COGNITIVE, ATTITUDINAL, AND BEHAVIORAL PREDICTORS OF COLLEGE SLEEP AND HEALTH

by

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ABSTRACT

HANNAH PEACH. Cognitive, attitudinal, and behavioral predictors of college sleep and health. (Under the direction of DR. JANE F. GAULTNEY)

College students are one of the top at-risk groups for chronic sleep loss and poor sleep quality, therefore research devoted to the identification of cognitive, attitudinal, and behavioral predictors of sleep is essential. The present study examined predictors of both self-reported and actigraphic measures of sleep quality and quantity, as well as tested direct and indirect associations of sleep with salient physical and mental health outcomes within a sample of American college students ($N = 142$). Results demonstrated that attitudes but not knowledge predicted self-reported sleep duration, self-reported sleep quality, sleep hygiene behaviors, and actigraphic measures of weekday and weekend sleep duration. In turn, self-reported sleep quality predicted subjective well-being and depression, and sleep hygiene yielded indirect effects via sleep quality. Actigraphic measures of sleep duration predicted body mass index, while actigraphic measures of sleep efficiency, a component of sleep quality, predicted diastolic blood pressure and depression. Sleep hygiene yielded indirect effects on blood pressure via sleep efficiency. Results shed light on the predictive validity of attitudes towards sleep and sleep hygiene, as well as inform application efforts targeting the improvement of sleep and health outcomes among the college population.

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DEDICATION

I would like to dedicate this Dissertation to my grandfather, Robert Scarburgh.

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LIST OF ABBREVIATIONS

NHANES	National Health and Nutrition Examination Survey
CDC	Centers for Disease Control and Prevention
BMI	body mass index
DBAS-16	Dysfunctional Beliefs and Attitudes about Sleep Scale
SSHAS	Sleep and Sleep Hygiene Attitudes Scale
SBS	Sleep Beliefs Scale
SHPS	Sleep Hygiene Practice Scale
PSQI	Pittsburgh Sleep Quality Index
BCC-SWB	BCC Subjective Well-Being Scale
CES-D	Center for Epidemiologic Studies Depression Scale Short Form
SEM	structural equation modeling
CI	confidence interval
CFI	comparative fix index
TLI	Tucker-Lewis index
RMSEA	root mean squared error of approximation

CHAPTER 1: INTRODUCTION

Sleep health is increasingly seen as a critical component within the fields of scientific research and clinical practice. While recognition of this health topic is expanding, "the cumulative effects of sleep loss and sleep disorders represent an under-recognized public health problem" (Institute of Medicine, 2006), therefore greater attention is warranted in order to adequately address this growing public health concern. Data from the 2005–2006 National Health and Nutrition Examination Survey (NHANES; Ram, Seirawan, Kumar, & Clark, 2010) showed that 4.2% of responders suffered from sleep apnea, 0.4% suffered from restless leg syndrome, 26.5% reported feeling unrested during the day, and 26% did not get enough sleep. While the prevalence rates of organic causes of poor sleep (e.g., sleep apnea, restless leg syndrome) are far lower, organic sleep disorders receive much more attention within research and clinical settings, for diagnosis and pharmaceutical or mechanical treatment of such problems are typically available and yield substantial profit. Poor sleep that stems from lifestyle-related causes, rather than organic disorders, affects a much larger portion of the population, yet less research examines non-disordered inadequate sleep. Thus, the present study focuses on inadequate sleep, defined as sleep durations shorter than the recommended age-appropriate amount (i.e., 7+ hours per night for young adults and adults; National Sleep Foundation, 2009), and/or poor sleep quality (Knutson, 2012). Objective sleep quality may include measures of awakenings through the night or calculated sleep efficiency (i.e., total time asleep divided by total time in bed). Perceived sleep quality consists of subjective report of the continuity and restfulness of sleep, including perceptions of sleep disruptions. While sleep quality and quantity are both indicators of poor sleep, they serve as distinct components of sleep and are shown to have independent effects on measures of health and well-being (Pilcher, Ginter, & Sadowsky, 1997).

While an estimated 50-70 million adults experience chronic sleep loss (Institute of Medicine, 2006), college students may be twice as likely as the general population to report negative sleep outcomes (Brown et al., 2001). In fact, studies suggest the adolescent/emerging adult population, including college students, is one of the top at-risk groups for chronic sleep loss (Forquer et al., 2008), poor sleep quality (Ahrberg et al., 2012) and significant daytime sleepiness (Lund et al., 2010; Oginska & Pokorski, 2006). These prevalence rates are alarming, for characteristics of inadequate sleep (i.e., short sleep duration, poor quality, and daytime sleepiness) serve as risk factors for a variety of affective, cognitive, and physiological outcomes, including depression, obesity, chronic disease (Knutson, 2012), poor academic performance (Ahrberg et al., 2012), risk-taking behaviors (O'Brien & Mindell, 2005), poor self-rated health (Luckhaupt et al., 2010), accidents, and even mortality (National Sleep Foundation, 2000). Thus, research is needed that identifies modifiable risk factors for sleep and sleep hygiene behaviors (i.e., practices believed to promote sufficient sleep quantity, good sleep quality, and full daytime alertness) among college students.

A body of social science research has examined knowledge and attitudes as predictors of health behaviors, such as smoking cessation and weight loss (Rise et al., 2008), and demonstrated that knowledge alone is not sufficient for behavior change.

Little research has examined these predictors of sleep while utilizing comprehensive theoretical frameworks, validated measures, considerations of the complexity of sleep as both a behavior and a biological state, and sleep hygiene as a mediating factor. The proposed dissertation study therefore examined both knowledge and attitudes among college students to determine their unique associations with sleep hygiene behaviors, direct and indirect effects on sleep characteristics, and the ability of the model to predict key health outcomes. The following literature review outlines theoretical frameworks for the biological need for sleep and describes sleep as both a behavior and physiological state. It then highlights the health risks associated with insufficient sleep and discusses the prevalence of inadequate sleep and related health problems salient within the United States. The college population is then examined as a particularly vulnerable population for sleep problems and resulting health consequences. The review explores research identifying cognitive and behavioral predictors of sleep, particularly the influence of knowledge, attitudes, and sleep hygiene on characteristics of sleep among college students. The theoretical frameworks utilized in the present study are described, and the literature review presents a description of the current study, outlining the rationale, aims and hypotheses. Lastly, the methodology of the present study is provided, results of the study are presented, and findings and implications are discussed.

CHAPTER 2: LITERATURE REVIEW

2.1 The Importance of Sleep

2.1.1 Theories of Sleep

Sleep and its importance in relation to health must be understood before examining factors that shape sleep. Sleep is a unique construct to define and study, for it can be considered a neurochemical process, a behavior, and a biological state characterized by variations in certain physiological functions. Clinically, sleep is defined by distinctive changes in central nervous activity, typically measured by polysomnography (Zisapel, 2007) that tracks patterns of brain wave activity, muscle tension, eye movement, oxygen levels, heart rate, and airflow (Morin & Espie, 2013). Behaviorally, sleep is characterized as a period of reduced activity typically involving a posture of lying down with eyes closed. Within this state, one experiences reduced responsiveness to external stimuli, yet sleep is relatively easy to reverse (i.e., waking one from this state) in comparison to other states of reduced consciousness, such as a coma (Healthy Sleep, 2007). Considering this complexity, the multitude of physiological roles that sleep plays in restoration and function are still being explored, yielding several theories for its evolutionary purpose and impact on health.

Several key sleep theories include the inactive theory of sleep, energy conservation theory, restoration theories, and brain plasticity theories (Healthy Sleep, 2007). Inactive theory, also known as evolutionary or adaptive theory, suggests that sleep serves as an adaptive survival mechanism by sustaining immobility during the night and therefore reducing vulnerability during this period of time and increasing chances of an organism's safety (Meddis, 2005). Theories of natural selection posit that within the evolutionary environment, staying still and quiet during the dark served as an optimal behavioral strategy of reducing risk of being hunted by predators and thus evolved to what is now recognized as sleep. Sleep may have also evolved for the purpose of allowing a period of energy conservation. The energy conservation theory (e.g., Siegel, 2005) theorizes that during the Paleolithic era, a significantly large amount of energy was required for humans in comparison to modern day, and such energy was utilized to maintain a constant body temperature, look for food, avoid predators, and so forth. Thus, the energy conservation theory, also referred to as the hibernation theory, proposes that sleep reduces energy expenditure by decreasing body temperature and activity level.

Sleep may serve as a period of reduced *physical* activity that increased survival and conserved energy, yet substantial *neurochemical* activity is occurring during sleep that promotes repair and restoration of bodily functions, which in turn generate an improved sense of energy and well-being following a night of sleep (Maquet, 1995; Zisapel, 2007). Within the restoration theory framework, repair and restoration occurs within numerous specified pathways of physiological functioning, such as regulation of metabolic, endocrine, and immune functioning (AlDabal & BaHammam, 2011), as well as thermoregulation and cardiovascular activity (Wang, Xi, Liu, Zhang, & Fu, 2012).

Theories of sleep and brain plasticity posit that vital restorative processes also occur within the brain, and such notions are largely supported by compelling empirical evidence confirming systemic and synaptic consolidation that occur during sleep. These consolidation processes promote both quantitative and qualitative changes in memory representations, evidenced by behavioral studies demonstrating that poor sleep impairs memory and learning outcomes (e.g., Balbo, Leproult, & Van Cauter, 2010; Diekelmann & Born, 2010; Drummond & Brown, 2001; Foo & Mason, 2003; Havekes, Vecsey, & Abel, 2012).

2.1.2 The Impact of Sleep on Health

Based on the proposed theories, it is reasonable to expect connections between sleep and many aspects of health. However, the present study narrows in on three focal areas of health that are interrelated and particularly relevant to current American public health: obesity, blood pressure, and mental health, operationalized two-dimensionally as subjective well-being and depression.

According to the World Health Organization (1995), obesity describes a degree of fat storage associated with a variety of health risks. Fat mass in the human body is difficult and expensive to assess in many research settings, therefore body mass index (BMI) is the basis for the practical definition of obesity (World Health Organization, 1995). BMI is a commonly used and fairly reliable indicator of body fatness calculated from an individual's height and weight (Keys, Fidanza, Karvonen, Kimura, & Taylor, 1972; Heymsfield, Gallagher, Mayer, Beetsch, & Pietrobelli, 2007). While BMI is not a direct measurement of fatness, this weight-height index is highly correlated with skinfold and body density measurements (Keys et al., 1972). Further, BMI has been studied as a phenotypic marker of adiposity, and research has demonstrated that weight, skeletal muscle, and adipose tissue all scale to height (Heymsfield et al., 2007). Thus, BMI can be used to generate reasonably reliable classifications of degrees of overweight for *most* adults categorized by one's deviation from a "normal" weight status based on height, and these categories stem primarily from identified associations between BMI and mortality (World Health Organization, 1995). These cut-offs should not be applied for medical diagnoses nor considered in isolation, but rather serve as proxies for obesity in combination with other genetic and behavioral determinants of health (World Health Organization, 1995).

The Centers for Disease Control and Prevention (CDC) has identified obesity as a top public health priority (May, Freedman, Sherry, & Blanck, 2013), for the prevalence of obesity among adults in the United States has increased nearly three-fold from 1960 to 2010 (Flegal, Carroll, Kit, & Ogden, 2012). Statistics from the 2011-2012 NHANES study show that nearly 17.5% of children and adolescents aged 2-19 is classified as obese, and 35% of the adult population is obese (Ogden, Carroll, Kit, & Flegal, 2014). Obesity serves as a risk factor for a host of chronic health conditions, including cardiovascular disease, Type 2 diabetes, and stroke, all of which can be fatal (Clinical Guidelines, 1998). The resulting health risks stemming from obesity are matched by economic consequences, with estimated medical costs of $147 billion in 2008 (Finkelstein, Trogdon, Cohen, & Dietz, 2009). Considering the high prevalence rate of obesity and associated chronic illnesses, the identification of modifiable determinants of obesity is essential.

It is widely recognized that a lack of physical activity and poor nutrition are risk factors for obesity, but less attention is given to the influence of sleep in which inadequate sleep can contribute to increases in BMI. A meta-analysis (Cappuccio et al., 2008) of 13 population samples of children and 22 population samples of adults found a consistent and significant negative association between sleep duration and BMI. Although all data were cross-sectional, results suggest a 60-80% increase in the odds of being a short sleeper among obese children and adults. Resulting fatigue from a lack of sleep may impair or reduce physical activity that influences BMI, and research suggests that inadequate sleep may contribute to the development of obesity by affecting appetite regulation via levels of hormones leptin and ghrelin, by increasing subjective appetite, and by decreasing energy expenditure (Knutson, 2012).

In addition to higher levels of BMI, sleep has also been associated with increased blood pressure, or the force of blood against the arterial walls. In adults, hypertension, or high blood pressure, is classified as systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg. Excessively high blood pressure causes substantial damage to the heart and is a risk factor for heart attack and stroke (Go et al., 2013). Hypertension is associated with more years lived with cardiovascular disease and a shorter life expectancy overall; studies show middle-aged males and females with hypertension have life expectancies approximately five years shorter than normotensive people of the same sex and age (Franco, Peeters, Bonneux, & de Laet, 2005). Additionally, hypertension contributes substantially to United States health care costs, with expenses of associated health care services, medications, and missed days of work estimated at $93.5 billion in 2010 (Heidenreich et al., 2011).

Sleep apnea has long been recognized as a causal risk factor for hypertension (Hoffstein, Chan, & Slutsky, 1991), and researchers are now examining adequate quality sleep as an avenue for the treatment and prevention of high blood pressure (Gangwisch, 2014). A recent literature review (Gangwisch, 2014) reported that in both cross-sectional and longitudinal studies, short sleep durations are associated with higher blood pressure. Further, experimental sleep deprivation studies demonstrate a causal link between sleep restriction and increases in blood pressure, and interventions studies with prehypertensive/hypertensive individuals report significant reductions in blood pressure with experimental sleep extension (Gangwisch, 2014). Sleep loss or fragmented sleep may lead to a reduction in nocturnal blood pressure dipping (Sayk et al., 2014) or longer exposures to elevated sympathetic nervous system arousal that increase blood pressure (Sapolsky, 2004; Spiegel, Leproult, & Van Cauter, 1999). Poor sleep may also increase blood pressure via metabolic and endocrine changes, for inadequate amounts of sleep can decrease glucose tolerance and increase cortisol levels (Spiegel et al., 1999), increase cholesterol levels (Kerkhofs et al., 2007*)*, diminish melatonin production (Zisapel, 2007), and increase salt retention (Gangwisch et al., 2006). Sleep may also indirectly impact blood pressure by increasing BMI or risk for obesity, as evident in both adult (e.g., Gangwisch et al., 2006) and adolescent (e.g., Peach, Gaultney, & Reeve, 2015) samples.

In addition to physical health, sleep plays a role in mental health and well-being. The unpleasantness experienced after a night of insufficient sleep is well known anecdotally, yet the impact of sleep on mental health runs far deeper. The World Health Organization (2003) describes mental health as a state of well-being whereby a person is aware of his or her own abilities, can cope with the normal stresses of life, is able to work productively and fruitfully, and can contribute to his or her community. As such, the present study conceptualizes mental health two-dimensionally, encompassing both positive (i.e., subjective or psychological well-being) and negative (i.e., psychopathology, such as depression and anxiety) aspects of mental health (Jones, 2013; World Health

Organization, 2004). Research devoted to mental health often centers upon the latter of the two and examines mental illnesses, as well as factors contributing to psychopathology. Depression is the most commonly reported mental illness in the U.S., affecting an estimated 26% of the adult population (Kessler, Chiu, Demler, & Walters, 2005). Depression has been associated with health conditions such as cardiovascular disease (e.g., Kuper, Marmot & Hemingway 2002) and is projected to be the second leading cause of disability by 2020 (Murray & Lopez, 1996). Depression is characterized by symptoms such as sad mood, reduced interest in activities, difficulty concentrating, fatigue, and thoughts of suicide, and five or more symptoms that persist for at least two weeks meet the diagnostic criteria for depression (American Psychiatric Association, 1994).

In adults, clinical research has consistently demonstrated comorbidity between sleep problems and depression (e.g., Roth & Ancoli-Israel, 1999). A recent meta-analysis (Alvaro, Roberts, & Harris, 2013) found significant relationships between sleep disturbance, anxiety, and/or depression in all nine studies under review, with four studies suggesting bidirectionality between sleep and depression. Further, characteristics of sleep problems, referred to as insomnia within the meta-analysis, predicted depression more consistently than depression predicted sleep. Another recent meta-analysis of 23 studies (Lovato & Gradisar, 2014) examined the bidirectionality of sleep and depression specifically in adolescents and yielded effect sizes from both treatment studies and longitudinal designs that suggest sleep disturbances precede the development of depression. The authors (Lovato & Gradisar, 2014) found little evidence that depression predicted sleep disturbances among adolescents and therefore proposed a unidirectional conceptual model in which characteristics of poor sleep quality can contribute to symptoms of depression. Hypothesized mechanisms underlying a sleep-depression link include common neurobiological processes such as neurotransmitter dysregulation, increased inflammation associated with sleep disturbances that also corresponds with depression, and genetic, social, or environmental influences that contribute to both sleep problems and depression (Alvaro et al., 2013).

While such research suggests poor sleep serves as a risk factor for psychopathology, the negative dimension of mental health, adequate quality sleep can also promote positive aspects of mental health, referred to in the present study as psychological well-being (Hamilton, Nelson, Stevens, & Kitzman, 2007). The present study broadly conceptualizes psychological well-being as the nature in which individuals emotionally and cognitively feel about themselves and how satisfied they are with the quality of their lives (Diener, Suh, Lucas, & Smith, 1999; Jones, 2013). Psychological well-being has shown “health protective biological correlates, including low cortisol output, reduced cardiovascular stress responsivity, and heightened antibody responses to vaccination,” (Steptoe, O'Donnell, Marmot, & Wardle, 2008, p. 409), and optimal sleep has been examined as a resource that may promote or improve well-being (Hamilton et al., 2008).

In a community sample of adults, Hamilton and colleagues (2008) found that optimal sleep was associated with better psychological well-being, particularly positive relations with others, purpose in life, and self-acceptance, even after accounting for indicators of depression. Other research has linked associations of aspects of well-being with fewer sleep problems (Steptoe et al., 2008) and better sleep quality (Hanson &

Ruthig, 2012) among samples of older adults. Research has even shown such relations among adolescents, and examinations of cross-sectional and longitudinal data revealed that not only was longer sleep duration concurrently linked to better psychological well-being, but longitudinal analyses showed that sleep durations predicted psychological well-being sixth months later, with no evidence for the reverse relationship of well-being predicting sleep (Kalak, Lemola, Brand, Holsboer-Trachsler, & Grob, 2014).

Explanatory models for a link between sleep and well-being suggest that sleep serves as a resource for energy needed to manage stress and for self-regulation (Drake, Roehrs, & Roth, 2003; Hamilton et al., 2008; Zohar, Tzischinsky, Epstein, & Lavie, 2005). Sufficiently long and consecutive sleep may provide the energy needed to effectively manage stress and sustain a focused, invigorated approach to self-regulation, thus improving one's psychological well-being (Hamilton et al., 2008). The notion of sleep as a modifiable resource in relation to well-being is strengthened by research suggesting sleep and mental health are not necessarily due to common genetic underpinnings. Some genetic research (Lázár et al., 2012) demonstrates that particular genotypes predict sleep-wake timing parameters and sleep duration, and sleep timing variables predict mental health. Yet, the targeted genotypes were not associated with mental health, suggesting that sleep timing is an independent and strong predictor of mental health.

2.2 College Health

2.2.1 American College Students as a Unique Population

The present study focuses on college students within the United States as a unique and relevant population to examine. The majority of individuals entering and completing their collegiate education are *emerging adults.* The theory of emerging adulthood was conceptualized by Arnett (2000; 2007) as a "new period of the life course within industrialized societies" (p. 68). Emerging adults are within the ages of late teens through mid-twenties, and this life period is characterized by distinctive developmental characteristics, including identity exploration and individualization whereby individuals are left to their own resources to move from one period of the life course to the next (Arnett, 2007). For emerging adults attending college, this developmental period often serves as a time of newfound freedom from parental rules, control, and monitoring, as well as freedom from a regimented school schedule seven hours a day on weekdays. College students are entrusted with the responsibility of setting their own schedules and choosing their own coursework and extracurricular activities, which lays the foundation for both positive and negative health opportunities. For emerging adults, the college years generate a "window of vulnerability" in which individuals are more vulnerable to particular health problems (Taylor, 2012), including inadequate sleep. Researchers have coined the phrase *college culture*, described as "social arrangements and behavior practices that negatively affect students' sleep, including communal living, frequent parties and drinking, poor time management, and high levels of stress and work" (Vargas, Flores, & Robles, 2014, p.6), and this culture places college students at greater risk for insufficient sleep.

2.2.2 Window of vulnerability

Average sleep durations among college students decreased by one full hour per night (7.5 to 6.5 hours) from 1969 to 1989, and frequency distributions from 2000-2001 were not significantly different from those in 1989 (Hicks, Fernandez, & Pellegrini, 2001). More recent reports have yielded similar averages, with college student reporting mean sleep durations from 6 hours 43 minutes to 6 hour 56 minutes (Galambos, Vargas Lascano, Howard, & Maggs, 2013). Reports from much larger samples yield similar results; the American College Health Association (2007) surveyed 94,806 students from 117 colleges across the country and found that 64.9% of participants reported not getting enough sleep to wake feeling rested at least 3 of the past 7 days. College students also experience poor sleep quality, with approximately 24% of the aforementioned sample (21,957 participants) reporting sleep difficulties (American College Health Association, 2007). Problems falling and staying asleep are common, with 33% of another college sample reporting that it took over 30 minutes for them to fall asleep, and another 43% reporting waking more than once per night (Forquer, Camden, Gabriau, & Johnson, 2008).

College students may be at greater risk for insufficient sleep in comparison to the general population (Brown et al., 2001) because of physiological, social, and contextual factors (Jensen, 2003) that generate a window of vulnerability. To begin, students just entering college are typically in their late teens, transitioning from late adolescence into emerging adulthood. Physiologically, these early college students may still be experiencing biologically-driven delayed sleep phase that characterizes adolescent physiology (Carskadon, Acebo, & Jenni, 2004). If students are unable to fall asleep earlier in the evening, bedtimes are delayed. While physiological rationales for later bedtimes are plausible, behavioral and social influences are also at play; without limitations of parental curfews, students are commonly sacrificing sleep in order to study or socialize (Galambos & Dalton, 2009; Orzech, Salafsky, & Hamilton, 2011). Late bedtimes may result in short sleep durations if students must wake up earlier for academic or work commitments and do not allow 7-9 hours between bedtimes and wake times (Gaultney, 2010). Research has supported such notions, with studies showing that male and female college students reported late bedtimes (average times between 1:20am and 1:45am) yet early wake times, particularly on the weekdays (8:27am – 8:39am) but also on the weekends (9:12am – 9:39am; Tsai & Li, 2004b). Further, students show high variability in sleep schedules (Jensen, 2003), which can generate difficulties initiating and maintaining sleep. Students also tend to accumulate sleep debt throughout the week, skipping sleep to study longer, and attempt to compensate by sleeping longer over the weekend (Jensen, 2003).

College students often struggle with time-pressure and finding ways to effectively utilize limited time to meet many demands (Jensen, 2003), and skipping sleep in order to prioritize academic or extracurricular responsibilities is common. To cope, students often turn to caffeine or energy drinks; Malinauskas and colleagues (2007) reported that the majority of their college sample regularly consumed energy drinks several times per week, and 67% of energy drink users consumed energy drinks for insufficient sleep. The use of energy drinks has been associated with poorer sleep quality among college students (Lohsoonthorn et al., 2013; Stasio, Curry, Wagener, & Glassman, 2011), generating a vicious cycle of stimulant dependency that impairs sleep. The time-pressures, academic responsibilities, and personal demands that characterize the collegiate culture generate stress, anxiety, and depression for students, which significantly impairs sleep quality (Jensen, 2003; Orzech et al., 2011). Research shows that some college students turn to alcohol as a coping strategy for emotional problems, and sleep problems have been found to precede alcohol use and dependency (Kenney, Paves, Grimaldi,., & LaBrie, 2014). Considering alcohol use and stress both adversely affect sleep quality, a cycle of poor stress coping and poor sleep emerges (Kenney et al., 2014).

Finally, generational and environmental factors that characterize the lifestyles of modern college students generate barriers to achieving optimal sleep. While the vast majority of U.S. citizens in the 21st century utilize the Internet and modern technology, Internet use is estimated to be the highest among young adults; rates have increased from 74% to 93% between 2000 and 2009 (Lenhart, Purcell, Smith, & Zickuhr, 2010). The Pew Internet Project also stated that 45% of respondents aged 18-29 years old reported using Internet access on their cell phones, and 72% of this age group use social networking websites (Lenhart et al., 2010). Social networking activity, in combination with school-related Internet and electronic use, generates major technology usage among college students, and higher usage of social networking, Internet surfing, and overall general technology use has been associated with partial sleep deprivation in college students (Melton et al., 2014).

Also unique to college students is their communal living environment. Many emerging adults enrolled in college reside in shared apartments or campus residence halls, and for many this is the first time they have shared a room or been exposed to a communal living arrangement in which control of light, sound, and noise levels is shared among roommates and neighbors (Sexton-Radek & Hartley, 2013). A recent study (Sexton-Radek & Hartley, 2013) utilized focus groups and survey data to identify commonly endorsed sleep environment disturbances, and students reported that typical interruptions of sleep included: disturbances in one's room after going to bed, noise in hallways at bedtime and earlier than regular wake up time, and cell phone calls, text, and chat notification sounds. Thus, college students experience sleep disturbances as a result of the unique communal living environment and high technology usage that corresponds with emerging adulthood and college life.

2.2.3 College Years as a Time Frame for Intervention and Prevention

While inadequate sleep is a health concern for any population, the impact of sleep on health is particularly important for college students. In addition to the effects of poor sleep on academic outcomes (e.g., Becker, Adams, Orr, & Quilter, 2008; Gaultney, 2010), it is of great benefit to public health to address the influence of sleep on blood pressure, BMI, and psychological well-being during emerging adulthood. The healthcare field is recognizing the importance of maintaining wellness throughout development and the need for early prevention of chronic diseases. Prevention and early interventions can save enormous economic costs and prevent physical and emotional suffering and disability that correspond with chronic illness and psychopathology. By recognizing the impact sleep can have on chronic conditions such as obesity and hypertension as early as emerging adulthood, intervention strategies during college years can eliminate the adverse effects of poor sleep and reduce health risks.

To elaborate, researchers have demonstrated significant "tracking" of body weight, or the notion that individuals maintain their relative position within their age-sex group over time (Kvaavik, Tell, & Klepp, 2003; Mahoney, Lauer, Lee, & Clarke, 1991). In other words, BMI at a younger age "tracks" or remains stable throughout a person's life, such that a rise in BMI during one's college years may remain throughout adulthood.

Elevated rates of weight and obesity are reported in college students, with studies showing that approximately one-third report BMI ≥ 25, the general cut-off for an overweight classification (American College Health Association, 2012; Huang et al., 2003). Longitudinal research (Kvaavik et al., 2003) has reported stability of relative body weight through life and yielded evidence that adolescent and emerging adult BMI can influence adult body weight. Such findings suggest that adolescence sets the foundation for adult body weight and that application efforts should emphasize modifiable behavior change at a young age to decrease the likelihood of obesity later in life (Kvaavik et al., 2003). Sleep patterns serve as a viable behavioral influence to address, for research has found associations between sleep duration and BMI in male young adults, as well as associations between BMI and trouble falling or staying asleep in female young adults (Meyer et al., 2012). Specifically within college students, sleep disturbances have been shown to predict BMI (Vargas et al., 2014), further emphasizing the importance of addressing sleep during college years as a preventive measure for obesity.

A substantial amount of research has also been devoted to blood pressure tracking from childhood to adulthood (e.g., Toschke, Kohl, Mansmann, & von Kries, 2010) and the development and prediction of hypertension (e.g., Echouffo-Tcheugui, Batty, Kivimäki, & Kengne, 2013). Findings suggest that early prevention is the optimal solution to reducing the incidence of hypertension. Stiffening of arterial walls takes years to develop and contribute to high blood pressure, and preventing this occurrence in younger years can delay or prevent hypertension later in life. While hypertension is not commonly diagnosed among college students, elevated blood pressure is not uncommon; a recent study (Morrell, Lofgren, Burke, & Reilly, 2012) of over 2,000 college students reported that 62.1% of male respondents and 21.2% of female respondents had high blood pressure. Thus, elevated blood pressure levels during emerging adulthood can track throughout life and increasing the likelihood of being diagnosed with hypertension in later adulthood (He, Marrero, & MacGregor, 2008).

The impact of poor sleep on mental health is highly relevant among the college population; college students may be at heightened risk for stress and depressive symptoms, for the transition to college generates a socio-contextual shift that couples with changes in social relationships, increased academic requirements, and greater responsibility for one’s own health and decision-making (Doane, Gress-Smith, & Breitenstein, 2014; Kerr, Johnson, Gans, & Krumrine, 2004). Studies suggest incoming undergraduate students experience high levels of depression and anxiety (e.g., Furr, Westefeld, McConnell, & Jenkins, 2001) and that 25% of students reported feeling depressed within in the past year, with men equally as likely as women to experience depression (Lindsey, Fabiano, & Stark, 2009). Research has estimated that 12% of students experience thoughts of suicide at some point during college (Wilcox et al., 2010). Poor mental health contributes to many negative physical and socioemotional outcomes, can impair academic performance (Wolfson & Carskadon, 2003), and serves as a risk factor for dropping out of college (Hartley, 2012).

Worse sleep quality and shorter sleep quantity have been associated with negative affect and general levels of stress among college students (Galambos, Howard, & Maggs, 2011). Sleep problems are longitudinally associated with anxiety and depression across the transition to college (Doane et al., 2014), and sleep disturbances have been shown to significantly predict depressive symptoms in female college students (Lee, Wuertz, Rogers, & Chen, 2013). Sleep quality can impact the well-being of college students (Vargas et al., 2014), and sleep loss can intensify negative emotions and reduce positive emotions (Zohar, Tzischinsky, Epstein, & Lavie, 2005). Within the framework of self-regulation theories and the cognitive-energy model (Drake et al., 2003; Hamilton et al., 2008; Zohar et al., 2005), considering sleep as a resource for stress management and energy suggests that healthy sleep habits among college students are essential to psychological well-being. Addressing sleep problems in college students could contribute to a reduction in the prevalence of depression and maintenance of positive psychological well-being on college campuses (Galambos et al., 2011).

2.3 Cognitive, Attitudinal, and Behavioral Predictors of Sleep

As evidenced by data demonstrating the effects of sleep on health, sleep serves as a life-sustaining activity and a resource for cognitive and physical energy. Considering the evolutionarily-determined biological drives for and benefits of obtaining adequate nightly sleep, it is counterintuitive that a *lack* of sufficient sleep is so prevalent among college students. While organic sleep disorders are one cause of poor sleep, easily modifiable risk factors for poor sleep are of interest in the current study. It is reasonable and potentially fruitful to examine behavioral and psychosocial factors that may be partially responsible for sleep loss and poor sleep quality among the college population.

2.3.1 Behavioral Determinants of Sleep

Sleep can be considered a behavior itself. Intentions to fall asleep require one to reduce activity and engage in a posture of lying down with eyes closed. Yet, it is widely known that engaging in this purposeful behavior does not equate the immediate achievement of sleep as a state of reduced consciousness; other factors can impair one from actually falling asleep, achieving sufficiently long sleep, or feeling rested upon awakening. *Sleep hygiene* behaviors have been recognized as salient predictors of characteristics of sleep (i.e., sleep duration, sleep quality, sleep disturbances, etc.). The development of sleep hygiene practices to promote sleep may date back to a book written by Paolo Mantegazza in 1864, but the fatherhood of sleep hygiene is generally ascribed to Peter Hauri who coined the term when providing clinical recommendations for insomnia patients (Gigli & Valente, 2013; Stepanski & Wyatt, 2003). Sleep hygiene behaviors are practices believed to promote sufficient sleep quantity, good sleep quality, and full daytime alertness. The behaviors typically span four domains: arousal-related behaviors, sleep scheduling and timing, eating/drinking behaviors, and sleep environment (LeBourgeois, Giannotti, Cortesi, Wolfson, & Harsh, 2005; Gellis, & Lichstein, 2009; Kor & Mullan, 2011; Stepanski & Wyatt, 2003). Thus, behavioral practices within these domains that impede proper sleep are considered poor sleep hygiene.

There is evidence for the association between poor sleep hygiene and inadequate sleep, with research showing that sleep hygiene practices such as arousal-related activities near bedtime, increased cognitive activity while in bed, worrying before bedtime, noisy bedroom environments, and uncomfortable temperature are worse among individuals classified as poor sleepers (Gellis & Lichstein, 2009). Studies have found connections between sleep hygiene practices and sleep quality as young as adolescence (LeBourgeois et al., 2005) and among student populations such as American medical students (Brick, Seely, & Palermo, 2010). Such relations are evident among undergraduate college students as well, with research identifying inconsistent sleep scheduling, noisy environments, and worrying before bed as predictors of poor sleep quality (Brown, Buboltz, & Soper, 2002). A recent study (Gellis, Park, Stotsky, & Taylor, 2014) found that improper sleep scheduling, arousal-related behaviors before bed, and uncomfortable sleeping environments were associated with severity of insomnia symptoms. Further, both cross-sectional and longitudinal (i.e., 2 month follow-up) data indicate improper sleep scheduling significantly predicted insomnia severity above and beyond well-established risk factors of gender, anxiety, and depression (Gellis et al., 2014).

2.3.2 Knowledge of Sleep and Sleep Hygiene Practices

The modification of sleep hygiene behaviors serves as a promising avenue for improving sleep, yet it is well-known that health behaviors are quite difficult and complex to explain, predict, implement, and maintain (Ajzen, 1991). Promotion of healthy lifestyles and practices requires that individuals are aware of health habits that pose risks for future disease, and educational appeals are often utilized that provide information regarding targeted health behavior(s) and associated health outcomes (Taylor, 2012). It is logical to suggest that one must have knowledge regarding a health risk, as well as the health habits that can contribute to the risk, in order to modify behaviors. Widely studied models of health behavior such as the health belief model (Rosenstock, Strecher, & Becker, 1988) and the theory of planned behavior (Ajzen, 1991) inherently assume that one possesses knowledge of a health behavior, and this knowledge can in turn influence consistency of, intentions to perform, and attitudes towards the behavior (Redding et al., 2000).

Thus, it is reasonable to examine if basic sleep knowledge (i.e., importance and function of sleep) is predictive of sleep outcomes (i.e., sleep quality and quantity), and if sleep hygiene knowledge (i.e., what practices improve or impede sleep) is predictive of sleep hygiene behaviors. In the present study, sleep knowledge is defined as accurate information regarding the science and physiology of sleep, factors that influence sleep, sleep requirements, characteristics of sleep disorders, and health outcomes of inadequate sleep. Sleep hygiene knowledge describes accurate information of sleep hygiene practices or behaviors, environmental conditions, and other factors that are believed to affect quantity and quality of sleep.

Research has investigated whether knowledge is predictive of sleep. Among a sample of undergraduate students, Tsai and Li (2004a) found that a sleep education program promoting the importance of sleep and awareness of its function was associated with sleep quality and nap time, but not sleep duration or bedtimes. Reviews of sleep education programs among the general population (Blunden et al., 2012) suggest that associations between sleep knowledge, sleep hygiene, and sleep characteristics are inconsistent, with some studies showing knowledge improves behaviors and sleep outcomes, while other research found no associations. Such findings mirror broader research within the field of health promotion that suggests the impact of educational appeals on health behavior change is limited (Taylor, 2012). While knowledge of the importance of sleep and what sleep hygiene practices influence sleep serves as a foundation for behavior modification, correct information does not guarantee improvements in health or health habits. Knowledge is necessary, but not quite enough (Higginbotham, 1992).

2.3.3 Attitudes towards Sleep and Sleep Hygiene

Attitude change is recognized as an approach to improving health habits (Taylor, 2012) and attitudes have served as significant predictors of health behaviors (Kraus, 1995) such as sun protective behavior (Prentice-Dunn, McMath, & Cramer, 2009) and smoking (Rise, Kovac, Kraft, & Moan, 2008). Attitudes have been conceptualized in various ways within psychological research, with a common definition from the theory of planned behavior describing attitudes as the degree to which a person holds a favorable or unfavorable evaluation or appraisal of a particular behavior (Ajzen, 1991). However, a conceptualization of attitudes as a unidimensional continuum of like-dislike does not adequately capture the complexity of an attitude towards a construct like sleep, which is both a behavior and a neurochemical process required for survival. The “umbrella” definition set forth by Eagly and Chaiken (1993; 2007) provides a more comprehensive framework that describes attitudes as psychological tendencies expressed by evaluating a particular entity (i.e., an attitude object) with some degree of favor or disfavor. The *attitude object* can be abstract or concrete, and the notion of *tendency* within the definition suggests that attitudes are comprised of a propensity, not necessarily of an enduring or temporary basis, to “give rise to judgments as well as other types of responses such as emotions and overt behaviors” (Eagly & Chaiken, 2007, p. 586) towards an attitude object.

The tendency for evaluative responding to the attitude object can be formed or expressed through cognitive, affective, and behavioral processes (Breckler, 1984; Eagly & Chaiken, 2007; Kwon, J., & Vogt, C. A. 2010). The cognitive processes of evaluation are associations established between the attitude object and attributes ascribed to it, such as necessity or burden (Eagly & Chaiken, 2007), as well as thoughts, beliefs, and ideas about the attitude object that can be accumulated throughout one's lifetime (Kwon & Vogt, 2010). Additionally, if the attitude object is a behavior, this component can include beliefs about the outcome of the behavior (Kwon & Vogt, 2010). The affective component refers to positive or negative emotions, feelings, and preferences towards the attitude object, and the behavioral aspect consists of actions, intentions to act, and/or prior behavioral experiences toward the attitude object. The components reflect particular types of information or experiences but are believed to holistically generate evaluations of a targeted entity rather than function as mutually exclusive processes (Eagly & Chaiken, 2007).

The clarification of the construct definition of attitudes is vital, for some research devoted to sleep attitudes has used the term "attitudes" but referred to a very different concept. A validated scale called the Dysfunctional Beliefs and Attitudes about Sleep Scale (DBAS-16; Morin, Vallières, & Ivers, 2007) is increasingly used in sleep research, including studies of sleep and sleep hygiene in young adults (Yang, Pei-Wern, Chou, & Hsiao, 2011) and college students (Woodley & Smith, 2006) that suggest dysfunctional attitudes are salient predictors. Yet attitudes are typically conceptualized as one's own evaluation or like/dislike of a phenomena (Ajzen, 1991; Eagly & Chaiken, 2007; 2011) and therefore cannot be characterized as wrong, faulty, or dysfunctional. Rather than assessing attitudes, the DBAS-16 is a measure of "psychological conceptualization of insomnia," or "faulty beliefs and attitudes about sleep" (Morin et al., 2007, p. 1547). While the title includes the term "attitudes," research suggests the scale actually serves to measure *beliefs*, particularly strong or rigid endorsement of beliefs that can be maladaptive (Carney & Edinger, 2006), and therefore should not be used to conceptualize or measure attitudes towards sleep.

By clarifying the theoretical framework utilized in this study, a *sleep attitude* is therefore the propensity to evaluate sleep with some degree of favor or disfavor that is formed, informed, and expressed by cognitive, affective, and behavioral processes. This definition can capture the complex evaluations and feelings regarding both the biological *necessity* of sleep and the *choice* to sleep, for the framework of attitudes as a tendency rather than a disposition acknowledges that attitudes towards a biological requirement and nightly behavior are not always static. The inclusion of cognitive, affective, and behavioral components also allows for the integration of beliefs regarding biological need for sleep and outcomes of sleep (e.g., restfulness, restoration, optimal functioning), positive or negative evaluations of sleep as important or a priority, emotions associated with sleep (e.g., satisfaction, annoyance, or relief), actions, intentions, and prior behavioral experiences related to sleep, such as skipping sleep to study, intentions to go to bed early, or prior problems making time for sleep.

Considering sleep hygiene is a distinct attitude object from sleep, a *sleep hygiene attitude* is therefore the tendency to evaluate identified sleep hygiene behaviors with some degree of favor or disfavor that are formed, informed, and expressed by cognitive, affective, and behavioral processes. The cognitive components can include beliefs that the sleep hygiene behaviors will or will not produce the expected outcome, such as avoiding caffeine before bedtime will improve sleep quality. Affective components can include feelings or preferences towards the sleep hygiene behaviors, such as positive evaluations of regular exercise or feelings of annoyance towards early bedtimes.

Behavioral components can include prior behavioral experiences with sleep hygiene behaviors, such as ensuring a comfortable room temperature while sleeping, or actions and intended actions, such as planning to sleep in on the weekend.

Sleep researchers are slowly recognizing the importance of attitudes within the field of sleep and health, and studies have assessed the state of attitudes towards sleep among populations across the world, such as out-patient and emergency room patients in Pakistan (Qidwai, Baqir, & Baqir, 2010) and undergraduate medical students in Ethopia (Bosie, Tefera, & Hailu, 2012) and Nepal (Shankar, 2008). Research within American samples has examined attitudes among physicians-in-training in a U.S. residency program (Rosen, Bellini, & Shea, 2004) and collected qualitative data regarding attitudes among a sample of male ages 20-59 (Meadows, Arber, Venn, & Hislop, 2008) and inner city middle school children (Owens, Stahl, Patton, Reddy, & Crouch, 2006). Two studies (Knowlden, Sharma, & Bernard, 2012; Kor & Mullan, 2011) have examined attitudes as predictors of sleep and sleep hygiene specifically within American college students, although results were inconsistent. Both studies conceptualized attitudes within the theory of planned behavior, yet Knowlden and colleagues (2012) found that attitudes significantly predicted behavioral intentions to sleep, while Kor and Mullen (2011) reported no predictive ability of attitudes.

While research specifically within college students is limited and inconsistencies in measurement and a lack of clearly defined cognitive constructs are apparent, the emergence of attitudes research within the field of sleep is very promising. Prior studies reporting that students sacrifice sleep for studying and socializing (Galambos & Dalton, 2009; Orzech et al., 2011), go to bed late (Tsai & Li, 2004a), replace sleep with caffeinated substances (Lohsoonthorn et al., 2013; Malinauskas et al., 2007; Stasio et al., 2011) and forego sleep for technology use (Melton et al., 2014) suggest that sleep is not a priority for this population. Attitudes, therefore, may be predictive of sleep habits and sleep outcomes.

CHAPTER 3: CURRENT STUDY

3.1 Rationale

Regular, sufficient sleep is vital to health and well-being, and college students are particularly vulnerable to sleep loss and poor sleep quality that can increase risk for obesity, high blood pressure, and poor mental health. Research has shown that sleep hygiene behaviors are salient predictors of sleep quality and quantity, and knowledge and attitudes may be important influences in determining sleep hygiene practices and shaping sleep. Thus, the goal of the present study was to examine the relations between sleep knowledge, attitudes, sleep hygiene, and sleep characteristics, as well as test for effects on physical and mental health outcomes. Such examinations could generate empirical evidence for and clarification of modifiable cognitive, attitudinal, and behavioral predictors of sleep variables and corresponding health outcomes. This information could contribute to the literature and possibly inform future intervention efforts.

In a description of necessities for evaluating behavior change within health promotion and disease prevention efforts, Higginbotham (1992) suggests that it is essential to first clearly and precisely identify the behavior to be changed and form a strict definition of the targeted behavior. The present study clearly distinguished between sleep and sleep hygiene behaviors and recognized cognitive and attitudinal predictors of both constructs. This study examined knowledge of both sleep (i.e., basic sleep knowledge and importance of sleep) and sleep hygiene practices (i.e., knowledge of what behaviors improve and impede sleep), which can provide clarification on what information future sleep education efforts should be targeting. The predictive validity of sleep knowledge would suggest the importance of increasing knowledge of sleep in order to improve motivation and intention to sleep regularly, while predictive validity of sleep hygiene knowledge would suggest the need to promote information about what behaviors and environments impact the ability to fall and stay asleep for a consistent amount of time. Similarly, a comprehensive framework for attitudes was clearly defined, and the study distinguished between attitudes towards sleep and sleep hygiene.

By utilizing precise construct definitions and psychometrically and valid measurement tools, the present study contributes to college health literature by testing the predictive ability of knowledge, attitudes, and sleep hygiene behaviors in relation to sleep characteristics. Clarifying such relations can provide a foundation for the design of future sleep education and intervention efforts specifically targeting college students. Further, the examination of indirect effects of sleep and sleep predictors on BMI, blood pressure, and psychological well-being could yield evidence for the impact of sleep on physical and mental health as early as emerging adulthood; such findings can support the notion of prevention efforts within the college population by addressing risk factors for chronic disease later in life.

3.2 Aims and Hypotheses

The first aim of the present study was to test the predictive ability of attitudes towards sleep and sleep hygiene. Prior sleep research has either failed to clearly define the construct of “attitudes,” or has utilized a unidimensional conceptualization. Therefore, no studies have examined the influence of attitudes on sleep and sleep hygiene behaviors as conceptualized within the current study. Utilizing the comprehensive "umbrella" attitudes framework of Eagly and Chaiken (2007; 2011), a researcher-developed scale was created specifically for college students called the Sleep and Sleep Hygiene Attitudes Scale (SSHAS; Peach & Gaultney, in preparation). A series of three studies was conducted to examine the psychometric properties of the SSHAS, and preliminary evidence indicated that the scale was content valid, internally consistent, independent of social desirability, and demonstrated acceptable temporal stability. The questionnaire distinguishes between sleep and sleep hygiene as attitude objects and measures both sleep attitudes and sleep hygiene attitudes. Thus, the current study used this measure of attitudes to first test associations with sleep and sleep hygiene. The models also included knowledge to determine if both predictors significantly contribute to variance in sleep and sleep hygiene. Hypotheses include:

H1: Sleep attitudes and sleep knowledge predict self-reported typical sleep quality and sleep duration, such that more favorable attitudes and greater knowledge are associated with better sleep quality and longer sleep duration.

H2: Sleep hygiene attitudes and sleep hygiene knowledge predict self-reported sleep hygiene behaviors, such that more favorable attitudes and greater knowledge are associated with less frequent engagement in poor sleep hygiene behaviors (See Figure 1).

The second aim of the present study was to determine the strength of associations of knowledge, attitudes, sleep hygiene behaviors and *objective* measures of sleep. Research has shown sufficient agreement between self-reported sleep duration and objective measurement such as actigraphy (Gangwisch et al., 2006), but objective measurement tools are preferred as a more accurate assessment of sleep characteristics. In comparison to polysomnography, the gold-standard of sleep measurement, activity monitoring technologies serve as adequate measurement devices for measuring sleep characteristics in normative population and can generate measures of sleep duration and sleep efficiency, an aspect of sleep quality defined as the time spent asleep divided into the time spent in bed (Montgomery-Downs, Insana, & Bond, 2012). Informed by prior research examining knowledge as a predictor of health behaviors, we expected sleep hygiene behaviors to be the strongest predictor of actigraphic sleep duration and sleep efficiency, followed by attitudes. Hypotheses included:

H3: Sleep knowledge, sleep attitudes, and sleep hygiene predict actigraphic measures of sleep duration and sleep efficiency (see Figure 2).

H4: Sleep hygiene knowledge and sleep hygiene attitudes indirectly predict actigraphic measures of sleep duration and sleep efficiency through associations with sleep hygiene (see Figure 3).

While Aims 1 and 2 were geared toward providing information regarding the predictive power of sleep knowledge and attitudes, Aim 3 centered upon the identification of direct and mediated pathways to salient health outcomes of poor sleep and sleep hygiene. Thus, the third aim of the study was to determine if self-reported and objective measures of sleep predict the health outcomes of blood pressure, BMI, and mental health, measured as both depressive symptoms and subjective well-being. The present study also tested if sleep hygiene behaviors indirectly predict health outcomes through associations with sleep. The Hypotheses included:

H5: Actigraphic measures of sleep duration and sleep efficiency directly predict BMI, blood pressure, mental health (operationalized as depression and subjective well-being), and sleep hygiene yields indirect effects via associations with sleep duration and efficiency.

H6: Self-reported measures of typical sleep duration and sleep quality directly predict BMI, blood pressure, and mental health (operationalized as depression and subjective well-being), and sleep hygiene yields indirect effects via associations with sleep duration and quality.

CHAPTER 4: METHODOLOGY

4.1 Participants

Participant inclusionary criteria for the present study consisted of current enrollment as an undergraduate college student and a required age between 18 and 25 years. These criteria were selected in order to analyze sleep and associated variables among traditional undergraduate college students in the developmental stage of emerging adulthood (Arnett, 2000; 2007; Knowlden et al., 2012). A power analysis was conducted to determine the targeted sample of the current study. Selected parameters were based upon criteria set within Knowlden and colleagues' (2012) study of attitudes and sleep among undergraduate college students; the researchers estimated an alpha of .05, a power of .80, and a population correlation coefficient of .20 in determining a sufficient sample size for evaluating the predictive validity of attitudes and related constructs. Using these criteria, we conducted a power analysis using G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) and found a sample size of 150 to fit the estimated parameters.

4.2 Procedure

Participants (N = 149) were recruited at an urban southeastern university through general psychology courses using the department online research recruitment system. Survey data were collected using a Qualtrics survey website and FitBit accelerometers (i.e., activity monitoring technology used in the present study for objective sleep measures). Using the online research recruitment system, student participants were recruited and offered research credits or extra credit as compensation for their time.

Participants met for an in-person Time 1 session during their scheduled time. Participants were asked to complete a series of online questionnaires. Participants were then asked to sit comfortably while the researcher took five blood pressure readings using an automated blood pressure monitor on the participants' non-dominant arm. The readings were recorded. Participants were then asked to stand, and the researcher used a tape measure to measure the participant's height. Participants were then asked to step on a digital bathroom scale to yield a measure of weight in pounds. Height and weight were recorded by the researcher.

Participants were then provided with a FitBit Flex wristband, and a charging cable and were briefed on instructions for wearing the wristband. All participants were given the option of downloading the FitBit app on their smartphones if they were interested in monitoring their own activity and sleep throughout the study. Participants were instructed to wear the wristband for seven consecutive days and nights, only removing the wristband when swimming or charging the device. Participants were asked to charge the FitBit Flex on the fourth day of the week, during the day, and then place the wristband back on before going to sleep that night. The participants were asked to "enter sleep mode" on the FitBit Flex each night at bedtime and exit sleep mode upon awakening. Participants received email reminders to set the FitBit Flex into sleep mode and to provide daily sleep logs. Participants were asked to complete daily sleep logs via Qualtrics surveys in which they reported bedtime, wake time, subjective sleep quality, and daytime sleepiness. The sleep logs included reminders for FitBit instructions of entering and exiting sleep mode. Participants were emailed daily sleep logs to ensure logs are in fact completed daily. If sleep logs were not completed by 5:00pm, additional email reminders were sent.

Participants were emailed an electronic version of the FitBit Flex manual as a resource. Participants signed up for a follow-up Time 2 session seven days later upon which they returned the FitBit and charging cable. They were also provided the contact information of the study researchers in case any questions or technical difficulties arose throughout the study. Participants returned the FitBit Flex wristbands and charging cables during their scheduled follow-up session, and their FitBit Flex devices were synced to a lab computer to extract data. Participants also completed another shorter series of online questionnaires (measures of depression and subjective well-being). Utilizing the same protocol as Time 1, five blood pressure readings were measured, as well as height and weight.

4.3 Measures

Demographic questions included age, year in school, gender, marital status/number of children, residence on or off campus, roommate status, major, and if the participant had ever been diagnosed with a sleep disorder. Participants were asked to indicate whether or not they provided consent for the researchers to access GPA records.

4.3.1 Cognitive, Affective, and Behavioral Measures

Knowledge: Sleep knowledge was measured using items from the Test Your Sleep I.Q. interactive sleep quiz provided by the National Center on Sleep Disorders Research website (http://www.nhlbi.nih.gov/about/org/ncsdr/patpub/sleepquiz.htm). This 10-item quiz includes statements regarding the functioning of sleep, sleep disorders, and impact of sleep on health (i.e., Sleep is a time when your body and brain shut down for rest and relaxation; If you regularly doze off unintentionally during the day, you may need more than just a good night's sleep). Participants indicated correctness of each statement by choosing "True" or "False." Each correct answer was coded as 1 point, and all items were summed such that higher scores indicate more sleep knowledge. Sleep hygiene knowledge was measured using the Sleep Beliefs Scale (SBS; Adan, Fabbri, Natale, & Prat, 2006). The SBS is a "psychometric instrument that allows the detection of the wrong sleep beliefs, assessing behaviors and cognitions incompatible with sleep" (Adan et al., 2006, p. 126) and asks participants to report how specific behaviors may influence quality and/or quantity of sleep in a positive, negative, or neutral manner. This scale includes items such as "Going to bed on an empty stomach" and "Diverting one's attention and relaxing before bedtime." Correct answering corresponds to a negative effect for all items except items 5, 9, 15, and 19 (which have a positive effect); thus, scores were coded such that correct responses receive 1 point, and all points were summed to create a total score. Higher scores indicate more correct beliefs about sleep behaviors. The scale demonstrated acceptable internal consistency (α =.67).

Attitudes: Sleep and sleep hygiene attitudes were measured using the SSHAS (Peach & Gaultney, in preparation). This 24-item scale includes a10-item measure of two dimensions of sleep attitudes (i.e., Sleep benefits/enjoyment and Sleep as a time commitment subscale) and a 14-item measure of four dimensions of sleep hygiene attitudes (i.e., Favorable sleep timing, Quiet sleep environment, Dark sleep environment, and Comfortable sleep environment).These items can be scaled as total attitude scores or quantified as subscales. Items that are negatively worded (i.e., indicating more unfavorable attitudes towards sleep and sleep hygiene) were reverse coded. Items for total scores and subscores were averaged, such that higher scores indicate more favorable attitudes towards sleep and/or sleep hygiene. Evidence suggests the scale is content valid and independent of social desirability. The scale has demonstrated reasonable internal consistency (α =.60 to .89) and sufficient temporal stability (*r* = 57 to .78) for total scales and subscales. In the current study, internal consistency estimates for the total scale (α =.86), sleep attitudes subscale (α =.78), sleep benefits/enjoyment subscale (α =.80), sleep as a time commitment subscale (α =.80), sleep hygiene attitudes subscale (α =.81), favorable sleep timing subscale (α =.78) , quiet sleep environment subscale (α =.90), dark sleep environment subscale (α =.76), and comfortable sleep environment subscale (α =.60) were reasonable.

Sleep hygiene: Sleep hygiene behaviors were measured using the Sleep Hygiene Practice Scale (SHPS). The SHPS (Lin, Cheng, Yang, & Hsu, 2007; Yang, Lin, Hsu, & Cheng, 2010) measures practices of daily life activities and sleep habits that can negatively impact sleep. The scale includes 30 items comprised of four hygiene domains (arousal-related behaviors, sleep scheduling and timing, eating/drinking behaviors, and sleep environment) that ask participants to rate how frequently they engage in each behavioral practice. Responses are indicated on a 6-point Likert scale ranging from 1 (never) to 6 (always). Items from each domain were summed to yield a total score and four subscores with higher scores indicating worse sleep hygiene. Prior findings produced Chronbach's alpha coefficients of .70 and .58 for arousal-related behaviors, .67 and .65 for sleep environment, .72 and .70 for eating/drinking habits, and .82 and .74 for sleep scheduling, respectively (Yang et al., 2010). In the present study, internal consistency estimates for the total scale (α =.86), arousal-related behaviors subscale (α =.72), sleep environment subscale (α =.78), eating/drinking habits subscale (α =.58), and sleep scheduling subscale (α =.69) were reasonable.

4.3.2 Sleep Measures

Sleep: Typical subjective sleep quantity and quality were measured via the Pittsburgh Sleep Quality Index (PSQI). The PSQI (Buysse et al., 1989) is a widely accepted, reliable and validated standardized measure of sleep quality over the "past month." The scale yields measures of sleep duration, as well as discriminates between "good" and "poor" sleepers. The scale includes 19 self-rated questions. Item scores can be calculated to yield a "global sleep score," as well as yield subscores of sleep disturbance, sleep latency, day dysfunction due to sleepiness, sleep efficiency, overall sleep quality, and necessity of medication in order to sleep. In the present study, PSQI self-reported sleep quality was measured via the item "During the past month, how would you rate your sleep quality overall?" on a scale ranging from 0 (very good) to 3 (very bad). This item was reverse coded such that high scores indicated better sleep quality. PSQI self-reported sleep duration was measured via the item "How many hours of actual sleep do you get at night? (This may be different than the number of hours you spend in bed)." Higher scores indicated longer sleep durations. Daily bedtime, wake time, subjective sleep quality and daytime sleepiness were also self-reported via sleep logs. For seven consecutive days, participants completed a 1-item scale of last night's sleep quality and a 1-item scale of current sleepiness, as well as reported bedtime and wake time.

Objective sleep quality and quantity were measured using FitBit® Flex activity monitoring. FitBits are wristband accelerometers that include Sleep Mode tracking. The

FitBits recorded data in 1-minute epochs, and minutes identified as sleep and wake were extracted and downloaded to the user website via the device's USB docking port. The FitBit uses three-dimensional motion sensing technology similar to the device that is used in the Nintendo Wii. According to Montgomery-Downs and colleagues (2012), "the manufacturer's site reports that, 'Sleep data from the Tracker correlates very strongly with results from polysomnograms found in sleep labs' but no evidence of this is provided" (p.914). FitBit data included total hours of sleep per night and sleep efficiency, calculated as time asleep / (total time in bed – time to fall asleep). Research suggests the FitBits serve as an affordable and acceptable activity measurement instrument for use with a normative population, although accuracy is limited in comparison to polysomnography (Montgomery-Downs et al., 2012). Sleep durations and sleep efficiency scores on weekday nights (i.e., Monday-Friday) were averaged to generate single estimates of weekday sleep duration and sleep efficiency. The same were conducted among sleep durations and sleep efficiency scores on weekend nights (i.e., Saturday-Sunday) to generate single estimates of weekend sleep duration and sleep efficiency. A recent study (Perez-Macias, Jimison, Korhonen, & Pavel, 2014) utilizing FitBit devices for a 7-10 day trial required recordings from at least three nights in order to be included in final analyses, therefore a minimum of two nights for weekday sleep and one night of weekend sleep were required for calculations in the present study.

4.3.3 Health Outcomes Measures

Mental health: Both positive (i.e., subjective well-being) and negative (i.e., depression) characteristics of mental health were measured. Subjective well-being was measured using the BCC Subjective Well-Being Scale (BCC-SWB; Kinderman, Schwannauer, Pontin, & Tai, 2011). The BCC-SWB is a 24-item scale demonstrating via factor analysis three distinct subscales of psychological well-being, physical health and well-being, and relationships. For scoring, item 4 was reverse scored. Item 14 (Do you feel able to grow and develop as a person?), an item within the psychological well-being subscale, was missing values for 11.3% of the sample; available data for item 14 significantly correlated with all other items in the psychological well-being subscale (r = .47-.71, p <.001), and the Chronbach's alpha coefficients for the subscale was .92. Therefore missing values were imputed as the average score of the eleven other items (i.e., items 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 15) in the psychological well-being subscale. After imputing missing values for item 14, items were summed to generate a total score as well as three subscores. The total 24-item scale has demonstrated good internal consistency (α = .93) and has shown significant associations with key demographic variables and measures of concurrent validity (Pontin, Schwannauer, Tai, & Kinderman, 2013). A recent study (Pontin et al., 2013) validated the scale in a sample of 23,341 participants using a 5-point Likert scale ranging from 1 (Never) to 5 (Almost Always) and demonstrated significant correlations with scores on the Goldberg Anxiety and Depression Scales and the List of Threatening Experiences Questionnaire. In the present study, internal consistency estimates for the total scale (α = .93), and psychological well-being subscale (α = .92) are excellent; internal consistency estimates for the physical health well-being subscale (α = .79) and relationships subscale (α = .74) are good. The scale demonstrated good temporal stability (r = 87) from Time 1 to Time 2 (i.e., seven day timespan).

Additionally, depression was measured via the Center for Epidemiologic Studies Depression Scale (CES-D) Short-Form. The CES-D (Radloff, 1977) is one of the mostly widely used and validated measures of depressive symptoms. The short-form scale includes 10 items pertaining to feelings and behaviors during the past week with Likert response scales ranging from 0 (rarely or none of the time) to 3 (most or all of the time). Items that describe positive experiences were reverse coded, and scores were summed, with higher total scores indicating more depressive symptoms. In the present study, the scale demonstrated good internal consistency (α =.80) and sufficient temporal stability (*r* = 74) from Time 1 to Time 2 (i.e., seven day timespan).

Body mass index: Height and weight were measured by the primary investigator or undergraduate research assistants using a tape measure and an Ozeri Rev Digital Bathroom Scale with Electro-Mechanical Weight Dial, respectively. Height was measured in inches and weight was measured in pounds. BMI was calculated using the standard formula (e.g., Keys et al., 1972; Heymsfield et al., 2007) of weight (lb) / [height (in)]^2 x 703. BMI was used to create the following obesity classifications: underweight (BMI <18.5), normal weight (BMI 18.5-24.99), overweight (BMI 25-29.99), and obese (BMI 30+).

Blood pressure: Blood pressure was taken by the ReliOn™ 741CREL digital blood pressure monitor. Research assistants were trained on application of blood pressure determination using the oscillometric technique (Pickering et al., 2005). After the participant had been seated comfortably for five minutes, five readings were taken using the participant's non-dominant arm. These five readings were recorded by the researcher, and the last three readings were averaged to create a single, stable resting blood pressure index (Pickering et al., 2005). Average readings were utilized to classify participants as normotensive (systolic blood pressure <120 and diastolic blood pressure <80), prehypertensive (systolic blood pressure 120-139 or diastolic blood pressure 80-89), Stage 1 hypertensive (systolic blood pressure 140-159 or diastolic blood pressure 90-99), or Stage 2 hypertensive (≥160 or diastolic blood pressure ≥100).

4.4 Analytical Plan

All measures were scaled according to survey instructions. Using the SPSS statistical software package, descriptive statistics for all variables were examined to ensure data are normal via reasonable standard deviations and means with no signs of outliers or entry errors, but also contain enough variance to be analyzed. To test Hypotheses 1-3, correlations were first examined to determine if total scales or subscales would be included in final analyses. Then a series of hierarchical multiple regression analyses was conducted. Knowledge variables were entered into block 1 of the model, and attitude scores were entered into block 2 to allow for the examination of changes in R^2. To test Hypothesis 1, self-reported typical sleep duration and sleep quality were regressed onto sleep attitude scores and sleep knowledge scores. To test Hypothesis 2, analyses were examined in which sleep hygiene was regressed onto sleep hygiene attitude scores and sleep hygiene knowledge scores. To test Hypothesis 3, actigraphic measures of weekday sleep duration, weekend sleep duration, weekday sleep efficiency, and weekend sleep efficiency were regressed onto sleep hygiene, sleep knowledge, and sleep attitudes.

Using the MPlus statistical software package (Muthén & Muthén, 2010), a series of structural equation modeling (SEM) analyses was conducted to examine models presented in Figures 3-4. SEM allows for the estimation of direct effects, indirect effects, and standard errors when multiple predictors, mediators, and/or outcome variables are present. Confidence intervals (CI) and significance testing for indirect effects were calculated via bootstrapping with 500 bootstrap iterations.

To test Hypothesis 4, SEM was employed to test model fit, calculate direct and indirect effects, and determine strength of regression coefficients. Correlations were first examined; the correlation between actigraphic sleep duration and sleep efficiency measures determined if both outcomes were included within the same or separate models. SEM was employed separately for weekday and weekend measures of sleep.

To test Hypotheses 5-6 (see Figure 4), SEM analyses were conducted to test model fit, calculate direct and indirect effects, and determine strength of regression coefficients. Measures of BMI, blood pressure, subjective well-being, and depression from Time 2 were used for these analyses to allow for time precedence in the mediation models such that all predictors preceded the outcome variables by seven days. Correlations were examined to provide the associations between BMI, blood pressure, subjective well-being, and depression measures; correlations determined whether the health outcomes were included within the same or separate models. Separate models were tested to determine the mediating effects of objective (i.e., Hypothesis 5) and subjective (i.e., Hypothesis 6) sleep measures.

CHAPTER 5: RESULTS

5.1 Preliminary Analyses.

Of the 149 participants who completed the study, six did not mean the inclusionary criteria of a required age between 18 and 25 years, and one participant completed the study in both the fall and spring semester of data collection; therefore seven cases were removed from analyses, leaving a final sample size of 142 participants. Full data were available for all Time 1 data except self-reported sleep quality, whereby 12 participants failed to answer this question within the survey. Time 2 depression, subjective well-being, BMI, and blood pressure data were missing for 16 participants, and actigraphic sleep duration and sleep efficiency were missing for 15 and 19 participants, respectively. Some data were missing at random due to FitBit technical errors and changes in protocol with measures recorded at Time 2. However some missing data were due to participants forgetting to enter the FitBit into sleep mode. Data were not imputed for the present study; listwise deletion was utilized for each analysis.

Demographic information for the total sample is provided in Table 1. The sample was majority female (77.5%) and approximately 50% White/Caucasian with an average age of 19.84 years. Descriptions of all variables are included in Table 2 and demonstrated that all variables yielded reasonable means and variability. Self-reported typical sleep duration (6.99 hours), as well as actigraphic measures of weekday sleep duration (7.04 hours) and weekend sleep duration (7.48 hours) approximately met the nationally recommended 7-8 hours per night for this age group (National Heart, Lung, and Blood Institute, 2011). Self-reported sleep duration was moderately correlated with actigraphic measures of weekday sleep duration (r = .40, p < .001) but weakly correlated with actigraphic measures of weekend sleep duration (r = .17, p = .06). On average, participants self-reported sleep quality (1.79) as slightly less than “fairly good,” and actigraphic measures of weekday and weekend sleep efficiency were 94.05% and 94.01%, respectively, suggesting high averages of sleep efficiency. Self-reported sleep quality significantly correlated with self-reported sleep duration (r = .42, p < .001) but did not correlate with any actigraphy data. Actigraphic sleep durations and sleep efficiency measures were all significantly correlated (r = .28-38, p < .001).

One participant self-reported a diagnosis of restless leg syndrome, four self-reported a diagnosis of bruxism (i.e., teeth grinding), and six participants self-reported a diagnosis of insomnia. Nine participants reported taking medications that may affect sleep, including Adderall, allergy medicine, buspirone, trazodone, melatonin, and methylphenidate (i.e., Ritalin). Of the total sample, 76.4% were classified as normotensive, 18.9% were classified as prehypertensive, and 4.7% were classified as Stage 1 hypertensive. Based on BMI obesity classification cutoffs, 7.1% of participants were underweight, 62.2% were of normal weight, 22% were overweight, and 8.7% were obese.

Females reported higher sleep hygiene knowledge (t(129) = -2.33, p <.05), worse arousal-related sleep hygiene practices (t(139) = -2.32, p <.05), worse sleep scheduling hygiene practices (t(139) = -2.24, p <.05), greater relationship well-being (t(40.83) = -2.90, p <.01), and lower resting systolic blood pressure (t(125) = 6.03, p <.001).

Participants who self-reported a sleep disorder (*N*=11) reported better arousal-related sleep hygiene practices ($t(140) = 3.03$, $p < .05$) and had shorter actigraphic weekend sleep durations ($t(121) = 2.07$, $p < .05$) than those who reported no known sleep disorders. Participants who reported taking medications that affect sleep (*N*=9) reported worse sleep quality ($t(123) = 3.21$, $p < .01$), less favorable sleep attitudes on the benefits/enjoyment subscale ($t(123) = -2.12$, $p < .05$), better sleep knowledge ($t(123) = 2.32$, $p < .05$), worse overall sleep hygiene practices ($t(123) = 2.09$, $p < .05$), worse arousal-related sleep hygiene practices ($t(123) = 2.57$, $p < .05$), and worse sleep environment hygiene practices ($t(123) = 2.42$, $p < .05$). One-way ANOVAs revealed that none of the primary variables significantly differed by year in school.

5.2 Planned Analyses

Hypothesis 1: The first hypothesis posited that sleep attitudes and sleep knowledge would predict self-reported typical sleep quality and sleep duration, with more favorable attitudes and greater knowledge being associated with better sleep quality and long sleep duration. Correlations of primary variables are presented in Table 3. The total attitudes score, sleep attitudes subscale, sleep hygiene subscale, sleep benefits/enjoyment subscale, sleep as a time commitment subscale, and favorable sleep timing subscale all significantly correlated with sleep duration and sleep quality. The quiet sleep environment subscale also significantly correlated with sleep quality. To examine associations between sleep attitudes and self-reported sleep outcomes, the sleep attitudes subscale was included in regression analyses. As shown in Table 4, sleep knowledge did not significantly predict self-reported sleep duration or sleep quality; however sleep attitudes significantly predicted both self-reported sleep outcomes, accounting for 19% of the variance in sleep duration and 18% of the variance in sleep quality. Hypothesis 1 was partially supported, such that more favorable sleep attitudes predicted better self-reported sleep quality and longer sleep duration.

Hypothesis 2: The second hypothesis posited that sleep hygiene attitudes and sleep hygiene knowledge would predict self-reported sleep hygiene behaviors, with more favorable attitudes and greater knowledge being associated with less frequent engagement in poor sleep hygiene behaviors (See Figure 1). As shown in Table 5, sleep hygiene knowledge did not significantly predict the total sleep hygiene score or any sleep hygiene subscale scores. However, sleep hygiene attitudes significantly predicted total sleep hygiene practices, accounting for 12% of the variance. Sleep hygiene attitudes also predicted all four sleep hygiene subscale scores, accounting for 5-9% of the variance in each outcome. Hypothesis 2 was partially supported, such that more favorable sleep hygiene attitudes predicted better sleep hygiene practices.

Hypothesis 3: The third hypothesis posited that sleep knowledge, sleep attitudes, and sleep hygiene would predict actigraphic measures of weekday and weekend sleep duration and sleep efficiency (see Figure 2). Correlations of actigraphic measures of sleep with sleep knowledge, sleep attitudes, and sleep hygiene variables are presented in Table 6. Using hierarchical multiple regression (see Table 7), the full models accounted for 4-11% of the variance in sleep outcomes. Similar to analyses examining self-reported sleep outcomes, sleep knowledge did not significantly predict any actigraphic sleep outcomes, although associations of sleep knowledge and actigraphic weekday sleep duration approached significance. Sleep attitudes uniquely accounted for 8% and 4% of the variance in weekday and weekend sleep duration, respectively, but did not significantly predict weekday or weekend sleep efficiency. Sleep hygiene did not significantly predict any actigraphic sleep variables, although associations with weekend sleep efficiency approached significance. Hypothesis 3 was partially supported in that only sleep attitudes significantly related to actigraphic measures of weekday and weekend sleep duration.

Hypothesis 4: The fourth hypothesis posited that sleep hygiene knowledge and sleep hygiene attitudes would indirectly predict actigraphic measures of sleep duration and sleep efficiency through associations with sleep hygiene (see Figure 3). Weekday and weekend actigraphic measures of sleep were examined within separate SEM models. Correlations between weekday sleep duration and sleep efficiency (r = .38, p <.001) and weekend sleep duration and sleep efficiency (r = .38, p <.001) revealed significant associations, therefore both outcomes were included within the same model.

Model fit indices including the comparative fix index (CFI) and the Tucker-Lewis index (TLI) are commonly used fit statistics for examining structural equation models, with recommended cut-offs of .90 to suggest a good-fitting model. Root mean squared error of approximation (RMSEA) is also commonly used and yields a recommended cut-off of .08 or lower to suggest acceptable fit. Model fit indices for actigraphic weekday sleep measures data (X^2 = 22.28, CFI = .76, TLI = .32, RMSEA = .14) and weekend sleep measures (X^2 = 23.23, CFI = .73, TLI = .39, RMSEA = .14) suggest a questionable fit for the data. Results for the two SEM analyses are provided in Table 8. Path weights demonstrate that sleep hygiene knowledge had no significant indirect effects on weekday sleep duration, weekday sleep efficiency, weekend sleep duration, or weekend sleep efficiency. Sleep hygiene attitudes yielded a significant indirect effect on weekday and weekend sleep efficiency via the pathway of sleep hygiene, but did not yield indirect effects on weekday or weekend sleep duration. Thus, Hypothesis 4 was partially supported, such that only sleep hygiene attitudes yielded indirect effects on weekday and weekend sleep efficiency.

Hypothesis 5: The fifth hypothesis posited that actigraphic measures of sleep duration and sleep efficiency would directly predict BMI, blood pressure, and mental health, operationalized as depression and subjective well-being. Additionally, it was predicted that sleep hygiene would yield indirect effects via associations with actigraphic sleep duration and efficiency. To determine if outcome variables would be included in separate models, correlations of health outcomes were examined. The mental health variables of depression and subjective well-being were strongly correlated (r = -.69, p <.001) and the physical health outcome of BMI significantly correlated with systolic blood pressure (r = .34, p <.001), although not with diastolic blood pressure (r = .05, p =.67). BMI did not significantly correlate with depression (r = .12, p <.18) or subjective well-being (r = -.17, p = .06). Systolic blood pressure significantly correlated with depression (r = .21, p <.05) and subjective well-being (r = -.22, p <.05), but diastolic blood pressure did not yield significant correlations with depression (r = .16, p = .08) or subjective well-being (r = -.09, p = .32). Considering such, separate models were analysed: models including physical health variables (i.e., BMI, systolic blood pressure, and diastolic blood pressure) and models including mental health variables (i.e., depression and subjective well-being).

Models examining direct and indirect effects on physical health outcomes are presented in Table 9. Model fit indices for weekday sleep measures data (X^2 = 18.48, CFI = .84, TLI = .40, RMSEA = .16) suggested a questionable fit for the data. Path weights indicated that weekday sleep duration directly predicted BMI (*b* = -.67, CI [-1.31, -.03]) and weekday sleep efficiency directly predicted diastolic blood pressure (*b* = -.40, CI [-.67, -.13]). Sleep hygiene did not yield any significant indirect effects on BMI, systolic blood pressure, or diastolic blood pressure. Model fit indices for weekend sleep measures data (X^2 = 21.49, CFI = .81, TLI = .29, RMSEA = .18) also suggested a questionable fit for the data. Weekend sleep efficiency directly predicted diastolic blood pressure (*b* = -.35, CI [-.58, -.10]), and sleep hygiene indirectly predicted diastolic blood pressure via weekend sleep efficiency (*b* = .03, CI [.001, .05]).

Models examining direct and indirect effects on mental health outcomes are presented in Table 10. Model fit indices for weekday sleep measures data (X^2 = 43.45, CFI = .69, TLI = -.05, RMSEA = .31) suggest a poor fitting model. Surprisingly, path weights indicate that neither weekday sleep duration nor weekday sleep efficiency directly predict subjective well-being or depression. Sleep hygiene yielded no significant indirect effects on mental health outcomes. Model fit indices for weekend sleep measures data (X^2 = 45.46, CFI = .60, TLI = -.05, RMSEA = .32) also suggest a poor fitting model. Only weekend sleep efficiency directly predicted depression (*b* = -.24, CI [-.43, -.05]). Sleep hygiene yielded no indirect effects on mental health outcomes. Hypothesis 5 was partially supported in that not all actigraphic measures predicted physical and mental health outcomes; only actigraphic weekday sleep duration predicted BMI, while sleep efficiency predicted diastolic blood pressure (both weekday and weekend) and depression (weekend). Sleep hygiene only yielded indirect effects to diastolic blood pressure.

Hypothesis 6: The sixth hypothesis posited that self-reported measures of typical sleep duration and sleep quality would directly predict BMI, blood pressure, and mental health (operationalized as depression and subjective well-being), and sleep hygiene would yield indirect effects via associations with sleep duration and quality. Again, physical and mental health outcomes were examined in separate models.

Results examining effects on physical health outcomes are reported in Table 11. Model fit indices for physical health outcomes (X^2 = 15.50, CFI = .90, TLI = .60, RMSEA = .14) suggest a questionable fit for the data. There were no significant direct or indirect effects on BMI, systolic blood pressure, or diastolic blood pressure via self-reported measures of sleep.

Results examining effects on mental health outcomes are reported in Table 12. Model fit indices for physical health outcomes (X^2 = 32.88, CFI = .83, TLI = .43, RMSEA = .27) suggest a poor fitting model. While self-reported sleep duration yielded no significant effects on mental health, self-reported sleep quality yielded significant direct effects on subjective well-being (*b* = 8.17, CI [4.7, 11.57]) and depression (*b* = -.38, CI [-5.34, -2.07]). Self-reported sleep quality also yielded significant indirect effects via sleep hygiene on subjective well-being (*b* = -.12, CI [-.19, -.04]) and depression (*b* = .05, CI [.02, .09]). Hypothesis 6 was partially supported in that physical health was not associated with self-reported measures of sleep, but self-reported sleep quality was directly and indirectly associated with mental health outcomes.

5.3 Secondary Analyses

Secondary analyses examined hypertension classification as the outcome within the proposed model for Hypothesis 5 rather than separate measures of systolic and diastolic blood pressure. Model fit indices for actigraphic weekday (X^2 = 18.67, CFI = .39, TLI = -.83, RMSEA = .25) and weekend (X^2 = 20.94, CFI = .35, TLI = -.95, RMSEA = .26) sleep measures suggest a questionable fit for the data. However, results (see Table 13) demonstrated that actigraphic weekday (b=-.03, p <.005) and weekend b=-.03, p <.01) sleep efficiency predicted hypertension classification, with sleep hygiene yielding significant indirect effects via weekend sleep efficiency (b=-.03, p <.005, CI[.00, .003]).

CHAPTER 6: DISCUSSION

6.1 Summary of Main Findings

The present study examined associations between knowledge, attitudes, sleep hygiene, and self-reported sleep, while also testing the effects of sleep hygiene and both subjective and objective measures of sleep on physical and mental health outcomes salient among college students. Findings provided empirical support for the predictive validity of sleep and sleep hygiene attitudes measured via the SSHAS (Peach & Gaultney, in preparation) and shed light on potential links from sleep hygiene behaviors and sleep characteristics to depression, subjective well-being, and resting blood pressure among a sample of American college students. Despite several limitations of the present study, findings yield empirical and application implications, as well as directions for future research.

Results from the present study demonstrated the predictive power of a newly-created and theoretically sound attitudes scale (Peach & Gaultney, in preparation). Sleep attitudes served as a significant predictor of self-reported and actigraphic sleep duration, as well as subjective reports of sleep quality. Sleep hygiene attitudes significantly predicted sleep hygiene practices and indirectly predicted actigraphic estimates of sleep efficiency. Results showed that knowledge of sleep and sleep hygiene yielded no associations with any self-reported or actigraphic measures of sleep. These results contribute to a body of inconsistent findings whereby some studies demonstrate significant associations between knowledge and sleep behaviors/outcomes, while others yield null results (Blunden et al., 2012).

Findings are novel in that, to our knowledge, no other studies of college students have compared the influence of both knowledge and attitudes towards sleep and sleep hygiene to determine which influence is stronger. While other studies (Knowlden et al., 2012; Kor & Mullan, 2011) have tested attitudes as predictors of sleep and sleep hygiene, our study contributes significantly to the literature by examining effects sizes of attitudes and knowledge within the same model. Further, the present study utilized a validated measure of sleep attitudes and sleep hygiene attitudes (Peach & Gaultney, in preparation), which to date has not been reported within the sleep literature.

Such findings lay the foundation for future research to test if changing attitudes translates into changes in sleep hygiene behavior; if such findings were evident, intervention strategies geared towards modifications of *attitudes,* rather than or in addition to the attainment of *knowledge* regarding sleep, may prove effective. In other words, how favorably one views sleep and sleep hygiene practices may generate a stronger influence on one's engagement in sleep hygiene behaviors and ability to achieve sufficiently long and sound sleep. These findings provide support for the limited impact of educational appeals and shed light on why prior sleep intervention programs among the college population have yielded limited efficacy. Previous sleep education programs among college students have been successful in actually improving sleep knowledge (e.g., Blunden et al., 2012; Kloss et al., 2014; Quan, Anderson, & Hodge, 2013), yet if knowledge yields little impact on behavior change, educational appeals may be in vain. In line with this argument, a review of 12 school-based sleep education studies (Blunden et al., 2012) found that most studies reported significant improvement in sleep knowledge, but only some studies found improved sleep hygiene and/or increases in sleep duration. A dissertation study piloting a college sleep education program found no impact of knowledge on sleep hygiene or sleep outcomes (Lamberti, 20013), and another sleep education program yielded “mild and limited effect on sleep patterns” among college students (Tsai & Li, 2004a, p. 837). However, some education studies have noted small but significant changes in sleep hygiene (Brown, Buboltz, & Soper, 2006), sleep quality (Brown et al., 2006; Tasi & Li, 2004a), sleep latency (Kloss et al., 2014), and nap time (Tasi & Li, 2004a). Future intervention programs may seek to incorporate the improvement of both knowledge and attitudes towards sleep and sleep hygiene to determine if modifications in one construct yield stronger effects, or if the combination of better knowledge and favorable attitudes yields the greatest change in sleep hygiene and/or sleep outcomes.

While findings shed light on the importance of attitudinal variables in relation to sleep and sleep hygiene, results from the present study also suggest possible links between sleep, sleep hygiene, and health outcomes relevant to college students. Actigraphic weekday and weekend sleep efficiency significantly predicted diastolic blood pressure. Further, sleep hygiene yielded indirect effects to diastolic blood pressure via sleep efficiency. Systolic blood pressure (i.e., arterial pressure when the heart beats and heart muscle contracts) and diastolic blood pressure (i.e., arterial pressure between heartbeats when the heart muscle is resting and refilling with blood) have been examined to determine independent associations with hypertension risk. While diastolic blood pressure was traditionally viewed as the most important element of blood pressure, a multitude of research has confirmed the importance of systolic blood pressure in hypertension risk (Strandberg & Pitkala, 2003). However, the combination of systolic and diastolic pressure together improves risk prediction (Strandberg & Pitkala, 2003), and secondary analyses within the present study that examined hypertension classification as the outcome showed that actigraphic weekday and weekend sleep efficiency predicted hypertension classification, with sleep hygiene yielding significant indirect effects via weekend sleep efficiency. Taken together, results from the present study suggest that sleep, and in turn sleep hygiene, may impact resting diastolic blood pressure and risk for hypertension in college students. The identification of risk factors for hypertension in adolescence and young adulthood is vital for preventing and predicting hypertension later in life (Toschke, Kohl, Mansmann, & von Kries, 2010), thus greater research is needed to examine elevated blood pressure and associated risk factors in young populations (Riley, Dobson, Sen, & Green, 2013). Research has shown associations between self-reported sleep duration and hypertension risk in young adolescents (Peach, Gaultney, & Reeve, 2015), as well as associations of blood pressure with self-reported sleep duration and sleep efficiency determined by polysomnography among older adolescents (Au et al., 2014). Less work has been done within college populations, but a recent study (Mezick et al., 2014) found that actigraphic sleep duration predicted diastolic blood pressure recovery in a sample of undergraduate males. Thus, findings from the present study significantly contribute to this small body of research by demonstrating associations of actigraphic sleep efficiency and risk for hypertension among college males and females.

Results also demonstrated that actigraphic measures of weekday sleep duration significantly predicted BMI, and actigraphic weekend sleep duration approached significance. Findings correspond with much research demonstrating associations between sleep duration and BMI (Cappuccio et al., 2008), although investigations specifically within college students are less common and yield mixed findings. Recent studies among college students have shown that self-reported sleep quality (e.g., Chang & Chang, 2014; Quick et al., 2014; Vargas et al., 2014) and self-reported total sleep time (Chang & Chen, 2014) predict BMI and/or obesity classification, while other studies have shown that obesity classification is not associated with self-reported sleep disturbances (Melton, Langdon, & McDaniel, 2013). The present study contributes to this literature by showing that *actigraphic* measures of sleep duration, rather than self-reported measures, can predict BMI among college students. Such findings highlight the importance of sleep habits among college students as a potential consideration in weight management.

Additionally, findings suggest components of sleep quality are important predictors of mental health outcomes. Associations between sleep quality and depression are widely documented (e.g., (Alvaro et al., 2013; Lovato & Gradisar, 2014), however empirical support from the present study demonstrating indirect effects of sleep hygiene on depression is novel. Findings suggest that good sleep hygiene practices may serve as a protective factor, albeit indirect, for depressive symptoms in college students. While less research has examined links between the positive aspects of mental health and sleep, research examining sleep and well-being in adolescents (Kalak et al., 2014) and older adults (Hanson & Ruthig, 2012; Steptoe et al., 2008) has generated promising results. The present study contributes to this literature by demonstrating associations between self-reported sleep quality, sleep hygiene, and subjective well-being specifically within college students. Such findings are important, for psychological well-being yields many protective health benefits for the cardiovascular and immune system (Steptoe et al., 2008). Results suggest that intervention efforts targeting the improvement of sleep hygiene and sleep quality among college students may also have indirect effects on student well-being, which can improve mental health among this at-risk population.

6.2 Limitations

While the present findings yield confirmation of cognitive, attitudinal, and behavioral predictors of sleep, as well as clarification of links from sleep variables to physical and mental health outcomes within young adults, several limitations of the present study are evident and provide direction for future research. Findings from the present study are inconsistent from subjective to objective measures of sleep. For example, self-reported measures of sleep were not associated with any physical health outcomes, while actigraphic measures predicted both BMI and blood pressure. Further, sleep hygiene was strongly associated with self-reported sleep duration and quality, but only weakly predicted actigraphic weekday/weekend sleep efficiency. Lastly, self-reported sleep quality directly and indirectly predicted both dimensions of mental health, while only actigraphic measures of weekend sleep efficiency predicted depression. These results suggest that the method of measurement matters, with several possibilities underlying such findings. While studies have reported reasonable agreement between self-reported sleep duration and objective measures of sleep (Gangwisch et al., 2006), the present study found moderate correlations between self-reported sleep duration and actigraphic weekday sleep duration ($r = .40$, $p < .001$) but weak associations with weekend sleep duration ($r = .17$, $p = .06$). It is possible that the actigraphic data include errors stemming from participants forgetting to enter the FitBit into sleep mode. While actigraphic weekday and weekend sleep durations reflect averages of at least two nights and one night of sleep data, respectively, missing data may have skewed estimates such that typical sleep durations and efficiency scores were not accurately reflected.

Additionally, self-reported sleep characteristics may reflect one's *perception* of achieved sleep quality and quantity, rather than actual quality and quantity, and thus may generate unique associations with related variables. While objective measures of sleep were more strongly associated with objective measures of physical health (i.e., BMI and blood pressure), self-reported sleep quality was strongly associated with mental health. Perhaps subjective measures of sleep are more important to mental health than objective measures, similar to research demonstrating stronger associations between psychological functioning and subjective socioeconomic status in comparison to objective socioeconomic status (Adler, Epel, Castellazzo, & Ickovics, 2000). Additionally, self-reported sleep quality may encompass a more comprehensive construct, including perceptions of sleep latency, continuity, and restfulness, although reports may be skewed by typical or current daytime sleepiness. Actigraphic sleep efficiency within the present study estimates a narrowed dimension of sleep quality (i.e., time asleep / [total time in bed – time to fall asleep]) and does not capture *sleep latency,* as FitBit calculations determine percentages of time spent asleep once the first minute of sleep is coded. Future studies may want to examine additional measures of objective sleep quality, such as number of awakenings and sleep latency, to determine if other aspects of objective sleep quality can be incorporated into proposed models. Further, sleep duration incorporates bedtime wake time that, to some extent, involve voluntary control, but sleep quality may also reflect unidentified sleep disorders. Future research may want to rule out or control for sleep disorders within analyses. Such research may shed light on the present study's limited covariation between sleep attitudes and actigraphic sleep efficiency scores.

Another limitation of the present study includes the absence of a validated measure of sleep knowledge, although validated scales were used for all other cognitive and attitudinal scales. Psychometrically-sound knowledge scales are scarce within the literature, and published scales identified within the present literature review were geared towards knowledge of sleep medicine among healthcare professionals or professionals in training (e.g., Sateia, Reed, & Christian, 2005). Sleep knowledge in the present study was measured via an interactive sleep quiz designed by the National Center on Sleep Disorders Research and publicly available on the organization's website. While this 10-item quiz generates a score of correctness regarding knowledge of aspects of sleep functioning, sleep disorders, and impact of sleep on health, the scale includes no prior psychometric properties and has not been validated in college students. The scale demonstrated very poor internal consistency (α =.20), suggesting the scale may not reflect a one-dimensional construct of *sleep knowledge* as defined within the present study. This serves as a limitation, and results demonstrating no associations between sleep knowledge and sleep outcomes should be interpreted with caution.

Lastly, the small sample size serves as a limitation of the present study. A power analysis based upon criteria set within Knowlden and colleagues' (2012) study of attitudes and sleep calculated a required sample size of 150 to fit estimated parameters. While the current sample (N = 142) was large enough to capture the predictive validity of sleep and sleep hygiene attitudes, the sample size may not have been large enough to capture smaller effect sizes, such as direct and indirect effects from sleep hygiene to sleep and health outcomes. Future studies should examine the proposed models within larger samples of college students. Additionally, females were overrepresented in the current sample; future research should strive for samples with a greater percentage of males to ensure results are not gender-specific.

6.3 Implications and Future Research

Despite these limitations, findings from the present study yield implications for both research and application efforts. Findings confirm the predictive validity of sleep and sleep hygiene attitudes and suggest the importance of such variables in relation to sleep outcomes. Results also highlight the importance of subjective versus objective measures of sleep, such that self-reported and objective measures of sleep may generate differential patterns with attitudinal, behavioral, and health variables. Additionally, findings may inform application efforts for the improvement of sleep and health among college students. While the college years generate a “window of vulnerability” where students are more prone to particular health problems, the educational context and developmental period also generate “teachable moments,” or unique circumstances that are better than others for teaching particular health behaviors (Taylor, 2012). College campuses serve as an ideal context for implementing intervention efforts related to sleep and health. Research (e.g., Hatzis, Papandreou, & Kafatos, 2010) has shown that school-based health education/intervention programs can yield long-term success in improving health and decreasing risk factors for chronic disease. College campuses provide a viable setting for risk assessment and educational appeals, and lifestyle changes at this stage of life may be transformed into lasting health behaviors (Morrell et al., 2012). Emerging adulthood is marked by identity exploration, a focus on self-sufficiency, and social cognitive maturity (Arnett, 2007), and attitudes and habits developed during this time frame can be solidified within one's identity that remain well into adulthood. Thus, sleep risk identification and behavior change during the college years are essential to adopting lifestyle modifications and prevention strategies that will serve in wellness maintenance and illness reduction (Morrell et al., 2012).

Future studies could utilize findings from the present study to design workshop or intervention programs geared towards modifying attitudes towards sleep and sleep hygiene, such that sleep is placed as a greater priority within one's schedule, and sleep hygiene behaviors are viewed as favorable and important. Programs could be provided to students within student health centers, campus workshops, and academic courses; researchers could track changes in attitudes, as well as examine potential influences on salient physical and health outcomes. By targeting the modification of *attitudes* within such programs, rather than focusing solely on educational appeals, sleep programs could take advantage of promising teachable moments within the college setting and potentially generate greater improvement in sleep and sleep hygiene behaviors than previous sleep education programs have demonstrated.

As Blunden and colleagues (2012) highlighted, generating successful behavior change programs among college students requires a theory-based approach, consideration of attitudinal constructs, and psychometrically sound measurement tools. Designing intervention efforts without first clarifying theoretical frameworks, clearly defining constructs, and confirming relations is ineffective and costly. Considering the sound theoretical framework of the present study, future application efforts targeting college students should consider attitudes as an important influence on sleep and sleep hygiene habits and utilize a psychometrically valid measurement tool. In both application and research efforts, sleep should be viewed as a salient predictor and potentially modifiable health behavior that may contribute to the prevention of hypertension, weight management, and preservation of mental health.

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APPENDIX A: TABLES

Participant Demographic Information

	Sample Size (%)	M (SD)
Age		19.84 (1.76)
Male	32 (22.5%)	
Year in School		
Freshman	52 (36.6%)	
Sophomore	36 (25.4)	
Junior	41 (28.9%)	
Senior	13 (9.2%)	
Marital Status		
Single	139 (97.9%)	
Married	3 (2.1%)	
Children (Yes)	4 (2.8%)	
Living on Campus (Yes)	55 (38.7)	
Residence		
Dorm Room	45 (31.7%)	
Apartment	62 (43.7%)	
House	35 (24.6%)	
Race/Ethnicity		
White/Caucasian	78 (54.9%)	
Black/African American	23 (16.2%)	
Asian	6 (4.2%)	
Hispanic/Latino	9 (6.3%)	
Multi-Racial	6 (4.2%)	
Native American	1 (0.7%0	
Other/Not Reported	19 (13.4%)	

Note. *N* =142. M=Mean, SD=Standard Deviation.

Table 2: Descriptive Statistics of Primary Variables

	M	*SD*	Range
SSHAS Total	5.06	.58	3.21-6.79
SSHAS Sleep Attitudes	4.80	.83	3.10-6.90
SSHAS Benefits	6.44	.60	4.00-7.00
SSHAS Time Com.	3.14	1.40	1.00-6.80
SSHAS Sleep Hygiene Attitudes	5.25	.75	3.07-6.71
SSHAS Favorable Sleep Timing	4.26	1.08	1.20-7.00
SSHAS Quiet Env.	5.45	1.44	1.00-7.00
SSHAS Comfort Env.	6.34	.62	4.00-7.00
SSHAS Dark Env.	5.61	1.26	1.00-7.00
Sleep Hygiene Knowledge	11.73	3.29	4.00-18.00
Sleep Knowledge	5.58	1.59	2.00-10.00
Sleep Hygiene Total	93.23	17.67	51.00-144.00
Arousal-Related Sleep Hygiene	30.15	6.67	14.00-49.00
Scheduling Sleep Hygiene	26.52	5.55	10.00-41.00
Eating/Drinking Sleep Hygiene	15.31	4.12	8.00-28.00
Sleep Env. Sleep Hygiene	21.24	6.90	8.00-39.00
Self-Reported Sleep Duration	6.99	1.23	4.50-11.00
Self-Reported Sleep Quality	1.79	.58	0.00-3.00
Actigr. Weekday Sleep Duration	7.04	1.11	3.41-10.59
Actigr. Weekend Sleep Duration	7.48	1.71	2.63-12.47
Actigr. Weekday Sleep Efficiency	94.05	5.38	57.80-99.60
Actigr. Weekend Sleep Efficiency	94.01	5.38	47.50-100
Depression	7.54	4.75	0.00-24.00
Well-Being Total Score	97.33	12.47	61.27-119.00
Psychological Well-being	49.58	7.02	27.27-60.00
Physical Well-being	27.70	3.82	18.00-35.00
Relationship Well-being	20.06	3.27	11.00-25.00
Body Mass Index	23.45	4.24	16.09-37.19
Systolic Blood Pressure	112.01	10.70	84.67-144.67
Diastolic Blood Pressure	70.49	8.68	51.33-94.00

Note. Com. = Commitment; Env. = Environment; Actigr. = Actigraphic.

Table 3: Correlations of Self-Reported Sleep with Knowledge, Attitudes, and Sleep Hygiene

	Sleep Duration	Sleep Quality	Sleep Knowledge	SH Knowledge	Sleep Hygiene Total	Arousal-Related SH	Scheduling SH	Eating/ Drinking SH	Sleep Env. SH
SSHAS Total Score	.44***	.41***	-.02	-.11	-.46***	-.41***	-.35	-.33***	-.31***
SSHAS Sleep Attitudes	.43***	.41***	-.04	-.04	-.46***	-.42***	-.33***	-.37***	-.29***
SSHAS Benefits	.30***	.30***	-.02	-.16	-.24**	-.23**	-.12	-.19*	-.17*
SSHAS Time Com.	.39***	.36***	-.04	.02	-.45***	-.40***	-.34***	-.36***	-.27**
SSHAS SH Attitudes	.34***	.30**	-.01	-.13	-.35***	-.30***	-.28**	-.22*	-.25**
SSHAS Fav. Sleep Timing	.41***	.34***	.01	-.01	-.40***	-.31***	-.41***	-.33***	-.19*
SSHAS Quiet Env.	.22**	.17	.02	-.14	-.27**	-.26**	-.13	-.14	-.24**
SSHAS Comfort Env.	.08	.05	-.03	-.16	.12	.10	.19*	.08	-.01
SSHAS Dark Env.	.06	.14	-.03	-.01	-.15	-.15	-.13	-.01	-.14
Sleep Knowledge	-.05	.04	-	.19	.13	.12	.09	-.01	.15
SH Knowledge	-.04	-.04	.19	-	.10	.11	.05	.01	.09
Self-Report Sleep Duration	-	.42***	-.05	-.04	-.35***	-.31***	-.29**	-.25**	-.21*
Self-Report Sleep Quality	.42***	-	-.04	.04	-.43***	-.39***	-.35***	-.16	-.31***

Note. *indicates $p < .05$; **indicates $p < .01$; ***indicates $p < .001$. Com. = Commitment; Fav. = Favorable; Env. = Environment; SH = Sleep Hygiene.

Table 4: Hierarchical Regression of Self-Reported Sleep with Cognitive and Attitudinal Predictors

		Sleep Duration			Sleep Quality		
		b	*S.E.*	Δ*R2*	*b*	*S.E.*	Δ*R2*
Block 1				.003			.001
	(Intercept)	7.21***	.38		1.72**	.19	
	Sleep Knowledge	-.04	.07		.01	.03	
Block 2				.19***			.18***
	(Intercept)	4.09***	.65		.26	.33	
	Sleep Knowledge	-.03	.06		.03	.03	
	Sleep Attitudes	.63***	.11		.29***	.06	

Note. ***indicates p< .001; *b* = unstandardized beta weight.

Table 5: Hierarchical Regression of Sleep Hygiene with Cognitive and Attitudinal Predictors

		SH Total Score			Arousal-Related SH			Sleep Scheduling SH			Eating/Drinking SH			Sleep Env. SH		
		b	*S.E.*	Δ*R2*	*b*	*S.E.*	Δ*R2*	*b*	*S.E.*	Δ*R2*	*b*	*S.E.*	Δ*R2*	*b*	*S.E.*	Δ*R2*
Block 1				.01			.01			.003			.00			.01
	(Intercept)	87.05**	5.51		27.45**	2.08		25.69**	1.74		15.12**	1.29		18.91*	2.15	
	SH Know.	.53	.45		.23	.17		.09	.14		.01	.11		.20	.18	
Block 2				.12***			.09**			.08*			.05*			.06*
	(Intercept)	129.99**	11.04		41.46**	4.23		36.16**	3.57		21.45**	2.70		30.93**	4.46	
	SH Know.	.54	.43		.24	.16		.09	.14		.01	.10		.20	.17	
	SH Att.	-8.21**	1.86		-2.68**	.71		-2.04*	.60		-1.19*	.46		-2.30*	.75	

Note. SH=Sleep Hygiene; Know. = Knowledge; Att = Attitudes; Env. = Environment. *indicates p <.05; **indicates p< .001; b = unstandardized beta weight.

Table 6: Correlations of Actigraphic Sleep Measures with Knowledge, Attitudes, and Sleep Hygiene

	Weekday Dur	Weekday SE	Weekend Dur.	Weekend SE
Sleep Knowledge	-.16	.04	.05	.04
SH Knowledge	-.05	.003	-.08	.06
Sleep Attitudes	.29**	.04	.20*	.11
SH Attitudes	.06	.01	.03	.08
Sleep Hygiene Total	-.16	-.14	.03	-.20*
Arousal-Related SH	-.13	-.09	-.06	-.15
Scheduling SH	-.24**	-.18*	-.01	-.23*
Eating/ Drinking SH	-.10	-.11	-.06	-.21*
Sleep Env. SH	-.03	-.06	.18	-.05
Depression	-.13	-.26**	-.14	-.31**
Well-Being Total	.04	.17	.15	.18
Psychological Well-Being	.01	.17	.08	.18
Physical Well-Being	.10	.15	.18	.16
Relationship Well-Being	.001	.12	.18	.10
BMI	-.19*	-.09	-.17	-.03
Systolic BP	-.11	-.20*	-.09	-.16
Diastolic BP	-.06	-.24*	.02	-.20*

Note. *indicates $p < .05$; **indicates $p < .01$. SE=Sleep Efficiency; Dur. = Duration; SH = Sleep Hygiene; Env. = Environment; BP = Blood Pressure.

Table 7: Hierarchical Regression of Actigraphic Sleep Measures with Cognitive, Attitudinal, and Sleep Hygiene Predictors

	Weekday Sleep Duration			Weekday Sleep Efficiency			Weekend Sleep Duration			Weekend Sleep Efficiency		
	b	*S.E.*	$\Delta R2$	*b*	*S.E.*	$\Delta R2$	*b*	*S.E.*	$\Delta R2$	*b*	*S.E.*	$\Delta R2$
Block 1			.03[a]			.002			.002			.01
(Intercept)	7.79***	.37		93.23***	1.79		7.20***	.57		93.05***	2.14	
Sleep Knowledge	-.12[a]	.06		.15	.31		.05	.10		.17	.37	
Block 2			.08**			.002			.04*			.01
(Intercept)	5.83***	.86		92.01***	3.33		5.21***	1.04		88.82***	3.93	
Sleep Knowledge	-.11	.06		.15	.31		.06	.10		.19	.37	
Sleep Attitudes	.38**	.13		.25	.58		.41*	.18		.87	.68	
Block 3			.00			.02			.02			.03[a]
(Intercept)	5.87***			98.97***	5.43		3.04	5.52		98.34***	6.88	
Sleep Knowledge	-.11	.06		.202	.31		.04	-.04		.26	.37	
Sleep Attitudes	.38**	.13		-.26	.66		.58**	-.17		.17	.81	
SH Total Score	.00	.01		-.05	.03		.02	.01		-.07[a]	.11	

Note. [a]indicates $p < .07$; *indicates $p < .05$; ** indicates $p < .01$; ***indicates p< .001; *b* = unstandardized beta weight. SH=Sleep Hygiene.

Table 8: Indirect Effects of Sleep Hygiene Cognitions and Attitudes on Actigraphic Measures of Sleep

	Weekday			Weekend		
	SH Total	Duration	Sleep Efficiency	SH Total	Duration	Sleep Efficiency
Total R^2	.13	.11	.03	.13	.09	.04
Effects						
SH Total						
Direct		.00	-.05*		.02	-.07*
CI		(-.01, .01)	(-.10, -.01)		(-.01, .04)	(-.13, -.02)
SH Knowledge						
Direct	.51			.54		
Indirect		.00	-.03		.01	-.04
CI	(-.34, 1.42)	(-.01, .10)	(-.08, .02)	(-.34, 1.42)	(-.01, .03)	(-.11, .03)
SH Attitudes						
Direct	-8.20***			-8.20***		
Indirect	-	.002	.42*		-.13	.59*
CI	(-12.08, -4.32)	(-.10, .11)	(.02, .83)	(-12.08, -4.32)	(-.33, .07)	(.12, 1.06)
Sleep Knowledge						
Direct		-.11	.20		.04	.26
CI		(-.22, .01)	(-.30, .70)		(-.14, .22)	(-.26, .79)
Sleep Attitudes						
Direct		.38**	-.26		.57**	.17
CI		(.14, .62)	(-1.05, .53)		(.17, .97)	(-.94, 1.29)

Note. *indicates p <.05; **indicates p <.01; ***indicates p < .001. CI=Confidence Interval; SH=Sleep Hygiene.

Table 9: Direct and Indirect Effects of Actigraphic Sleep Measures on Physical Health

	Weekday Actigraphy					Weekend Actigraphy				
	Sleep Dur.	Sleep Eff.	BMI	SBP	DBP	Sleep Dur.	Sleep Eff.	BMI	SBP	DBP
Total R^2	.02	.02	.03	.03	.06	.00	.04	.04	.02	.08
Effects										
SH Total										
Direct	-.01	-.05*				.004	-.07*			
CI	(-.01, .02)	(-.13, -.02)				(-.01, .02)	(-.13, -.02)			
Indirect via Dur.			.01	.003	-.003			-.002	-.001	.003
CI			(-.004, .02)	(-.02, .03)	(-.02, .02)			(-.01, .01)	(-.01, .01)	(-.01, .02)
Indirect via. Eff			.00	.02	.02			-.003	.02	.03*
CI			(-.01, .01)	(-.01, .04)	(-.004, .04)			(-.02, .01)	(-.01, .04)	(.001, .05)
Sleep Dur.										
Direct			-.67*	-.29	.27			-.47[a]	-.26	.67
CI			(-1.31, -.03)	(-1.60, 1.09)	(-1.35, 1.90)			(-.94, .01)	(-1.60, 1.08)	(-.28, 1.60)
Sleep Eff.										
Direct			-.01	-.36	-.40**			.04	-.22	-.35**
CI			(-.30, .28)	(-.72, .28)	(-.67, -.13)			(-.23, .31)	(-.71, .20)	(-.58, -.10)

Note. [a]indicates p <.06; *indicates p <.05; **indicates p < .01; CI=Confidence Interval; SH=Sleep Hygiene; Dur. = Duration; Eff. = Efficiency; BMI=Body Mass Index; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure.

Table 10: Direct and Indirect Effects of Actigraphic Sleep Measures on Mental Health

	Weekday Actigraphy				Weekend Actigraphy			
	Sleep Dur.	Sleep Eff.	Well-Being	Depress.	Sleep Dur.	Sleep Eff.	Well-Being	Depress.
Total R^2	.03	.02	.03	.06	.001	.05	.03	.11
Effects								
SH Total								
Direct	-.01	-.05*			.003	-.08*		
CI	(-.02,.002)	(-.09, -.00)			(-.02, .02)	(-.14, -.02)		
Indirect via Dur.			.004	.002			.002	.00
CI			(-.02, .03)	(-.01, .01)			(-.02, .03)	(-.01, .01)
Indirect via. Eff			-.02	.01			-.02	.02
CI			(-.05, .01)	(-.01, .03)			(-.05, .01)	(-.004, .04)
Sleep Dur.								
Direct			-.41	-.22			.73	.03
CI			(-2.59, 1.78)	(-1.08, .644)			(-1.00, 2.36)	(-.59, .65)
Sleep Eff.								
Direct			.41	-.21			.25	-.24*
CI			(-.05, .87)	(-.46, .04)			(-.21, .71)	(-.43, -.05)

Note. * indicates $p < .05$; **indicates $p < .01$; ***indicates $p < .001$. CI=Confidence Interval; SH=Sleep Hygiene; Dur. = Duration; Eff. = Efficiency; Depress.=Depression.

Table 11: Direct and Indirect Effects of Self-Reported Sleep Measures on Physical Health

	Sleep Dur.	Sleep Qual.	BMI	SBP	DBP
Total R^2	.12	.29	.03	.03	.01
Effects					
SH Total					
Direct	-.02***	-.01***			
CI	(-.04, -.01)	(-.02, -.01)			
Indirect via Dur.			.002	-.03	-.01
CI			(-.01, .02)	(-.07, .02)	(-.05, .03)
Indirect via. Qual.			.02	.03	.01
CI			(-.004, .04)	(-.02, .09)	(-.03, .05)
Sleep Dur.					
Direct			-1.11	1.12	.53
CI			(-.66, .45)	(-5.44, 2.79)	(-.99, 2.05)
Sleep Qual.					
Direct			-1.11	-2.40	-.54
CI			(-2.43, .20)	(-5.84, 1.05)	(-3.43, 2.34)

Note. *indicates $p < .05$; **indicates $p < .01$; CI=Confidence Interval; SH=Sleep Hygiene; Dur. = Duration; Qual.= Quality; BMI=Body Mass Index; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure.

Table 12: Direct and Indirect Effects of Self-Reported Sleep Measures on Mental Health

	Sleep Dur.	Sleep Qual.	Well-Being	Depress
Total R^2	.12	.18	.15	.20
Effects				
SH Total				
Direct	-.02***	-.01***		
CI	(-.04, -.01)	(-.02, -.01)		
Indirect via Dur.			-.001	-.01
CI			(-.04, .04)	(-.03, .01)
Indirect via. Qual.			-.12**	.05**
CI			(-.19, -.04)	(.02, .09)
Sleep Dur.				
Direct			.04	.41
CI			(-1.62, 1.70)	(-.52, 1.34)
Sleep Qual.				
Direct			8.17***	-.38***
CI			(4.77, 11.57)	(-5.34, -2.07)

Note. **indicates p <.01; ***indicates p < .001; CI=Confidence Interval; SH=Sleep Hygiene; Dur. = Duration; Qual.= Quality; Depress.= Depression.

Table 13: Direct and Indirect Effects of Actigraphic Sleep Measures on Hypertension

	Weekday Actigraphy			Weekend Actigraphy		
	Sleep Dur.	Sleep Eff.	Hyp.	Sleep Dur.	Sleep Eff.	Hyp.
Total R^2	.03	.02	.08	.001	.04	.11
Effects						
SH Total						
Direct	-.01	-.05*		.003	-.07**	
CI	(-.02, .002)	(-.09, -.003)		(-.01, .02)	(-.13, -.02)	
Indirect via Dur.			.00			.00
CI			(-.002, .001)			(-.001, .001)
Indirect via. Eff			.001			.002*
CI			(.00, .003)			(.00, .003)
Sleep Dur.						
Direct			.02			.05
CI			(-.11, .15)			(-.02, .11)
Sleep Eff.						
Direct			-.03**			-.03**
CI			(-.05, -.01)			(-.05, -.01)

Note. * indicates $p < .05$; **indicates $p < .01$. CI=Confidence Interval; SH=Sleep Hygiene; Dur. = Duration; Eff. = Efficiency; Hyp. = Hypertension.

APPENDIX B: FIGURES

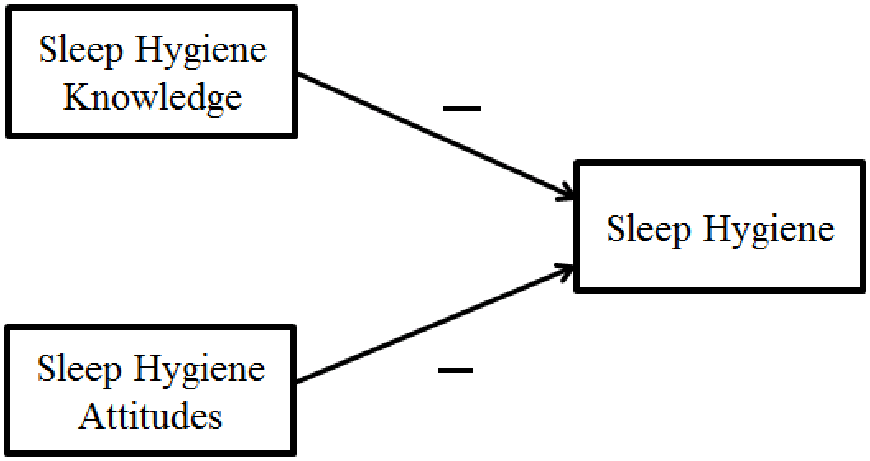

Figure 1: A conceptual model in which sleep hygiene knowledge and sleep hygiene attitudes predict sleep hygiene practices. *Note.* Higher scores of sleep hygiene indicate worse practices.

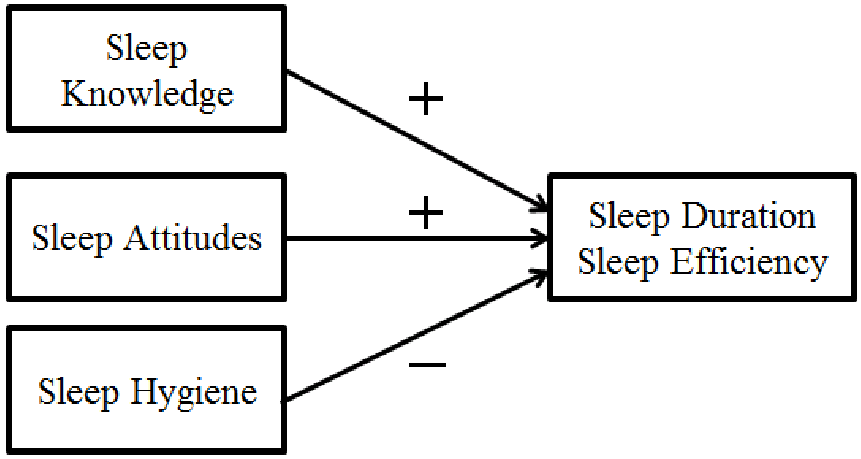

Figure 2: A conceptual model in which sleep knowledge, sleep attitudes, and sleep hygiene predict actigraphic sleep duration and sleep efficiency. *Note.* Higher scores of sleep hygiene indicate worse practices.

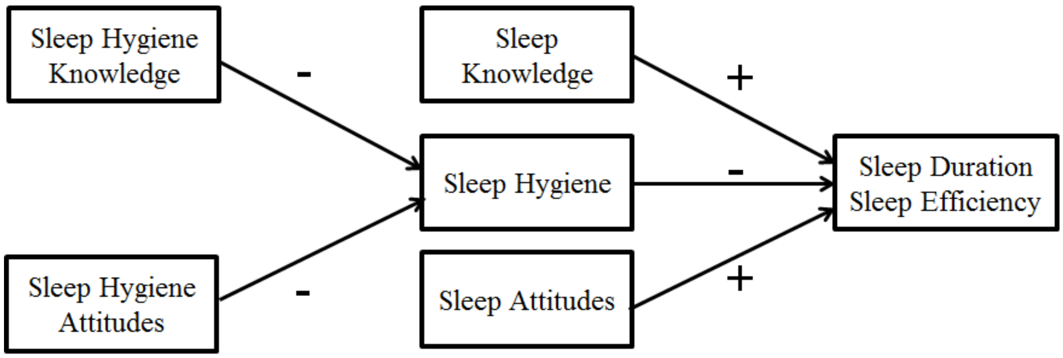

Figure 3: A conceptual model in which sleep hygiene knowledge and sleep hygiene attitudes indirectly predict actigraphic sleep duration and sleep efficiency. *Note.* Higher scores of sleep hygiene indicate worse practices.

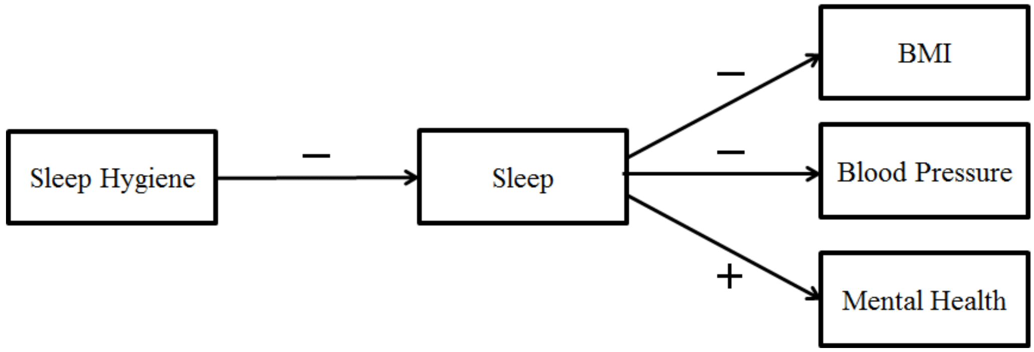

Figure 4: A conceptual model in which sleep (operationally defined as self-reported sleep duration, self-reported sleep quality, actigraphic measures of sleep duration, and actigraphic measures of sleep efficiency) predicts BMI, blood pressure, and psychological well-being, and sleep hygiene yields indirect effects. *Note*. Higher scores of sleep hygiene indicate worse practices. Separate models will be tested for each measure of sleep. Mental health will be operationally defined as both depression and subjective well-being.