j to 0) > 9 and $\leq$ 18, THEN set value to 2

IF Q5b + Q5c + Q5d + Q5e + Q5f + Q5g + Q5h + Q5i + Q5j (IF Q5JCOM is null or Q5j is null, set the value of Q5j to 0) > 18, THEN set value to 3

Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQILATEN **SLEEP LATENCY**

First, recode Q2 into Q2new thusly:
IF Q2 $\geq$ 0 and $\leq$ 15, THEN set value of Q2new to 0
IF Q2 > 15 and $\leq$ 30, THEN set value of Q2new to 1
IF Q2 > 30 and $\leq$ 60, THEN set value of Q2new to 2
IF Q2 > 60, THEN set value of Q2new to 3
Next
IF Q5a + Q2new = 0, THEN set value to 0
IF Q5a + Q2new $\geq$ 1 and $\leq$ 2, THEN set value to 1
IF Q5a + Q2new $\geq$ 3 and $\leq$ 4, THEN set value to 2
IF Q5a + Q2new $\geq$ 5 and $\leq$ 6, THEN set value to 3

Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQIDAYDYS **DAY DYSFUNCTION DUE TO SLEEPINESS**

IF Q8 + Q9 = 0, THEN set value to 0
IF Q8 + Q9 ≥ 1 and ≤ 2, THEN set value to 1
IF Q8 + Q9 ≥ 3 and ≤ 4, THEN set value to 2
IF Q8 + Q9 ≥ 5 and ≤ 6, THEN set value to 3
Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQIHSE **SLEEP EFFICIENCY**

Diffsec = Difference in seconds between day and time of day Q1 and day Q3

Diffhour = Absolute value of diffsec / 3600
newtib =IF diffhour > 24, then newtib = diffhour – 24
IF diffhour ≤ 24, THEN newtib = diffhour
(NOTE, THE ABOVE JUST CALCULATES THE HOURS BETWEEN GNT (Q1) AND GMT (Q3))
tmphse = (Q4 / newtib) * 100

IF tmphse ≥ 85, THEN set value to 0
IF tmphse < 85 and ≥ 75, THEN set value to 1
IF tmphse < 75 and ≥ 65, THEN set value to 2
IF tmphse < 65, THEN set value to 3
Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQISLPQUAL **OVERALL SLEEP QUALITY**

Q6
Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQIMEDS **NEED MEDS TO SLEEP**

Q7
Minimum Score = 0 (better); Maximum Score = 3 (worse)

PSQI **TOTAL**

DURAT + DISTB + LATEN + DAYDYS + HSE + SLPQUAL + MEDS
Minimum Score = 0 (better); Maximum Score = 21 (worse)
Interpretation: TOTAL ≤ 5 associated with good sleep quality
TOTAL > 5 associated with poor sleep quality

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