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The relationships of sleep quality, length, and napping to physical performance

Rebecca M. Hoffmann

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THE RELATIONSHIPS OF SLEEP QUALITY, LENGTH, AND NAPPING TO PHYSICAL PERFORMANCE

By

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A Dissertation Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy

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ABSTRACT

College students suffer from more sleep disturbances than the general population. Sleep difficulties can lead to lower levels of performance, memory, and cognitive ability. Sleep quality is known to impact individuals’ physical and psychological health. The relationship between sleep variables (i.e., sleep quality, sleep length, sleepiness, and a nap/relaxation) and physical performance (i.e., flexibility, grip strength, and peak performance) has not been fully examined. The purpose of this study was to explore the relationship between sleep quality, sleep length, and sleepiness and physical performance (e.g., flexibility, grip strength, and peak power), as well as to determine if a short nap diminishes the effect of poor sleep on the same physical performance measures.

Participants of this study were students at a mid-sized southern United States university who were recruited from classes in the College of Education. The relationship between sleep quality, length, and sleepiness and flexibility, grip strength, vertical jump height, and peak power was assessed using the Sleep Quality Index, the Adult Sleep-Wake Scale, the Sleep Habits Questionnaire, the Epworth Sleepiness Scale, the Karolinska Sleepiness Scale, hand dynamometer, vertical jump test, and sit-and-reach box. A two-way analysis of variance (ANOVA) was conducted to determine the effect of a nap/relaxation on flexibility, grip strength, vertical jump height, and peak power, with gender as an independent variable. Correlations were also conducted to determine the relationship between sleep quality, sleep duration, and sleepiness and flexibility, grip strength, and peak power.
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CHAPTER 1

INTRODUCTION

Sleep is a natural reversible state of unconsciousness in which individuals rest their minds and bodies. Sleep is also an active process during which complex physiological, neurological, and hormonal changes transpire. Sleep has been found to be imperative to learning and cognitive functioning, as well as physical and emotional health. Difficulty sleeping is one of the most common and consistently increasing health complaints among young adults (Hicks, Mistry, Lucero, Lee, & Pelligrini, 1989). Many college students do not get enough sleep and may not realize the impact that lack of sleep has on their functioning.

College years are a time of transition that entails multifaceted challenges in academic, social, psychological, and developmental adjustment. In response to newfound personal stressors and environmental variables, college students may compensate with modification of sleep behaviors and patterns. Brown, Soper, and Buboltz (2001) found that one-third of college students report regular, severe sleep difficulties. Studies have found that college students have more sleep problems than the general population. The National Sleep Foundation recommends that adults 18-54 years of age sleep between seven and 8.5 hours per night. Coren (1994) indicated that over 30% of college students reported having difficulty sleeping. Buboltz, Brown, and Soper (2001) noted that over 70% of college students have regular sleep difficulties. In comparison to the general
population, college students tend to have more difficulty sleeping (Buboltz et al., 2001; Coren, 1994; Lack 1986).

Sleep is an important and essential function of humans, comprising nearly one-third of our lives. Though sleep is understood to be necessary, the specific physiologic function of sleep remains unknown (Sejnowski & Destexhe, 2000). Disruption of sleep has been demonstrated to have adverse neurocognitive effects. For example, meta-analyses have shown reductions in performance on cognitive and motor tasks after sleep deprivation (Philibert, 2005; Pilcher & Huffcutt, 1996). A lack of sleep alters physiological states that affect cognitive functioning, metabolism, inflammation, and neurobehavioral functioning (Dimitrov, Lange, Tieken, Fehm, & Born, 2004).

Research has shown that impaired sleep has adverse effects on cognitive performance, mood, and other physiological and psychological aspects of human functioning (Alapin et al., 2000; Forbes et al., 2008; Jean-Louis, von Gizycki, Zizi, & Nunes, 1998; Kahn-Greene, Killgore, Kamimori, Balkin, & Killgore, 2007; Pilcher, Ginter, & Sadowsky, 1997; Pilcher & Ott, 1998; Tomasi et al., 2009; Van Dongen, Maislin, Mullington, & Dinges, 2003; Yegneswaran & Shapiro, 2007). A sleep-deprived person is likely to demonstrate impaired judgment as well as declines in executive function, working memory and higher-level cognitive functions (Akerstedt, Kecklund, Alfredsson, & Selen, 2007; Durmer & Dinges, 2005). Engle-Friedman et al. (2003) reported that sleep loss in college students resulted in choice of behaviors that take a lesser amount of effort and that those who are sleep deprived do not perceive a reduction in their effort. These effects in a college setting may lead students to attribute poor
academic performance to their own abilities when poor sleep may be the source of suboptimal functioning.

Relatively mild sleep deprivation, restriction to six hours of sleep per night, resulted in decrements in neurocognitive task performance during an experimental sleep deprivation protocol (Van Dongen et al., 2003). Further, insufficient sleep has been implicated as a contributing factor in motor vehicle accidents and a number of industrial accidents, including the Chernobyl nuclear disaster and Challenger shuttle explosion (Lyznicki, Doege, Davis, & Williams, 1998; Mitler et al., 1988; Young, Blustein, Finn, & Palta, 1997). More recent literature suggests that short sleep duration is also a risk factor for cardiovascular outcomes, glucose dysregulation, and even death (Ayas et al., 2003; Gottlieb et al., 2005; Patel et al., 2004).

Though too little sleep has a number of health consequences, many people do not get enough sleep each night. As more and more is packed into the days, the time allotted for sleep is curtailed. The 2008 National Sleep Poll, an annual survey of sleep habits of Americans, found that 44% of Americans average less than seven hours of sleep a night on work days. Only recently has there been more of a focus placed on the college-aged population, 44% of whom reported enough severe daytime sleepiness that it interferes with normal daily functioning (USDHHS, 2003).

Individuals commonly complain about sleep quality; 15-35% of the adult population complains of frequent disturbances in their sleep quality, such as difficulty falling asleep and remaining asleep (Bixler, Kales, Soldatos, Kales, & Healey, 1979; Karacan et al., 1976; Karacan, Thornby, & Williams, 1983; Lugaresi et al., 1983; Mellinger, Balter, & Uhlenhuth, 1985; Welstein, Dement, Redington, & Guilleminault,
1983). Sleep quality includes several aspects of sleep, such as sleep length, sleep latency, number of awakenings, as well as depth of restfulness of sleep (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989).

Studies have reported a high prevalence of sleep problems and sleep-related disturbances among young adults (Ohayon, Roberts, Zulley, Smirne, & Priest, 2000; Racinais, Hue, Blonc, & Le Gallais, 2004; Yang, Wu, Hsieh, Liu, & Lu, 2003). Poor sleep quality can contribute to problems in many different aspects of a young adult’s life. College students often report poor sleep quality, irregular sleep habits, and daytime sleepiness (Alapin et al. 2000; Buboltz et al., 2001; Campos-Morales, Valencia-Flores, Castano-Meneses, Castaneda-Figueiras, & Martinez-Guerrero, 2005; Carney, Edinger, Meyer, Lindman, & Istre, 2006; Pilcher, Schoeling, & Prosansky, 2000; Yang et al., 2003).

Global trends of working more and the increase in domestic and social demands have resulted in sleep reduction and daytime sleepiness, which has stimulated interest in conducting research on the benefits of brief naps. Naps as brief as 19.8 (Gillberg, Kecklund, Axelsson, & Akerstedt, 1996), 10.8 (Horne & Ryner, 1996), 10.2 (Takahashi & Arito, 2000), 10 (Tietzel & Lack, 2001; Tietzel & Lack, 2002), and 9.1 (Hayashi, Motoyoshi, & Hori, 2005) minutes have been found to improve alertness and performance in individuals whose sleep was restricted. The improvement in alertness and performance due to taking a brief nap could also benefit physical performance. In addition, brief naps in the workplace have been found to be beneficial during a nightshift (Purnell, Feyer, & Herbison, 2002; Signal & Gander, 2002).
Research on meditation has found that the conscious mind may play a role in enhancing psychological and physical health (Chiesa & Serretti, 2010; Goldin, Ramel, & Gross, 2009; Perlman, Salomons, Davidson, & Lutz, 2010; Zeidan, Gordan, Merchant, & Goolkasian, 2010). Autogenic training (Schultz & Luthe, 1959), which produces sensations of warmth and heaviness in the athlete's body, has been widely used by European athletes to aid in the control of psycho-physiological activation levels (Cox, 2012).

Statement of the Problem

There are many studies that have examined the effects of physical activity on sleep. However, few studies have examined the effects of sleep on physical performance. In addition, many of those studies had very few participants. Of the few studies conducted, Racinais and colleagues (2004) found a relationship between sleep deprivation and poor shuttle run performance in 22 adult athletes. Reilly and Piercy (1994) determined that there was a significant effect of sleep loss on bench press, leg press, and dead lift performance with eight male participants. In addition, sprint times were found to be improved by a post-lunch nap following partial sleep loss with 20 young males (Waterhouse, Atkinson, Edwards, & Reilly, 2007).

The relationship between sleep and physical performance has not been fully examined. Sleep quality has been found to be more salient to college students’ health, life satisfaction, levels of tension and depression, and psychological well-being (Pilcher et al., 1997), as well as general cognitive performance (Pilcher & Walters, 1997). Sleep quality is known to impact individuals’ physical and psychological health (Pilcher et al., 1997). A study with female college students in Taiwan found that individuals with poor sleep
quality had poorer flexibility, poorer muscular endurance, and lower cardiovascular fitness compared to individuals with good sleep quality (Lee & Lin, 2007). However, males were not included in this study, nor were sleep duration and sleepiness examined. Daytime sleepiness in older adults was associated with physical functional impairments and decreased exercise frequency (Chasens, Sereika, Weaver, & Umlauf, 2007).

Researchers have examined college students’ sleep habits, sleep patterns, and sleep difficulties (Buboltz et al., 2001; Caldwell, 2002; Coren, 1994; Lack, 1986; Trockel, Barnes, & Egget, 2000). Studies have indicated that college students have more sleep difficulties than the general population (Buboltz et al., 2001; Coren, 1994; Lack, 1986). Sleep habits were the most predictive of college students’ academic performance out of all health related behaviors (Trockel et al., 2000). In addition, fatigue may be caused by a slight reduction in sleep duration, especially when paired with an erratic sleep schedule. Caldwell (2002) found that 75% of college students experiencing fatigue even when they get seven hours per night of sleep, combined with having a varying schedule.

Many studies have examined the effects of sleep on academic performance, but have neglected studying the effects of sleep on physical performance (Curcio, Ferrara, & De Gennaro, 2005; Gomes, Tavares, & de Azevedo, 2011; Lowry, Dean, & Manders, 2010; Peters, Joireman, & Ridgeway, 2005; Singleton & Wolfson, 2009). However, many of the same impaired functions disrupted by poor sleep are the same in physical performance as academic performance. For example, lack of sleep alters physiological states that affect cognitive functioning, metabolism, inflammation, and neurobehavioral functioning (Dimitrov et al., 2004).
The primary purpose of this study is to determine if a short nap diminishes the effect of poor sleep on physical performance, as well as to explore the relationship between sleep quality and physical performance (e.g., flexibility, grip strength, and peak power) and sleep length and physical performance. More research is needed to clearly delineate the effects of these sleep variables on the physical performance variables. This study will add to the existing sleep literature and initiate new knowledge on the relationships between sleep and physical performance.

**Justification**

In regard to physical performance, there is little information about the effects of limited sleep loss (Legar, Metlaine, & Choudat, 2005) and of any effects that naps may have. Such information would be valuable when there is a requirement for physical activity in individuals who are suffering from some degree of sleep loss. Additionally, it is also relevant to athletes, because even small differences in physical performance may mean the difference in winning or losing. Sleep may have a greater impact on the athlete when they are in unfamiliar surroundings, feeling apprehensive the night before a competition or game, or not being accustomed to noise from sports fans. Sleep can also be affected when there is a time zone change or they have to awaken earlier than usual. These things can all influence the athlete's physical performance.

**Literature Review**

**Stages of Sleep**

According to the 2007 American Academy of Sleep Medicine (AASM) standards, individuals cycle through three stages of sleep, known as non-rapid eye movement
(NREM) sleep, and rapid eye movement (REM) sleep. The NREM stages are referred to as: N1, N2, and N3. Stage 3 of NREM sleep (N3) is also called delta sleep or slow-wave sleep (SWS) (Sible et al., 2007). NREM sleep comprises 75% of the night, whereas REM sleep accounts for 25% of the night. The order that an individual cycles through stages of sleep is N1, N2, N3, back to N2, and then REM.

Individuals cycle through these stages of sleep on average approximately every 90 to 110 minutes (Caldwell, 2003; Carlson, 1999). Each cycle of REM sleep lasts approximately 20-30 minutes; therefore, individuals typically experience four or five cycles of REM sleep per night. Individuals experience a greater amount of deep sleep (stage N3) earlier in the sleep cycle, but have longer periods of REM sleep later in the sleep cycle and prior to natural awakening. We enter NREM sleep when we start to fall asleep.

Upon falling asleep, individuals enter Stage N1 sleep as their muscles begin to relax and there is a loss of alertness. There is a transition from alpha waves having a frequency of eight to 13 Hz, which is common in the state of wakefulness, to theta waves having a frequency of 4-7 Hz, on an EEG (Carlson, 1999). A common sign of disturbed sleep is a greater percentage of Stage N1 sleep (Soldatos & Paparrigopoulos, 2005). Research indicates that individuals with insomnia often spend more time in stage N1 sleep than those without insomnia (Carskadon & Dement, 2000). Therefore, they usually obtain more sleep than they realize, but it may not be good quality sleep.

Stage N2 typically lasts for 10 to 25 minutes in young adults (Carlson, 1999). Stage N2 of sleep is characterized by sleep spindles and K complexes. Sleep spindles are short bursts of EEG waves that occur between two and five times per minute during the
stages of non-REM sleep, but predominantly in stage N2. The K complexes are abrupt, sharp waves. These two types of wave bursts are associated with keeping an individual in a sleeping state (Bowersox, Kaitlin, & Dement, 1985; Steriade & McCarley, 1990). This stage accounts for 45-55% of total sleep in adults.

Stage N3 is also known as slow wave sleep and is the deepest level of sleep. In this stage of sleep, delta waves are present, which are slow, high amplitude waves (less than 3.5 Hz) that constitute more than 50% of brain waves during this stage (Carlson, 1999). After approximately 45 minutes in stage N3, an individual cycles back to stage N2 (Carlson, 1999). During the second time in stage N2 of sleep, the K complexes and spindles give way to the rapid eye movements of REM sleep.

REM is the stage of sleep in which people dream and it accounts for 20-25% of total sleep time in most adults (Carlson, 1999). REM sleep is known as paradoxical sleep because beta waves are present but the brain paralyzes muscular activity to protect individuals from injury through acting out dreams. The rapid eye movements will return to K complexes and spindles return and the individual enters stage two of sleep once again and repeats the cycle. When this cycle is disrupted individuals may experience numerous sleep disturbances.

Following total sleep deprivation, REM sleep does not return to normal until the second night thereafter (Carlson, 1999). This demonstrates how the body places precedence on the physical health systems which are restored during the first stages of sleep. Therefore, a person with chronic poor sleep habits may remain physically healthy while the consequences of REM sleep deprivation (e.g., concentration, learning, and mood difficulties) may not be readily attributed to inadequate sleep.
The utility of REM sleep is substantiated by studies of selective sleep deprivation. Researchers have reported that REM sleep is important for consolidating newly learned information (De Koninck, Lorrain, Christ, Proulx, & Coulombe, 1989; Karni, Tanne, Rubenstein, Askenasy, & Sagi, 1994; Nesca & Koulack, 1994). Studies of students have also shown that those deprived of REM sleep perform worse on academic tests than those who were not deprived (Karni et al., 1994; Pilcher & Huffcutt, 1996; Pilcher & Ott, 1998; Pilcher & Walters, 1997; Smith & Lapp, 1991).

**Naps.** Short daytime naps of less than 30 minutes, which rarely contain Slow-Wave Sleep (SWS), have been widely reported to have positive effects on daytime alertness (Takahashi, 2003). The recuperative effects of daytime naps of less than 30 minutes have been confirmed by research. These shorts naps are mainly composed of stage 1 and stage 2 sleep. Tietzel and Lack (2002) examined whether 30 seconds or 90 seconds of stage 1 sleep had recuperative effects and found that these ultra-brief naps had no recuperative power. They also found that a 10-minute brief nap had a recuperative effect, suggesting that the recuperative power of a short nap depends on stage 2 sleep, not stage 1. However, they did not show the sleep variables of the 10-minute nap. A study by Hayashi and colleagues (2005) examined whether the recuperative effects of short naps depend upon which of the sleep stages are present in the nap (i.e., stage 1 or 2 sleep). Participants in this study were 10 university students. The results suggest that stage 2 sleep has recuperative power, while these recuperative effects are limited in stage 1 sleep. It has been reported that the recuperative effects of sleep depend on SWS and that this is also the case for daytime naps (Mednick, Nakayama, & Stickgold, 2003; Tilley, Donohoe, & Hensby, 1987).
Short naps of approximately 10 minutes do not contain SWS, suggesting that stage 2 sleep during a daytime nap, independent of SWS, has recuperative effects. However, delta- and theta-band EEG activities during the waking-sleeping transition period intensify rapidly during stage 2 sleep (Morikawa, Hayashi, & Hori, 1997). It could be argued that background EEG delta activity during stage 2 sleep might contribute to the recuperative effects of the daytime short nap. Spectral analysis of EEG during the nap might be required. The study by Hayashi and colleagues (2005) confirmed that stage 2 sleep plays an important role in the restorative function of sleep and that a minimum of three minutes of stage 2 sleep had recuperative effects of daytime alertness and performance after restricted nocturnal sleep, while these effects were limited in stage 1 sleep.

**Physiological Processes of the Sleep-Wake Cycle**

There are three main physiological processes that directly affect the sleep-wake cycle (National Institute of Health, 1998; Refinetti, 2000). They are the autonomic nervous system, homeostatic drive for sleep, and circadian rhythm (National Institute of Health, 1998; Refinetti, 2000). These are especially important, because sleep difficulties typically result from a disruption in any of these processes.

**Autonomic Nervous System.** The autonomic nervous system is a subcomponent of the peripheral nervous system that controls individual’s level of arousal in reaction to both environmental and internal stimuli. The autonomic system is further broken down into the sympathetic system, which activates vital systems of the human body in response to a stressor or anticipated danger and the parasympathetic system, which relaxes the body. Sleep is associated with increased parasympathetic and decreased sympathetic
functioning (Parmeggiani, 1994). Electrical stimulation of parasympathetic activating systems in the brain results in behavioral signs of sleep in mammals. Specifically, stimulation of the anterior hypothalamic and preoptic areas of the brain produces parasympathetic signs such as a slower heart rate, lower blood pressure, and constriction of the pupils (Parmeggiani, 1994).

On the other hand, many aspects of the sympathetic nervous system's response to stressors can be extremely disruptive to sleep. This response can occur just as readily to imagined stressors as real environmental stressors. In fact, even the frustrations associated with transient difficulties falling asleep or worries that develop as people are trying to fall asleep can significantly impair the ability to fall asleep or stay asleep (Parmeggiani, 1994). While most people occasionally have difficulty sleeping, it is when such difficulties become behaviorally associated with the bedroom that chronic sleep problems may develop. As a result, transient sleep difficulties can turn into chronic insomnia (Hauri, 1991).

In summary, the autonomic nervous system plays a strong role in the ability to fall and stay asleep. This system is organized to react immediately and can rapidly impair sleep (Parmeggiani, 1994). However, autonomic relaxation is not the only factor that can influence sleep readiness. This is important since people do not want to fall asleep any time they begin to feel relaxed. On the other hand, people who have not slept for several days may fall asleep relatively quickly even if under stress. The homeostatic drive thus plays a key role in sleep propensity and can help regulate the sleep cycle.

Homeostatic Drive. The longer people remain awake the sleepier they become (Carskadon & Dement, 1981). Periods of sleep deprivation result in shorter sleep onset
and even more rapid entry into deep sleep (Roehrs, Carskadon, Dement, & Roth, 2000). In people without sleep disorders the need for sleep can often be inferred by the length of time it takes to fall asleep or sleep latency. In addition to experimental evidence, this makes intuitive sense and is most likely what contributed to Aristotle’s hypnotoxin theory of sleep (Thorpy, 1991). While the term toxic may be a little strong, it does appear that certain substances accumulate in the body while awake and are reduced during sleep. Such substances promote sleepiness and are partially responsible for the decreased sleep latency after sleep deprivation. When the body and brain are in the awakened stage, ongoing metabolic activity breaks down adenosine monophosphate (AMP) into adenosine. Adenosine is accumulated as the day progresses. This buildup of adenosine leads to inhibition of the basal forebrain, part of the brain responsible for alertness. As adenosine levels increase, the propensity to maintain alertness decreases, resulting in increased drowsiness and sleep (Porkka-Heiskanen, 1999). While asleep, the metabolic activity responsible for the buildup of adenosine decreases, thereby, allowing the body to return to lower adenosine levels and increase alertness.

Additionally, type d2 prostaglandins, are endogenous hormones that promote sleep. Prostaglandins (d2) stimulate neurons that inhibit the arousal response of certain hypothalamic cells (Scamel et al., 1998). These chemicals are present throughout most of the body. Prostaglandins are a natural by-product of immune system activity. Normally, healthy people produce prostaglandins, but they are produced at a faster rate when the immune system is fighting infection. This is why people often feel sleepier when ill. The increased levels of prostaglandins that are produce while an individual is fighting an infection tends to override the normal sleep-wake cycle and may lead to sleep at
inappropriate times. Additionally, prostaglandins (d2) may also play a key role in promoting sleep in a person who has been awake for an extended period of time (Ram et al., 1997), as their levels of prostaglandins are relatively high since they have not slept and given the body time to reduce the level of prostaglandins.

While the autonomic nervous system can influence people's ability to fall asleep by affecting levels of arousal (Parmeggiani, 1994), the homeostatic processes plays a strong role in the tendency to fall asleep. However, entering a state of relaxation after a night of sleep deprivation still does not ensure eight hours of restful sleep outside of the normal sleep-wake schedule (Parmeggiani, 1994). Timing that is consistent with the circadian rhythm or sleep-wake cycle, is the third factor required for good sleep (Cohen & Albers, 1991; Gillette & McArthur, 1996).

**Circadian Rhythm.** The natural environment provides living organisms with a variety of external stimuli, many of which follow a rhythmic pattern (e.g., the lunar-tidal, solar-daily, and seasonal-yearly patterns of light). Such patterns are quite predictable, and animals have adapted their physiology to contend with these environmental changes (Strubbe & Woods, 2004). Humans too have adapted to the natural rhythms in the environment. Similar to most other animals, human beings have a number of biological rhythms that serve as internal clocks. These rhythms vary in length, including annual rhythms (e.g., the secretion of testosterone in males) and monthly rhythms (e.g., the menstrual cycle in women). However, many biological rhythms are circadian rhythms that follow approximately 24-hour cycles. Sleep follows a circadian rhythm, but one to which human beings continue to adapt. The natural sleep-wake cycle follows a rhythm that is closer to a 25-hour cycle, and thus must be reset on a daily basis. The normal
period of inactivity starts several hours after dark and persists for some time into the daylight portion of the day (Boivin, Duffy, Kronauer, & Czeisler, 1994). Our internal clock is re-synchronized to a 24-hour cycle by external cues such as light. These external cues are commonly referred to as zeitgebers (German for “time givers”) (Aschoff, 1979). It has been shown with several species of animals (including humans) that a brief period of bright light will reset circadian rhythms after a maintained period of constant darkness (Aschoff, 1979). With the help of sunlight as a natural zeitgeber, human beings have adapted to a 24-hour sleep-wake cycle.

The portion of the brain that appears primarily to be responsible for regulation of circadian rhythms is the suprachiasmatic nucleus (SN), which is located in the hypothalamus (Refinetti & Menaker, 1992). The SN controls patterns of sleeping and waking primarily by regulation of the secretion of the hormone melatonin from the pineal gland. The SN becomes less active a few hours before a person’s regular bedtime, while the pineal gland begins to release melatonin into the bloodstream, causing the person to become sleepy within about an hour (Cajochen, Kraeuchi, & Wirz-Justice, 1997). Near a person’s normal waking time, production of melatonin decreases and the person becomes more alert. The SN follows a seasonal rhythm as well, secreting larger amounts of melatonin during the winter to account for the longer periods of darkness (Ralph & Lehman, 1991). If the SN is damaged, the flow of melatonin goes largely unregulated. Subsequently, people with such damage have difficulties maintaining alertness during the day (Cohen & Albers, 1991).

The SN receives messages from a bundle of nerves called the retinohypothalamic tract, which extends from the non-visual photoreceptors in the retina of the eye. Refinetti
and Menaker (1992) that when this bundle of nerves is damaged, circadian rhythms
become free running, and resistant to zeitgebers. However, the retinohypothalamic track
appears to be able to receive input from non-visual photoreceptors in the skin as well as
the retina. Campbell and Murphy (1998) found that when a bright light was focused
behind the knees (without contact with the eyes) of human subjects that were kept in dim
light for several days, circadian rhythms of the participants were reset. Circadian rhythms
did not reset in the control group, which did not receive the light treatment.

Another circadian rhythm in humans that has been closely linked with sleep is
body temperature rhythm. It is easiest to fall asleep when body temperature is near its low
point (Campbell & Zulley, 1989). During sleep, muscular activity is almost non-existent.
Thus, a major source of body heat is basically turned off, and body heat production is
reduced. While heat production is down, cooling production continues. The shivering
response to cooler temperatures is not active during sleep, yet the sweating response
remains, and can promote cooling. These processes help maintain the general decline in
body temperature during sleep (Hobson, 1995). During REM sleep, central temperature
control is essentially lost and reliant upon the environment or arousal to maintain stable
body temperature. It is believed neurons that control heat in the hypothalamus are rested
during REM sleep to enable them to control temperature more effectively during
wakefulness (Parmeggiani, 1977). This theory is further supported by sleep deprivation
studies that have shown that prolonged sleep deprivation generally results in a significant
drop in body temperature (Horne, 1988). A study of extreme sleep deprivation in rats
indicates that if an animal is deprived of sleep for long enough, the animal apparently will
die from complications resulting from the loss of ability to conserve body heat
Rechtschaffen, Gilliard, Bergmann, & Winter, 1983). The precise relationship between thermoregulation and sleep remains unclear, but it is evident that body temperature relates to the sleep-wake cycle, and that sleep may be crucial for thermo regular maintenance.

Circadian rhythms are of varying importance for human being and animal functioning. However, circadian rhythms can become desynchronized with those in the external environment when people change their daily routines, which can result in sleep disturbances (Carlson, 1999). Modern society often has demands that do not match natural circadian rhythms. This is evident in people who perform shift work and must change from working during the day to night. Night shift workers often drive home during the morning daylight. Since daylight is a natural zeitgeber, this may cause sleep difficulties. Additionally, night workers often attempt to shift back into a daytime schedule during days off, causing further circadian rhythm disruptions, and making it utterly impossible to adjust fully to one schedule of sleep and wakefulness (Akerstedt, 1988). Poor daytime sleep and circadian rhythm disruption have been linked to poor job performance, higher rates of traffic accidents, and health complications (Monk, Folkard, & Wedderburn, 1996). Studies have also shown a significant relationship between shift work and health complications, including headaches, gastric problems, and chronic cardiovascular difficulties (Parkes, 1999; Smith, Folkard, & Fuller, 2003). Additionally, Mitler and colleagues (1988) have found that engineering and industrial disasters happen most frequently between the hours of midnight and 6:00 a.m.
The Theories of Sleep Function

Approximately one-third of our lives are spent sleep; therefore, it must serve an important purpose. However, we do not know all of the benefits of sleep. There are different theories of sleep function, including the restoration model, the neurotransmitter replenishment theory, the evolutionary/circadian sleep models, the developmental model, and the learning model.

The Restoration Model. The restoration model suggests that we need to sleep in order to recover from daily physical activity (Hess, 1965; Walker, 2008). If this theory is correct, it would mean that the activity that wears down the body should increase sleep. Research conducted on sleep-deprivation supports this view, indicating that if we want to function at our best, we need sleep. A study of ultra-marathon runners, ages 18-26 years, found that they slept much longer and spend a greater percentage of time in slow-wave sleep on the two nights following their 57-mile run (Shapiro, Bortz, Mitchell, Bartel, & Jooste, 1981). A meta-analysis of 38 studies found that on the days that individuals exercised, they tend to sleep approximately 10 minutes longer (Youngstedt, O’Conner, & Dishman, 1997).

It is not precisely known what gets restored during sleep, but researchers report that a cellular waste product called adenosine plays a role (Alam et al., 2009). During sleep, it is thought that neurotoxins are neutralized and tissue restitution occurs (Adam & Oswald, 1977; Hartmann, 1973). Another possibility is that sleep evolved as a means for the body to conserve energy during the night to aid in thermoregulation during the coldest part of the day (Hobson, 1995).
The Neurotransmitter Replenishment Theory. The neurotransmitter replenishment theory suggests that aminergic neurons stop firing during sleep to allow their neurotransmitter supply to regenerate (Hobson, 1995). Neurotransmitters may be depleted if there is a limited supply, because neurons continuously fire during wakefulness. Most neurons in the body show decreases in activity during sleep. Aminergic neurons that release norepinephrine and serotonin stop firing altogether which provides a resting period so that these neurotransmitters can regenerate. It is hypothesized that aminergic neurons continue to generate norepinephrine and serotonin while resting. This allows these neurotransmitters, believed to be involved in learning and memory (Siegel & Rogawski, 1988), to create a reserve necessary to assist in cognitive activities the next day.

The Evolutionary/Circadian Sleep Models. The evolutionary/circadian sleep models emphasize that the main purpose of sleep is to increase an individual’s chance of survival in relation to environmental demands (Webb, 1974). Prehistorically, individuals were not active at night, because it would have been more dangerous to be hunting, food gathering, and traveling at night. Over the course of evolution, each species developed a circadian sleep-wake pattern that was adaptive in terms of its status as predator or prey, its food requirements, and its methods of defense from attack. Sleep may also have evolved as a mechanism to conserve energy. The body’s metabolic rate is approximately 9-25% slower during sleep than during wakefulness (Reich, Geyer, & Karnovsky, 1972; Wouters-Adriaens & Westerterp, 2006).

The Developmental Model. The developmental model suggests that sleep has a vital role in brain development (Carlson, 1999; Hobson, 1995). Current theories focus on
REM sleep because of its prominence in utero and infancy (Hobson, 1995). The fetus spends up to 80% of its time in REM sleep (Inoue et al., 1986; Petre-Quadens & DeLee, 1974; Roffwarg, Muzio, & Dement, 1966). This falls to 70% during early infancy and further declines to 30% at six months of age. This corresponds to the most active period of brain development. It is hypothesized that the activation during REM sleep provides an opportunity for the brain to practice future behaviors (Roffwarg et al., 1966). When fetal lambs were observed through Plexiglas windows implanted in the uterine wall, they were seen making chest breathing movements during REM sleep during brain development; they fail to explain the reason REM sleep is present in adults.

The Learning Model. The learning model suggests that the main function of sleep is to facilitate memory consolidation and integration (Carlson, 1999; Greenberg & Pearlman, 1974). Animal studies have suggested that REM sleep aids learning (Carlson, 1999). Animals deprived of REM sleep during training were found to learn tasks more slowly (Smith, 1996). Daytime learning in humans also appears to be hindered by lack of sleep (Hobson, 1995). Steriade and McCarley (1990) found that as neural pathways are strengthened, a new protein structure is created, which in turn allows new information to be stored in the brain. Therefore, a new memory is formed. Due to the instability of the new protein structure, it must be refreshed. The new neural pathways formed by learning information appear to be activated during REM sleep. This could be a reason REM sleep is crucial to learning and memory. It has been suggested that during REM sleep, the brain is aroused and begins to process information stored in memory which may reinforce both new and old memories (Antrobus, 1986). Students who demonstrated a significant increase in REM sleep followed a period of intense learning were found to perform
significantly better on an examination than students who did not show an increase in REM sleep (De Koninck et al., 1989).

The relationship between REM sleep and the integration of new information into long-term memory is not limited to the period immediately following learning. Research suggests this relationship extends well beyond the night the information was originally integrated (Buboltz et al., 2006). Smith and Lapp (1991) found that after students studied for final exams, during the five-day period following exams, REM sleep actually increased. As REM sleep increased, there was no concomitant increase in amount of sleep, nor was there an increase in number of REM sleep periods. These findings suggest that information was being integrated into long-term memory well after the exam. Because the increases in REM density occurred later in the evening, those individuals getting a full night of sleep profited from the increase in memory consolidation occurring after the initial learning period (Buboltz et al., 2006; Smith & Lapp, 1991). Therefore, students who cram for exams (i.e. study for long periods immediately prior to an exam) may miss out on the potential benefits of several nights of increased REM sleep.

In addition to the potential benefits of several nights of increased REM sleep, students who cram for exams by staying up all night also suffer a complete lack of REM sleep and the consequence this has on memory integration. Research suggests that lack of REM sleep coupled with sleep loss and/or poor sleep quality, are associated with significant impairments in cognitive functioning (Buboltz et al., 2006). Logical reasoning and decision-making in adults were demonstrated to be impacted be a single night of sleep loss (Blagrove & Akehurst, 2001; Harrison & Horne, 1999). Sleep deprivation also appears to have a negative effect on working memory (short-term memory used for
thinking and problem-solving). Sleep loss due to poor sleep quality is also linked to poor
cognitive functioning, false recall of recently learned words, and decreased visuomotor
skill (Roediger & McDermott, 1995).

**Sleep Difficulties of College Students**

Most studies exploring the sleep habits and difficulties of college students focus
on describing general sleep difficulties rather than supplying information about the
prevalence of diagnosis. Considering that these studies report results recorded primarily
through self-report, describing rather than diagnosing is more appropriate.

From 1969 through 1989, there was a notable decline in the average length of
time students' sleep. Hicks and Pellegrini (1991) point out that the median hours of
students sleep was 7.75 hours in 1969, 7.13 hours in 1979 and 6.75 hours in 1989. In
1969, 9% of students reported their average sleep duration as less than 6.5 hours of sleep.
However, in 1979, 26.9% of students reported receiving less than 6.5 hours sleep. The
amount of sleep continued to decline through 1989, during which 41.5% of students
reported consistently receiving less than 6.5 hours of sleep. This is supported by re-
analyzing the data found in the Hicks and Pellegrini's (1991) study which demonstrates
that the mean hours of sleep was fairly close to the median hours reported. In 1969 mean
hours of sleep was 7.50 (SD = .92), in 1979 the mean was 7.18 (SD = 1.67) and in 1989
the mean was 6.8 (SD = 1.01). While these findings do not include sleep quality indices,
they certainly present an alarming trend in college students sleep habits. Further, this
trend discounts the idea that poor sleep is simply a part of students' lives – it was not for
the majority of students in 1969.
Hicks and Pellegrini's (1991) study is not the first to demonstrate that sleep difficulties are becoming an increasing problem for college students. Over thirty years ago, Domino and Fogl (1980) noted their surprise at the lack of normative sleep studies for college students and thus proceeded to explore sleep habits and patterns of college students. They developed and administered a sleep scale they called the SQ 51, which was administered to a random sample of undergraduate students that consisted of 60 males and 71 females. The results indicated that 7% used medication for sleep difficulties, 13% reported their sleep was usually restless, and 39% reported that they often had highly irregular sleep schedules (Domino & Fogl, 1980).

Several years later, in a sample of Australian college students, Lack (1986) found that the most commonly reported symptoms were difficulty falling asleep (18%), early morning awakening (13.2%), general sleep difficulties (12.8%), and difficulty staying asleep (9%). Only 8% reported never having had sleep difficulties. Notably, when sleep complaints were examined for each student, 17% of the students had symptoms consistent with Delayed Sleep Phase Syndrome (DSPS). This is more than twice the estimated prevalence for the general population, which is about 6-7% (American Psychiatric Association, 1994, Lack, 1986). Further, it is noteworthy that students who met the criteria for Delayed Sleep Phase Syndrome had lower grades, greater feelings of drowsiness, and irritability when compared to the rest of the sample. In addition to the general findings, older subjects reported less sleep during the week, reduced perceived need of sleep, and greater drowsiness during the day. Younger subjects reported more variability in their sleep habits, longer sleep onset and greater difficulty falling asleep. Females reported a greater perceived need for sleep, but reported less total sleep time in
general and received less adequate sleep on weekends. Females also indicated more frequent
naps, greater irritability, and were more likely to describe themselves as insomniacs than
males. There were no significant gender differences for sleep onset time, difficulty falling
asleep, difficulty staying asleep, or sleep depth (Lack, 1986).

Brown and colleagues (2001) found that a sample of US college students also reported a
higher prevalence of Delayed Sleep Phase Syndrome than the general population. These
results showed a lower prevalence rate of DSPS than the Australian sample but higher rates
of some specific sleep complaints. Sleep difficulties most commonly reported “frequently” or
“almost always” were early morning awakenings (25.5%), general sleep difficulties (21.9%)
difficulty falling asleep (19.5%), daytime napping (15.1%), and difficulty staying asleep (10.9%).
Generally, however, the findings support a consistent pattern of poor sleep habits in college
students in these two geographically diverse samples. Students in the US sample went to bed
later on the weekend than the week and received less sleep during the week. Additionally,
females reported more frequent difficulties falling asleep and staying asleep than males.

Buboltz and colleagues (2001) found that only 11% of college students reported symptoms
consistent with good sleep quality, 73% of the sample reported moderate sleep problems,
and 15% of the sample had symptoms consistent with poor sleep quality, according to a
standardized sleep quality measure. Compared to the general adult population, these
students reported 60% greater incidence of poor sleep quality, than the original
standardization sample of working adults.

Another study (Hawkins & Shaw, 1992) examined sleep logs at three different, week-long
periods during the academic semester. The sleep logs were comprised of a
seven-item questionnaire that included items regarding the amount of time in bed, level of satisfaction with sleep and questions related to sleep quality and quantity. The amount of time in bed declined as the semester progressed and the demands placed on respondents increased. However, with the decreased time in bed, also came a decrease in the amount of nocturnal awakenings. At the same time, students rating of sleep quality did not change throughout the semester. It should be noted that the authors’ definition of sleep quality was based on one item that asked, basically how good their sleep was. Thus, these sleep quality findings are difficult to compare with other studies since researchers usually include the length of time to fall asleep, number of nocturnal awakenings, morning status, and general sleep satisfaction in their definitions of sleep quality. Despite some of the limitations with certain aspects of their study, it is clear that there was a noteworthy decrease in sleep length as the semester progressed.

Brown, Buboltz, and Soper (2002) explored the combined relationship of sleep quality, quantity, and sleepiness on students’ academic performance. They found that students’ ratings of sleepiness became higher as the academic quarter progressed. There was also a reduction in the length of sleep from the beginning ($M = 8.26$ hours) to the end ($M = 6.81$ hours) of the quarter. Using the Sleep Quality Index (Urponen, Partinen, Vuori, & Hasan, 1991) 16.7% of the students were classified as poor sleepers, while about 12% had symptoms consistent with Delayed Sleep Phase Syndrome. Only 8.9% of those surveyed reported that their sleep was free from difficulties. The prevalence of symptoms was similar in this study to previous prevalence studies in college students.

After reviewing the prevalence of sleep difficulties in students, especially their inconsistent sleep wake schedules, it seems likely that discrepancies between students’
social and academic schedules may negatively impact sleep quality. There is, in fact, empirical support for this contention. Students who were able to sleep late in the morning due to classes scheduled later in the day had more consistent sleep-wake schedules than those required to awaken for early morning classes. Further, students who had morning responsibilities showed evidence of partial sleep deprivation during the week. These results indicate that students may have healthier sleep habits if they are able to take classes and work later in the day (Machado, Varella, & Andrade, 1998).

That a high percentage of college students have poor sleep quality and habits is probably not a surprise for most students and faculty. However, it is surprising that despite both the empirically demonstrated high prevalence of sleep difficulties and intuitive sense that students do not sleep well, there do not seem to be any studies that focus on developing interventions to reduce student sleep difficulties. Nor does there appear to be many studies suggesting that colleges and universities are concerned about students sleep habits.

**Factors that Affect Sleep in College Students**

Over the past 25 years, there have been numerous studies exploring the sleep habits, patterns, and difficulties of college students. Studies on sleep deprivation, variation, and reduction have illuminated the numerous aversive effects that poor sleep quality and habits can have on students (Dinges, Whitehouse, Orne, & Orne, 1988; Karni et al., 1994; Kelly, Kelly, & Clanton, 2001; Lack, 1986; Pilcher & Huffcutt, 1996; Pilcher & Walters, 1997). Sleep difficulties take a variety of forms. There is a plethora of potential contributing factors that are salient in a college student population which may
impact their sleep habits and quality and in turn interfere with their functioning in a number of areas.

For many late adolescents, beginning college is a major life transition. Often this involves living away from family and friends for the first time. Depending upon the intensity, level of emotional preparation, and the relationship between the student and parents, separation from home can be a particularly difficult transition for many students (Hoffman & Weiss, 1987; Lopez, Campbell, & Watkins, 1988; Rice, Cole, & Lapsley, 1990). A host of other factors have been identified that can affect social life and adjustment to college, including level of self-esteem (Bettencourt, Charlton, Eubanks, Kernahan, & Fuller, 1999), perfectionistic tendencies (Chang & Rand, 2000), and masculinity and femininity traits (Sharpe & Heppner, 1991). Although there are many individual factors that can affect adjustment, the research ultimately suggests that for many the transition to college life can be a very difficult period.

College is also a time of other transitions. Students are given responsibility for various aspects of their lives, including sleep habits and patterns. Although many young adults relish their autonomy and independence, they nevertheless are subjected to substantial social and academic demands (Kleeman & Richardson, 1985; Russell & Petire, 1992). Many college freshmen live away from their families for the first time and may be involved with a barrage of social activities, such as fraternities and sororities, and academic and athletic clubs. This is often in the midst of adjusting to new surroundings, making new acquaintances, choosing a class schedule, and meeting the challenge of college academic requirements. Given the varying schedules to which college students
are often subjected, it is not surprising that this population encounters a great deal of sleep difficulties.

The demands of college adjustment bring potential for high levels of stress. Stress and worry have been linked to poor sleep quality (McCann & Stewin, 1987). Sleep and stress among college students appears to bring potential for a spiraling effect as changes in sleep patterns, in and of themselves, are often identified as stressful. A study by Ross, Neibling, and Hechert (1999) investigated 40 potential stressful situations that are commonly faced by college students, including interpersonal, intrapersonal, academic, and environmental sources of stress. Of the 40 potential stressors, change in sleeping habits was identified as one of the top five sources of stress for college students.

While many students may stay up late on weekends to engage in social events, they also frequently engage in late night study sessions to meet academic responsibilities, with some students reporting depriving themselves of sleep for 24-48 hours around examination periods (Hawkins & Shaw, 1992). Since many students may be able to identify changes in sleep habits as a source of stress, they may seek ways to combat this potential stressor. A common method used to compensate for lost sleep during the week is to sleep later on the weekends in an attempt to “catch up on sleep” (Machado et al., 1998; Pilcher & Walters, 1997). Unfortunately, this type of variable sleep pattern is conducive to a condition known as Delayed Sleep Phase Syndrome (DSPS), (Brown et al., 2001; Lack, 1986). DSPS is a circadian rhythm disorder resulting in excessive morning drowsiness and difficulty falling asleep on weeknights.

Another factor related to sleep difficulties among college students is the use of alcohol and sleep medication. Research indicates that the overall prevalence of binge
drinking (five or more drinks in a row) among college students is approximately 40-45% 
(O’Malley & Johnston, 2002; Wechsler, Davenport, Dowdall, Moeykens, & Castillo, 
1994; Wechsler et al., 2002; Wechsler & Nelson, 2008). Alcohol can expedite sleep onset 
and, depending on the quantity, can increase the amount of slow wave sleep a person 
obtains. However, the effects are paradoxical in that they actually decrease the amount of 
REM sleep, and can be associated with insomnia (Roehrs & Roth, 1997). While students 
who binge drink may believe they are benefiting from alcohol induced sleep because they 
fall asleep faster and may sleep longer, alcohol can inhibit the most important stage of 
sleep. Furthermore, students who reported drinking more alcoholic beverages fell asleep 
in class more often than those who drank less (Jean-Louis et al., 1998). Sleep medications 
also can have paradoxical effects. Students who choose to use sleep medications for sleep 
difficulties are in danger of exacerbating the problem. While sleep medications often 
leave individuals feeling less than alert due to the residual effects of the drug, most over 
the counter sleep medications can also inhibit REM sleep. Even short-term use of sleep 
medications can result in rebound insomnia (insomnia symptoms that are more severe 
than the originals) upon discontinuation of the medication (Roehrs, Vogel, & Roth, 
1990). Pharmacological treatments have demonstrated little, if any, effectiveness in 
treating long-term sleep problems (Morin & Wooten, 1996).

While some college students use medication to induce sleep at night, others use 
stimulants to stay awake during the day. The most common stimulant among college 
students is undoubtedly caffeine (Gilbert, 1986). One study found that 42% of college 
students drank coffee and 29% drank tea on a regular basis (Mathieson, Faris, Stam, & 
Egger, 1992). Even in fairly mild doses (100-150 mg., about one cup of brewed coffee)
caffeine has been shown to cause sleep disturbances, including delayed sleep onset, reduced sleep time, increased number of spontaneous awakenings, and increased amounts of light sleep (Caldwell, 2003; Pressman & Orr, 1997). The duration of caffeine activity in adults is 3-5 hours, but people can experience effects for up to 10 hours. Thus, even one cup of coffee in the afternoon can disrupt sleep, but this may depend on the individual’s sensitivity to caffeine (Nehlig, Daval, & Debry, 1992). People who use caffeine on a regular basis may develop a tolerance to the drug, and be less likely to have sleep difficulties than people that use caffeine occasionally. However, frequent caffeine users tend to have more sleep disruptions than non-users (Roehrs & Roth, 1997).

The use of illicit stimulants is also common among college students. Low and Gendaszek (2002) found that 35% of students from a small liberal arts college reported using prescription amphetamines at least once in the past year without a prescription. Similarly, 34% of the sample reported using cocaine or methylenedioxymethamphetamine (MDMA) in the past year, and 8% reported using at least once a week. While the full effects of illicit stimulants are unknown, oftentimes these substances have much longer lasting effects than milder stimulants such as caffeine, and thus have potential to cause even greater sleep difficulties.

Cigarette smoking may be related to sleep difficulties. A total of 28% of college smokers report they began smoking regularly after reaching college age (Wechsler, Rigotti, Glendhill-Hoyt, & Lee, 1998). Considering the massive amounts of negative exposure in the media and warning labels directly on packages, it is probably safe to assume that college students are aware of the potential detrimental health effects of smoking (i.e., cardiovascular disease, emphysema, lung cancer, etc.). However, students
may not be cognizant of the fact that nicotine is a stimulant. While, ironically, heavy smoking (more than 15 cigarettes a day) does not appear to affect sleep, light smoking has recently been linked with insomnia (Riedel, Durrence, Lichstein, Taylor, & Bush, 2004). Perhaps light smokers have not built up a tolerance to the drug, resulting in a stronger reaction to the stimulatory effect. Thus, students who have recently begun smoking and students who only smoke occasionally may be suffering from symptoms of insomnia and be completely unaware of this potential source of the problem.

Effects of Inadequate Sleep Length

In a sample of healthy adults (ages 21-38 years), restriction to four or six hours of sleep duration per night over two weeks resulted in significant and cumulative deficits in performance on cognitive tasks. These results of chronic sleep deprivation were comparable to those found with total sleep deprivation for one to two days (Van Dongen et al., 2003). Individuals who are sleep deprived demonstrate impaired judgments and are more likely to make mistakes. Research has shown that an individual who stays awake for 24 hours has a reduction in hand-eye coordination similar to an individual who had a blood alcohol content of 0.08% (Maruff, Falleti, Collie, Darby, & McStephen, 2005) and cognitive impairment similar to an individual with blood alcohol content of 0.05% (Falleti, Maruff, Collie, Darby, & McStephen, 2003).

Students who sleep for less than six hours per night are prone to miss one or more of their REM sleep periods, because REM sleep occurs in the latter part of an eight hour sleep period at this developmental stage in young adulthood (Karni et al., 1994; Smith & Lapp, 1991). Supporting that REM sleep is vital to memory consolidation of newly
learned material, students who receive more REM sleep demonstrate better learning efficiency (De Koninck et al., 1989).

Students who do not get a full night of sleep may be unknowingly weakening their ability to learn new information. Also, students who do not sleep as well the night before an exam will more likely demonstrate a decrease in test performance (De Koninck et al., 1989; Pilcher & Ott, 1998). Additionally, college students who sleep less than six hours per night or more than nine hours per night are more likely to have mild depressive symptoms compared to students sleeping between six and nine hours per night (Buela-Casal, Miro, Ianez, & Catena, 2007).

Sleep and Health

Research suggests that there is a relationship between sleep and quality/length and physical health. One study liked chronic insomnia to coronary artery disease (Bonnet & Arand, 1998). In a sample of over 5000 individuals over the age of 65 a link was found between poor sleep quality and decreased physical healthy including cardiovascular disease (Asplund, 2000; Newman, Enright, Manolio, & Haponik, 1997). Sleep difficulties were also linked to cardiovascular disease in a sample of adults (Appels & Mulder, 1984).

One sleep disorder in particular that can lead to health difficulties is sleep disordered breathing (e.g. sleep apnea). Mild sleep disordered breathing has been shown to be associated with an increase in complaints of bodily pain in children as young as five years of age (Rosen, Palermo, Larkin, & Redline, 2002). Mild sleep disordered breathing has also been associated with lower scores on a health-related quality of life measure in a sample of five to 17 year olds as well as a sample of 30 to 60 year olds (Finn, Young,
Palta, & Fryback, 1998). Mild sleep disordered breathing is even associated with other chronic conditions such as arthritis, angina, hypertension, diabetes, and back problems.

In a sample of 5,090 Japanese white collar workers poor sleepers were more likely to take sick leave, suffer physically and psychologically poor health and have problems in work related activities and personal relationships (Doi, Minowa, & Tango, 2003). The specific factor that was related to poor sleep quality was hypertension.

Edell-Gustafsson (2002) also examined the relationship between sleep and health in a sample of 40 men ages 45-70 who were about to undergo a coronary artery bypass surgery in Sweden. He found that poorer overall physical health was significantly related to longer sleep latency. These individuals displayed a decreased percentage of phases three and four sleep.

Individuals who reported poor sleep quality also endorsed more physical illness (Lund, Reider, Whiting, & Prichard, 2010). In this study, 12% of poor sleepers reported missing class three times or more in the last month due to illness compared to only 4% of the rest of the sample. In a sample of junior high students, a relationship was found between sleep quality and physical health with participants who reported poor sleep quality also reported a higher number of illnesses and lower scores on measures of general health (Tanaka et al, 2003). In a community sample, any sleep problems, inadequate sleep, difficulty falling asleep, and persistent nightmares were all associated with higher rates of migraines (Vgontzas, Cui, & Merikangas, 2008).

There has been growing interest in sleep quality and quantity as they relate to obesity. One longitudinal study found that in young adults (under age 40 years) there was a negative correlation between sleep length and BMI (Hasler et al., 2004). This finding
has very important implications for college students who have been shown to have a higher degree of sleep difficulties than the general public. If this contributes to a higher rate of obesity, this could mean that college students are at a higher risk for numerous health complications that result from obesity.

Many early studies examined the relationship between sleep and health from a biomedical model (Parmeggiani, 1977; Roffwarg et al., 1966; Sassin et al., 1969; Webb & Agnew, 1974). This model purports that health and illness are a function of biology, or that poor health is always the result of pathogens (Engel, 1977). Additionally, the biomedical model biological processes are essentially independent from psychological and social processes. However, recent research has shown that physiological health can be greatly impacted by psychological factors (e.g., placebo effects), and that psychological health can influence physiological health (e.g., biological illness resulting in depression). Thus, psychologists (and many physicians alike) have begun to approach the topic of health from a much broader biopsychosocial model. This model suggests that health can best be explained by examining biological processes, psychological processes, and social influences (Peterson, 1997). In this section, the relationship between sleep and health will be examined from each of the components of the biopsychosocial model.

Among the most common sleep disorders is insomnia, with prevalence estimates that range between 15% to 20% for chronic insomnia, and 30% to 40% for transient or occasional insomnia (Mellinger et al., 1985). Chronic insomnia has been linked with the coronary artery disease (Bonnet & Arand, 1998). In addition to adversely affecting physiological health, insomnia can also affect mood, relationships, and overall psychological well-being (Lacks, 1987; Sloan & Shapiro, 1993).
Sleep difficulties have been linked to a variety of physiological ailments in various populations. A condition that often causes sleep difficulty is sleep-disordered-breathing. Although sleep disordered breathing can be caused by respiratory disease, it is generally associated with sleep apnea; a condition in which an individual's airway is obstructed during sleep, and the individual is awakened several times a night due to lack of oxygen (Thorpy & Yager, 2001). One study found that children as young as five years old with mild-sleep-disordered-breathing (MSDB) reported significantly more bodily pain complaints (Rosen et al., 2002). MSDB was also related to lower scores on a measure of health-related quality of life for children ages 5-17, and increased effects were apparent with more severe sleep disordered breathing. A study involving adults 30-60 years of age reported similar results, with even mild cases of sleep disordered breathing resulting in decrements on a general health survey (Finn et al., 1998). The severity of health problems related to poor sleep resulting from sleep disordered breathing is noted in the fact that the magnitude of decrements on the health survey were comparable to other chronic conditions, such as: arthritis, angina, hypertension, diabetes, and back problems.

Sleep difficulties appear to have an impact on physiological health in people of all ages. In a study involving junior high school students, a link was found between general quality of sleep and physiological health, with adolescents who reported poor sleep also reporting a higher number of illnesses and lower scores on a measure of general health (Tanaka, et al, 2003). Poor sleep has been linked with poor health in the geriatric population, as well. Two studies, each consisting of over 5,000 participants over the age of 65, linked poor sleep to reduced physical health, including limitations in activities of daily living, and increased reports of cardiovascular disease (Asplund, 2000; Newman et
al., 1997). Research by Appels and Mulder (1984) found that sleep difficulties in adults were related to cardiovascular disease, while Elashoff et al. (1983) found an association between sleep and gastrointestinal disorders.

Another interesting area that is gaining a great deal of attention is the possible link between sleep quality and length and obesity. Research is beginning to emerge indicating that individuals who sleep less on a regular basis tend to increase their body mass index (BMI). Hasler et al. (2004) in a longitudinal study found that short sleep duration was associated with an increase in BMI for younger adults, but that the association disappeared for individuals over the age of 40. This finding was consistent with previous research that had examined the relationship between sleep length and obesity. The finding that sleep is related to BMI or obesity in younger adults points to age-specific pathophysiologic mechanisms of obesity (Comings, Gade, MacMurray, Muhleman, & Peters, 1996). Taken together these results may indicate that the amount of sleep that a younger individual receives may be related to obesity. This may be especially important in the college population as results have consistently shown that students tend to sleep less than the general population. The finding that sleep duration is related to obesity may have numerous implications for health as obesity has been shown to be a major contributor to a variety of health difficulties.

Another common source of sleep difficulties is the lack of a consistent sleep schedule that disrupts the body’s natural sleep circadian rhythm. Having wake times that vary even just a couple of hours can greatly affect sleep quality and cause sleep disturbances (Lack, 1986). Ultimately, inconsistent sleep schedules can result in decreased physiological, psychological, and social health. When it comes to college
students, the research clearly indicates that poor sleep habits and patterns are associated with a variety of difficulties. Among these are increased tension, depression, decreased psychological well-being, and generally lower life satisfaction (Pilcher et al., 1997). In a study by Taub and Hawkins (1979), young adults who reported irregular sleeping schedules had lesser tendencies toward achievement potential, intellectual efficiency, self-control, and sociability. One of the more serious disruptions to a regular sleep schedule is shift work. Studies have shown a significant relationship between shift work and health complications, including headaches, gastric problems, depressed cellular immune function, respiratory tract infections, and chronic cardiovascular difficulties (Irwin et al., 1994; Parkes, 1999).

In terms of psychological health, a clear relationship has been established between poor sleep quality and negative mood states (Bonnet, 1985; Gau, 2000; Gray & Watson, 2002; Lacks & Morin, 1992; Pilcher & Huffcutt, 1996). The most common negative mood state associated with poor sleep is depression. Unfortunately, the direction of the sleep/depression relationship (whether depression causes sleep difficulties, sleep difficulties cause negative mood, or they interact) remains unclear. However, since sleep difficulties are one of the hallmark symptoms of depression (APA, 1994), it is certainly possible that the relationship is cyclical, in that depressed mood can lead to poor sleep quality, and in return poor sleep quality can exacerbate negative mood states.

Albeit somewhat counterintuitive, there also appears to be a link between sleep deprivation and decreased symptoms of depression. Studies have shown that short-term sleep deprivation is correlated with positive changes in both thought content, as well as improvement on clinical assessments of depression (Kraft, 1984; Vein & Airapetov,
1984). Although it is not clear why symptoms of depression often decrease following sleep deprivation, researchers suggest that neurophysical and biochemical processes that occur during sleep, are responsible for one’s emotional state (Vein & Airapetov, 1984). Not surprisingly, research on REM sleep deprivation (rather than total sleep) appears to have an effect on depressive symptoms. The negative emotion connected with emotionally important memories appears to decrease following sleep deprivation (Greenberg, Pearlman, Schwartz, & Grossman, 1983). However, positive changes in mood due to short-term sleep deprivation appear to be ephemeral, as individuals in these studies tend to return to baseline levels of depression after a regular night of sleep (Kraft, 1984; Vein & Airapetov, 1984).

There is also a body of research linking sleep quality with clinical (abnormal) aspects of psychological health. Poor sleepers not only tend to have higher scores on scales of depression than good sleepers, they also have been shown to score higher on scales that measure symptoms of anxiety, and social introversion (Aikens & Mendelson, 1999; Monroe, 1967). Similarly, poor sleep appears to be related to Type A personality. Type A behavior involves a chronic, incessant, struggle to achieve more and more in less time, which can result in health difficulties (Friedman & Rossman, 1974; Krantz, Arbrier, Davia, & Parker, 1988).

In addition to the manifestations of health difficulties that appear to be related to poor sleep, sleep loss may have adverse effects on normal growth and development, as well as maintaining a healthy immune system. Both protein synthesis and growth hormones play a substantial role in physical growth, and are at their highest levels during REM sleep (Parker et al., 1980; Sassin et al, 1969). After only a few nights of poor sleep,
metabolic and hormonal function can be adversely affected (Murphy, 2000).

Additionally, the number of natural killer T-cells that are crucial to the body's immune system in fighting infection have been shown to be reduced up to 50% in individuals who obtain less than six hours of sleep (Irwin et al., 1996). Subsequently, loss of sleep can exacerbate existing health difficulties, including hypertension and Type II diabetes, resulting in more severe complications (Murphy, 2000).

The literature also suggests a relationship between sleep habits and social and psychological health. As early as in pre-adolescence, poor sleep quality has been linked with poor mental health (Meijer, Habekothe, & Van Den Wittenboer, 2000). One study involving college students found that individuals considered to be psychologically healthy reported increased somatic complaints, greater tendency toward obsessive-compulsive activities, higher levels of interpersonal reactivity, more symptoms of depression and anxiety, and higher social discomfort, after only a single night of poor sleep (Zammit, 1988). Additionally, Carpenter (2001) noted that Attention Deficit Hyperactivity Disorder is often associated with sleep difficulties. Poor sleep may exacerbate health difficulties in individuals who are afflicted with psychological disorders. The relationship between traumatic stress symptoms and health functioning was fully mediated by sleep in a study comprised of urban police officers with posttraumatic stress symptoms; only those who reported poor sleep also reported somatic health problems (Mohr et al., 2003).

College students who are able to fall asleep faster and who have fewer sleep disturbances also have been found to report fewer mental and social health difficulties (Lowry, Dean, & Manders, 2010). Recent studies also have linked sleep loss to changes
in mood, personality, and cardiovascular disease (Blagrove & Akehurst, 2001; Boland et al., 2002; Taylor & McFatter, 2003). Sleep loss, whether due to sleep disorders, deprivation, or poor quality, appears to have a negative impact on the total functioning of humans. Ultimately, poor sleep habits and patterns, as well as sleep difficulties, appear to have significant adverse effects across measures of physical, mental and social health.

**Sleep and Obesity/Health Status.** Research has indicated that sleep difficulties have made a serious impact on various aspects of human functioning (Pilcher & Walters, 1997). These studies examined the effects of sleep quality on an individual’s ability to function. Sleep quality is generally defined by the number of nighttime awakenings (including the amount of time required to return to sleep), sleep latency (the amount of time required to fall asleep), a feeling of fatigue/restfulness upon awakening in the morning, sleep duration (the amount of time in a sleeping state) and a general satisfaction with the sleep received (Pilcher & Walters, 1997).

Studies of sleep quality and obesity often focused on the relationship of sleep quality and eating behaviors. Hicks, McTighe, and Juarez (1986) found that college students with poor sleep quality were more likely to stray from eating three meals per day and were more likely to snack than those with good sleep quality. More recently, Tanaka and colleagues (2002) showed that junior high school students who were poor sleepers were less likely to eat breakfast and had poorer overall dietary habits than the good sleepers. Specifically, this line of research suggests that sleep quality relates to eating behavior, and thus weight gain/obesity.

A new line of obesity research has related a specific aspect of sleep quality, sleep duration, to weight gain and obesity. Evidence from laboratory studies with animals and
humans indicate a link between sleep deprivation and an increased body weight
(Gangwisch, Malaspina, Boden-Albala, & Heymsfield, 2005). Further, based on results
from a longitudinal study, Kripke, Garfinkel, Wingard, Klauber, and Marler (2002) found
consistent increases in BMI among individuals who habitually slept less than seven hours
a night. Along these lines, Hasler and colleagues (2004) found results in a 13-year
longitudinal study that indicated as the amount of sleep per night decreased, BMI
increased. Finally, Taheri, Lin, Austin, Young, and Mignot (2004) found that individuals
who slept less than the recommended eight hours a night showed increased BMI, which
was proportional to the amount of decreased in sleep time.

The results of the preceding studies indicate that sleep durations of less than seven
to eight hours are associated with an increased BMI (Kripke et al., 2002; Taheri, Zeitzer,
& Mignot, 2002) and with obesity (Gangwisch et al., 2005; Hasler et al., 2004). Although
the precise mechanism relating lowered sleep duration to weight gain/obesity remains
unclear, recent research has indicated a hormonal component involving leptin and ghrelin
(Prinz, 2004).

Lower levels of leptin, a peptide hormone responsible for suppressing food intake
and increasing energy levels (Prinz, 2004), has been related to increased BMIs and sleep
duration of less than eight hours (Spiegel, Tasali, Penev, & Van Cauter, 2004; Taheri et
al., 2004). Conversely, higher levels of ghrelin, a peptide hormone responsible for
stimulating appetite, fat production, and body growth (Prinz, 2004), have been related to
increased BMIs and less than eight hours of sleep (Speigel, Tasali, Penev, & Van Cauter,
2004; Taheri et al., 2004). Spiegel and colleagues (2004) found that young men who had
their sleep curtailed had lower levels of leptin, increased ghrelin levels and increased
appetite and hunger ratings. It was noted that the men in the experimental condition reported craving sweets and high starch food compared to controls. Research has indicated that those with sleep restriction or decreased sleep show a decrease in insulin response to glucose (Spiegel, Leproult, & Van Cauter, 1999). This typical hormone pattern found in individuals with decreased sleep is a pattern that consistently has been associated with decreased energy expenditure and increased appetite and obesity (Prinz, 2004).

In adults, less than seven hours of sleep per night can effect normal growth and development as well as the maintenance of a healthy immune system. Both protein synthesis and growth hormones play a substantial role in physical growth, and are secreted at their highest level during REM sleep (Parker et al., 1980; Sassin et al., 1969), which occurs at a higher frequency at the end of the sleep cycle. Further, individuals who obtain less than six hours of sleep can have 50% reduction in natural killer T-cells that aid the body’s immune system in fighting infections (Irwin et al., 1996). Finally, Taylor and McFatter (2003) linked sleeplessness to cardiovascular disease.

During the sleep period following a night of sleep deprivation, SWS predominates over the other stages and significantly less REM sleep takes place (Angus, Heslegrave, & Myles, 1985; Bonnet, 2000). Stage four sleep increases after unusually high amounts of exercise (Trinder, Paxton, Montgomery, & Fraser, 1985). Additionally, the greatest amounts of growth hormone are released during SWS (Sassin et al., 1969). These findings demonstrate the important role played by SWS in maintaining physical health.

The literature also suggests a relationship between sleep quality and psychological health. Poor sleep quality has been linked with poor mental health as early as
preadolescence, with a clear relationship established between poor sleep quality and negative mood states for adults, as well (Bonnet, 1985; Gau, 2000; Gray & Watson, 2002; Lacks & Morin, 1992; Pilcher & Huffcutt, 1996). Stress and worry have been linked to poor sleep quality (McCann & Stewin, 1987), as have increased tension, decreased psychological well-being, and general lower life satisfaction (Pilcher et al., 1997). Similarly, poor sleep appears to be related to Type A personality, the latter involving a chronic incessant struggle to achieve more and more in less time, which can result in health difficulties (Krantz et al., 1988). Buboltz and colleagues (2006) found that college students who were able to fall asleep faster with fewer sleep disturbances had fewer mental and social health difficulties. In a study by Taub and Hawkins (1979), adults who reported irregular sleeping schedules demonstrated fewer tendencies toward achievement potential, intellectual efficiency, self-control, and sociability.

Research on sleep deprivation and psychological health has demonstrated that sleep deprivation of only one night is related to increased excitability and impulsiveness (Sicard, Jouve, & Blin, 2001; Vein, Dallakyan, Levin, & Skakun, 1983). One study involving psychologically healthy college students found a relationship between sleep loss and decreased psychological health, with increased somatic complaints, obsessive-compulsive activities, higher levels of interpersonal reactivity, and higher social discomfort after only a single night of sleep loss (Zammit, 1988). Other studies have linked sleep loss to changes in mood (Blagrove & Akehurst, 2001).

Cognitive skills also are affected by poor sleep quality perhaps due to a relationship of cognitive abilities and REM sleep (Pilcher & Walters, 1997). Research has demonstrated that the last half of a full night’s sleep, specifically REM sleep, may be the
most important in the learning process (Smith & Lapp, 1991). When this sleep is
terminated prematurely, cognitive abilities are negatively affected. Blagrove and
Akehurst (2001) and Harrison and Horne (2000) found dramatic negative effects on
cognitive functioning, impacting logical reasoning and decision making in adults
following the loss of only one night of sleep. Adults reporting excessive sleepiness also
report negative effects on working memory (short-term memory used for thinking and
problem solving), psychomotor reactivity, and increased suggestibility (Blagrove &
Akehurst, 2001). Other studies have shown that sleep difficulties can significantly impair
academic performance, learning, visuomotor skills, and general cognitive ability
(DeKonick, Lorrain, Christ, Proulx, & Coulombe, 1989; Lack, 1986; Schredl, Weber, &
Heuser, 1998). Attention is susceptible to partial sleep deprivation, poor cognitive
functioning, as well as false recall of recently learned words and decreased visuomotor
skill (Grosvenor & Lack, 1984; Karni et al., 1994; Webb & Agnew, 1974).

There also is a body of research linking sleep quality with clinical (abnormal)
aspects of psychological health. Studies indicate a relationship between higher rates of
Carpenter (2001) also found that Attention Deficit Hyperactivity Disorder is often
associated with deficits in sleep quality. Further, in a study comprised of urban police
officers with posttraumatic stress symptoms, only those who reported poor sleep quality
also reported somatic health problems (Mohr et al., 2003).

The studies of sleep disturbances and depression have yielded contradictory
results. Aikens and Mendelson (1999) found higher rates of depression were associated
with deficits in sleep quality. Zammit (1988) confirmed these results by finding increased
symptoms of depression after sleep loss. However, Kraft (1984) found that short-term sleep deprivation was linked with decreased symptoms of depression. This contradiction indicates the need for further research on the psychological effects of sleep disturbances.

**Sleep and Learning/Academic Performance**

The link between sleep and cognitive performance has been well documented (Karni et al., 1994; Ohayon, Caulet, Philip, Guilleminault, & Priest, 1997; Smith & Lapp, 1991). REM sleep has been shown to be the most critical part of the sleep process, in terms of consolidating memory and learning experiences from the prior day into long-term memory. REM sleep is also the most difficult to obtain in sufficient quantities, due to the nuances of the sleep cycle. REM occurs at the end of each sleep cycle; for the first few complete cycles, there is a quite limited amount of REM sleep occurring at the end of each cycle. However, if a person remains asleep long enough the amount of time spent in REM sleep becomes longer. After about 7-8 hours of sleep, the amount of REM sleep is then sufficient to integrate the complex material acquired during the day into long-term memory.

Animal studies have suggested that REM sleep aids learning (Carlson, 1999). In a study on learning in rats it was found that rats learning a complex maze made the largest gains in learning following the largest periods of REM sleep (Bloch, Hennevin, & Leconte, 1977). Animals deprived of REM sleep on the other hand were found to learn the task more slowly. Daytime learning in humans also appears to be hindered by lack of sleep (Hobson, 1995). As the neural pathways are strengthened a new protein structure is created which in turn allows the new information to be stored in the brain in the form of memory (Steriade & McCarley, 1990). It appears that the new protein structure must be
refreshed to remain strong due to its instability. It is during REM sleep that new neural pathways formed by learning information appear to be activated. This could be why REM sleep is crucial to learning and memory. It has also been suggested that during REM sleep the brain is aroused and begins to process information stored in memory, which may reinforce both old and new memories as well as recently learned material (Antrobus, 1986). This may explain the large amounts of time that infants and young children spend in REM sleep. They are consolidating new information and building new neural pathways at prolific rates. This would give further credence to the importance of REM sleep in the learning process of college students given that the college environment represents a substantial increase in the cognitive demands placed on students relative to high school.

Additionally, there appears to be greater learning efficiency among those who obtain sufficient REM sleep. De Koninck et al, (1989) found that among students enrolled in a 6-week French immersion course, those students who demonstrated increased REM sleep the night following intensive learning periods were better able to recall newly acquired information, with lower error rates as well, than were students who did not demonstrate comparable increases in REM sleep. It should also be noted that this study also found that increases in other stages of sleep did not result in any improvements in memory whatsoever, further underscoring the importance of REM.

The relationship between REM sleep and the integration of information into long-term memory is not limited to the period immediately following learning. In fact, research suggests that this relationship extends well beyond the night that the information was integrated. For instance, Smith and Lapp, (1991) found that when students studied
for final exams, that REM sleep actually increased in density in the five-day period after their exams had taken place. Despite this increased REM sleep density, there was no concomitant increase in the amount of sleep per se, nor was there any increase in the number of REM sleep periods. Additionally, these periods of increased REM sleep density were occurring in the latter part of the evening. Taken together, these findings suggest that information was still being integrated into long-term memory well after the exam, and since the increases in REM density were occurring later in the evening, this means that only those individuals who were getting a full night of sleep were able to profit from this increase in memory consolidation which was occurring after the initial learning period. It naturally follows from these studies that students who cram, that is study for long periods immediately prior to an exam, are missing out on the potential benefits of several nights of increased REM sleep. These findings could also be used to explain the superiority of distributed practice over mass practice. Individuals who spread their learning and studying over several nights prior to an exam will get the benefits of the increase in REM sleep density and improve the integration of new memories and learned material (Smith & Lapp, 1991).

Considering the importance of REM sleep in improving the integration of material into long-term memory, the question of what effects the complete lack of REM sleep might have on memory integration naturally follows. This question would be moot were it not for the fact that cramming for exams is virtually synonymous with the college experience and it occurs at all levels of education and across all ability and motivation levels. It is important to remember that this cramming can affect sleep in different ways; for instance, some students may study for several hours into the early morning and then
get a few hours of sleep, while others may simply skip sleep altogether. In either case, students are losing out on REM sleep. In fact, research has borne out that both REM sleep loss and/or poor sleep quality are associated with significant impairments in cognitive functioning. A night of sleep loss has been shown to impact logical reasoning and decision making negatively in adults (Blagrove & Akehurst, 2001; Harrison & Horne, 1999). Sleep deprivation appears to affect working memory negatively (short-term memory used for thinking and problem solving), psychomotor reactivity, and increase suggestibility (Blagrove & Akehurst, 2000; Sagaspe, Charles, Taillard, Bioulac, & Phillip, 2003). Sleep loss due to poor quality of sleep has also been linked to poor cognitive functioning, false recall of recently learned words, and decreased visuomotor skill (Roediger & McDermott, 1995).

The impact of sleep deprivation or partial sleep deprivation and poor quality of sleep goes beyond just memory consolidation and acquisition of new knowledge. Research has indicated that poor sleep is related to impairments in attention and concentration ability during the day, results in less vigilance, longer reaction times and perceptual distortions (Horne, 1988; Pilcher & Huffcutt, 1996; Tilley & Brown, 1992). Additionally, even a single night of restricted sleep has been shown to result in decreases in verbal creativity, abstract thinking and concept formation (Randazzo, Muehlbach, Schweitzer, & Walsh, 1998). These researchers also noted that sleep deprived individuals also had difficulty verbally expressing their ideas or thoughts. This may have implications for students in the learning environment as the impact of poor sleep quality may interfere with their ability to ask questions and clarify important information that may be necessary for optimal performance. As if the problem of sleep deprivation and
poor sleep quality impact on various aspects of performance were not enough. Students who were sleep deprived or had poor quality of sleep rated their performance after completion of a cognitive task as significantly better than individuals who were not sleep deprived. They also rated their concentration and attention level as being higher than non-sleep deprived individuals. In actuality their performance was just the opposite. It was found that the sleep deprived individuals performed lower on the actual cognitive task and showed signs of concentration and attention problems while attempting the task (Pilcher & Walters, 1997). These findings are very disturbing. If students believe that their performance is superior when they are sleep deprived or under poor sleep quality conditions there is little impetus for them to alter their sleep habits or seek professional help. In conjunction with this students may make inaccurate attributions about the causes of their actual performance. It is likely that students will attribute their poor performance to such things as poor instruction, lack of resources, or not enough study time, but not to poor sleep habits and quality which may be a major contributing factor to their poor performance.

Although, the link between cognitive performance and REM sleep have been fairly well established, it is much more difficult to establish the relationship as clearly between sleep difficulties (e.g., decreased REM) and other more global measures of cognitive performance such as Grade Point Average (GPA). Jenkins, Buboltz, and Wilkinson, 2003 reported that the majority of studies that have examined the relationship between REM sleep and cognitive performance have been conducted in laboratory settings and have been able to manipulate the actual amount of time that individuals have been able to spend in REM sleep. Moving outside of the laboratory environment brings
numerous issues that may create difficulties. The conclusions drawn may not be as specific due to lack of experimental control, but similar patterns have emerged in the research on the relationship between sleep habits and quality and academic performance. Overall, the results have been fairly consistent with findings indicating that students who report poor sleep quality and habits have lower overall GPA’s (Jenkins, Buboltz, & Wilkinson, 2003).

In examination of the few studies that have explored this relationship a variety of findings related to various sleep habits and quality have emerged. It is clear that no one particular form of sleep difficulty is responsible for lower GPA’s. Lack (1986) found that students who met the criteria for Delayed Sleep Phase Syndrome (DSPS) had significantly lower grades, greater feelings of drowsiness, and irritability when compared to the rest of the sample. However, he did not find any relationship between grades and overall sleep quality.

In a study of health related variables students who went to sleep later on weekdays and also who awoke later on weekdays showed a significant negative correlation with GPA (Trockel et al., 2000). These findings indicate that the sleep-wake schedule of students may have a negative impact on academic performance. Lowry and colleagues (2010) examined the relationship between overall sleep quality and GPA. They found that overall sleep quality was significantly negatively related to GPA. Their study examined all aspects of sleep quality and would go counter to some of the findings of Lack (1986) which did not find a relationship between sleep quality and grades.

Finally, Gray and Watson (2002) examined the relationship between sleep quality, sleep length, sleep schedule and GPA. Their findings were somewhat mixed compared to
the previous findings. They did not find any significant relationship between overall sleep
quality or sleep length and GPA. However, they did find a significant negative
correlation between sleep schedule and GPA. It should however, be noted that the
correlations between sleep quality and length and GPA were in the negative direction, but
did not reach significance. Taken together it appears clear that sleep difficulties and
quality have an impact on student GPA. The exact nature of this relationship is difficult
to determine at this time due to the limited number of studies and the fact that the studies
have all been correlational in nature.

The evidence is clear: sleep is essential to high-caliber academic performance,
because sleep in general and REM sleep in particular are essential to the acquisition of
long-term memory and integration of new material. Even when examined outside of the
laboratory findings are fairly consistent that sleep difficulties in various forms impact the
GPA’s of students.

**Sleep Quality and Physical Performance**

Sleep quality and physical fitness are important for young adults' growth and
health. However, little research has examined the relationship between sleep quality and
physical fitness in young adults. Lee and Lin (2007) conducted a study with 291 female
college students in Taiwan, which investigated the association between subjective sleep
quality and physical fitness. The Chinese version of the Pittsburgh Sleep Quality Index
(PSQI) was used to measure sleep quality. The results indicate that participants with poor
sleep quality had a significant short distance for the sit-and-reach (flexibility), fewer
repetitions for the curl up test (muscular strength and endurance), and a longer time to
finished the 800-m run/walk test (cardiovascular fitness) than participants with good sleep quality.

Poor sleep has been associated with reduced physical function in older adults (Foley, Ancoli-Isreal, Britz, & Walsh, 2004; Foley, Monjan, & Brown, 1995; Kutner, Ory, Baker, & FICSIT Group, 1994; Whitney et al., 1998), although all of these studies used subjective measures of sleep. Abnormal sleep patterns were reported by over 15% of older adults who also indicated ambulatory limitations (Rantanen et al., 2003). Studies using objective measures of sleep and physical functioning are needed.

Goldman et al. (2007) examined the association between disturbed sleep and daytime physical functioning in 2,889 older women. The study used actigraphs to assess sleep variables. Gait speed, chair stands, and grip strength were the neuromuscular performance measures. The results indicate that participants with poor sleep walked slower, took longer to complete chair stands, and had lower grip strength. The participants with a total sleep time between 6.0 and 7.5 hours tended to perform better on neuromuscular performance. In addition, participants with more fragmented sleep (as measured by minutes of wake after sleep onset) had worse neuromuscular performance and were more likely to have functional impairments. Finally, women who took a nap greater than or equal to one-hour had a higher chance of having a functional limitation than those who took less than a 30-minute nap.

**Napping and Physical Performance**

A short nap is effective for recovery of attention, concentration, and brain function (Shirakawa, Takase, Tanaka, & Yamamoto, 1999), all of which are used in
physical performance. Tietzel and Lack (2001) have reported that sleep inertia occurs after a 30-minute nap, while that is not the case for a 10-minute nap.

Sleep inertia is a state of lowered arousal that an individual experiences immediately upon awakening (Tassi & Muzet, 2000). The longer the nap, the greater the chance there is of experiencing more effects of sleep inertia. Even naps of 30 minutes in length show negative effects of sleep inertia (Tietzel & Lack, 2001). Brooks and Lack (2006) found that out of 5-, 10-, 20-, and 30-minute naps, the 10-minute nap produced immediate improvements in sleep latency, subjective sleepiness, fatigue, vigor, and cognitive performance, and it was the most effective nap duration. There was evidence of sleep inertia effects following the 30-minute nap; however, there was no evidence of sleep inertia effects after the other naps.

The aim of the study by Waterhouse and colleagues (2007) was to examine the effects of a post-lunch nap on alertness and performance after partial sleep loss. Participants in this study were 20 males in Libya. The physical performance measures used were handgrip strength and sprint running times over two and 20 m. Results indicated that naps produced an improvement in sprint performance after sleep loss during the previous night. In contrast, a nap did not improve grip strength; there was actually a decline in grip strength. Because the researchers examined each score on the hand dynamometer instead of taking the best of the three scores, this decline could be explained by muscle fatigue. Additionally, naps improved alertness and decreased sleepiness.
Relaxation

Relaxation techniques encompass several types of relaxation designed to decrease physiological arousal, which can assist in decreasing the time it takes to fall asleep (Morin & Wooten, 1996). Research has demonstrated a relationship between physiological arousal and sleep quality (Bonnet & Arand, 1995; Monroe 1967). Relaxation techniques decrease sleep latency (Bootzin & Perlis, 1992; Friedman, Bliwise, Yesavage, & Salom, 1991; Hryshko-Mullen, Broeckl, Haddock, & Peterson, 2000; Morin, Culbert, & Schwartz, 1994; Morin & Woten, 1996). Relaxation is a popular clinical and educational tool that benefits health, well-being, and performance (Khasky & Smith, 1999).

Relaxation Techniques. Relaxation techniques focus on decreasing arousal level to induce sleep onset. Different relaxation techniques include progressive muscle relaxation, deep breathing, and mental imagery. Progressive muscle relaxation (PMR) teaches individuals to recognize and manage physical muscle tension by systematically tensing and relaxing the major muscle groups (Stepanski, 2000). Deep breathing is another relaxation technique that is often combined with PMR. Mental imagery is a technique that decreases cognitive arousal, such as racing thoughts or worrying, by visualizing oneself in a specific scene that is associated with a calm relaxed state. Mental imagery may entail imagining oneself on a beach or other pleasant place like lying in the sun, if it is a positive situation for the individual. Imagining feeling of warmth also help. Behavioral approaches tend to work well with simple physical restlessness, while imagery is effective for people who have both mental and physical restlessness, such as ruminating about the day's events (Morin & Wooten, 1996).
For all relaxation approaches it is beneficial for the therapist or counselor to first instruct the individual how to relax using the chosen technique in session. Homework geared toward between-session practice with a review at the next session for fine tuning and feedback can facilitate effectiveness. In each instance close monitoring on the part of the therapist tends to increase compliance and effectiveness of relaxation techniques.

Counselors are encouraged to help individuals create their own relaxation tapes. Making a tape encourages individuals to import their interests and ideas into their treatment. For deep muscle relaxation audio-taping the individual session exercise and giving the tape to the individual for home practice can be beneficial. Listening to a tape when attempting to fall asleep takes less cognitive effort than trying to remember the steps to relaxation taught by a therapist (Buboltz et al., 2002). Further, expecting those with sleep difficulties to spend hours in therapy learning relaxation techniques may simply create a situation for non-compliance, whereas creating a relaxation tape enables them to continue treatment with less professional monitoring. No matter what approach to relaxation that is used by the therapist and individual, it is important that the individual consistently apply the approach on a regular basis. Without consistent application, effectiveness of relaxation techniques to reduce sleep difficulties diminishes.

Efficacy studies generally support the use of relaxation therapies to decrease sleep latency (Bootzin & Perlis, 1992; Morin & Wooten, 1996). However, not all individuals with sleep difficulties are physiologically hyper-aroused. Some studies demonstrate relationships between poor sleep quality and physiological arousal (Bonnet & Arand, 1995; Monroe, 1967). Relaxation therapies are likely to work for physiologically aroused individuals that are experiencing sleep difficulties. On the other hand, some people are
not physiologically aroused, but are cognitively aroused. For such people, cognitive therapeutic interventions may be more appropriate.

**Guided Imagery.** Guided imagery encompasses versatile mental techniques of visualization and imagining and has become a powerful and very effective therapeutic tool that is often applied in health and sport psychology. Guided imagery is a mental technique that allows athletes to focus on and imagine a particular physical behavior, action or task, integrating mind-body sensory and neuro-physiological functions (Richardson & Latuda, 1995). The purpose of guided imagery is to evoke and imagine physical features of a desired technical skill or sport related technical execution by utilizing physiological arousal in imaginative and confirmative visualization that increases technical ability, self-confidence and motivational factors (Law, Driediger, Hall, & Forwell, 2006; Mamassis & Doganis, 2004).

Guided imagery is also an active mental process that is often used in relaxation procedures with athletes in order to regulate their arousal before competition, lessen maladaptive behaviors, balance negative thoughts as well as to enhance concentration and focus (Peluso, Ross, Gfeller, & La Voie, 2005; Vempati & Telles, 2002; Watanabe et al., 2006). Thus, guided imagery synthesizes multipurpose modalities which can be applied for relaxation purposes in order to reduces stress and balance psycho-physiological arousal before competitions as well as improve exercise-motor behaviors, rehearse specific technical skills, strengthen psycho-neuromuscular functions, and reinforce cognitive, concentrative, motivational and learning abilities of athletes (Giacobbi, Foore, & Weinberg, 2004; Martin, Moritz, & Hall, 1999; Utay & Miller, 2006).
Hypotheses

The literature suggests that there is a relationship between sleep and physical performance. However, an exhaustive review of the literature was unable to produce a single study that examined the effects of sleep quality, sleep length, sleepiness, and a nap/relaxation on flexibility, grip strength, and peak performance. Because previous research suggests certain relationships between components of this study, specific hypotheses can be posited.

Hypothesis 1A

A nap/relaxation will be related to flexibility in the lower back and hamstrings. More specifically, individuals in the experimental group who take a 10-minute nap/relaxation will have significantly higher scores on the sit-and-reach test.

Hypothesis 1B

A nap/relaxation will be related to grip strength in the hand and forearm. More specifically, individuals in the experimental group who take a 10-minute nap/relaxation will have significantly higher scores on the hand dynamometer test.

Hypothesis 1C

A nap/relaxation will be related to vertical jump height. More specifically, individuals in the experimental group who take a 10-minute nap/relaxation will have significantly higher scores on the vertical jump test.

Hypothesis 1D

A nap/relaxation will be related to peak power. More specifically, individuals in the experimental group who take a 10-minute nap/relaxation will have significantly higher scores on estimated peak power.
Justification of Hypotheses 1A, 1B, 1C, and 1D. Naps as brief as 19.8 (Gillberg et al., 1996), 10.8 (Horne & Ryner, 1996), 10.2 (Takahashi & Arito, 2000), 10 (Tietzel & Lack, 2001; Tietzel & Lack, 2002), and 9.1 (Hayashi, Motoyoshi, & Hori, 2005) minutes have been found to improve alertness and performance in individuals whose sleep was restricted. The improvement in alertness and performance due to taking a brief nap could also benefit physical performance. Waterhouse and colleagues (2007) found that naps produced an improvement in sprint performance after sleep loss during the previous night.

Relaxation is a popular clinical and educational tool that benefits health, well-being, and performance (Khasky & Smith, 1999) and similar to a short nap in its effects. Guided imagery is also an active mental process that is often used in relaxation procedures with athletes in order to regulate their arousal before competition, lessen maladaptive behaviors, balance negative thoughts, and enhance concentration and focus (Peluso et al., 2005; Vempati & Telles, 2002; Watanabe et al., 2006).

Hypothesis 2A

Poor sleep quality will be significantly related to flexibility in the lower back and hamstrings. More specifically, an individual who is a poor sleeper will have significantly lower scores on the sit-and-reach test.

Hypothesis 2B

Poor sleep quality will be significantly related to grip strength in the hand and forearm. More specifically, an individual who is a poor sleeper will have significantly lower scores on the hand dynamometer test.
**Hypothesis 2C**

Poor sleep quality will be significantly related to vertical jump height. More specifically, an individual who is a poor sleeper will have significantly lower scores on the vertical jump test.

**Hypothesis 2D**

Poor sleep quality will be significantly related to peak power. More specifically, an individual who is a poor sleeper will have significantly lower scores on estimated peak power.

**Justification for Hypotheses 2A, 2B, 2C, and 2D.** Brown and colleagues (2002) found that when compared to the general adult population, college students have a decreased level of sleep quality. Poor sleep quality adversely affects visual-motor reaction time, critical thinking abilities, vigilance, attention to task, and reaction time (Taub, 1980). All of these are important in physical performance. Lee and Lin (2007) found that female college students in Taiwan with poor sleep quality had a significantly shorter distance for the sit-and-reach (flexibility), fewer repetitions for the curl up test (muscular strength and endurance), and a longer time to finished the 800-m run/walk test (cardiovascular fitness) than participants with good sleep quality.

**Hypothesis 3A**

Sleep duration will be related to flexibility in the lower back and hamstrings. More specifically, individuals with shorter sleep duration will have significantly lower scores on the sit-and-reach test.
Hypothesis 3B

Sleep duration will be related to grip strength in the hand and forearm. More specifically, individuals with shorter sleep duration will have significantly lower scores on the hand dynamometer test.

Hypothesis 3C

Sleep duration will be related to vertical jump height. More specifically, individuals with shorter sleep duration will have significantly lower scores on the vertical jump test.

Hypothesis 3D

Sleep duration will be related to peak power. More specifically, individuals with shorter sleep duration will have significantly lower scores on estimated peak power.

Justification for Hypotheses 3A, 3B, 3C, and 3D. A study reported that the duration of average night's sleep for college students in 1989 was 6.5 hours, representing a decrease of about one hour per night over the previous 20 year period (Hicks & Pellegrini, 1991). This drop is particularly notable since individuals who report sleeping six hours or less have a greater incidence of cognitive and emotional difficulties (Hicks & Gilliland, 1981; Taub & Berger, 1973). This increase in cognitive difficulties can impact physical performance.

Hypothesis 4A

Sleepiness will be significantly related to flexibility in the lower back and hamstrings. More specifically, individuals with higher levels of sleepiness will have significantly lower scores on the sit-and-reach test.
Hypothesis 4B

Sleepiness will be significantly related to grip strength in the hand and forearm. More specifically, an individual with higher levels of sleepiness will have significantly lower scores on the hand dynamometer test.

Hypothesis 4C

Sleepiness will be significantly related to vertical jump height. More specifically, individuals with higher levels of sleepiness will have significantly lower scores on the vertical jump test.

Hypothesis 4D

Sleepiness will be significantly related to peak power. More specifically, individuals with higher levels of sleepiness will have significantly lower scores on estimated peak power.

Justification for Hypotheses 4A, 4B, 4C, and 4D. Insufficient sleep and daytime sleepiness rank among the most frequent of sleep problems reported by college students (Buboltz et al., 2001; Lack, 1986). Particularly relevant to college students, cognitive performance effects of sleep deprivation reveal a "fatigue effect," which become worse as time on the task increases. Furthermore, tasks may be undertaken in an effective manner, but performance declines as the task duration extends (Durmer & Dinges, 2005). This decline in performance can include physical performance.
CHAPTER 2

METHOD

This section describes the methods that were used to collect and analyze the data. The section includes participants, measures, and the procedure.

Participants

Participants were 98 students at a mid-sized southern university in the United States who were recruited from classes in the College of Education. Participants were informed that their participation was voluntary. The study, measures, and materials were approved by the university’s institutional review board (Appendix A). Prior to participating in the study, participants were asked to read and sign the consent form (Appendix B) and were notified of their right to refuse participation. In addition, the informed consent documents and data were stored separately to ensure confidentiality.

Measures

Demographics Form

The researcher constructed a demographics form (Appendix C), which is comprised of eight items. These items inquire about gender, age, race/ethnic origin, school classification, height, weight, NCAA athlete, and sports.
Sleep Quality Index

The Sleep Quality Index (SQI; Urponen et al., 1991) was used to assess sleep quality and general sleep difficulties (Appendix D). The SQI consists of eight self-report items with three response categories, which are weighted as 0, 1, or 2 (with a response of two indicating the most common or severe symptom). On item 1, participants choose from three responses: “< 10 minutes,” “11-30 minutes,” and “>30 minutes.” The response categories for items 2-5 and item 7 are: “no,” “< three days/week,” and “3-7 days/week.” For item 6, the response choices are: “very or mostly alert,” “don’t know,” and “very or mostly tired.” The response categories for item eight are: “no,” “occasionally,” and “at least once per week.” Sample items include: “Time to fall asleep,” “Difficulties falling asleep during the past three months,” and “Wake up too early in the morning during the past three months.”

The eight items are added together to provide a total sleep quality score. Sleep quality is categorized based on the following scores: 0-1 indicates good sleep quality, 2-8 indicates occasional sleep difficulties, and 9-16 indicates poor sleep quality. The SQI was divided into good sleep quality and poor sleep quality for analysis. Participants were categorized as having good sleep quality if they had a SQI score of 0-8, and they were labeled as having poor sleep quality if they had a SQI score of 9-16. The means for good sleep quality ($M = 3.67$, $SD = 2.07$) and poor sleep quality ($M = 11.15$, $SD = 1.68$) do not overlap. The SQI has a Cronbach’s alpha of .73 for men and .75 for women, indicating an acceptable internal consistency. Validity is supported by the significant positive relationship between sleep quality score and subjective health (Urponen et al., 1991). The
test-retest reliability coefficients range from .74 to .96 with undergraduate college
students, and have a mean of .84 (Jenkins, 2005).

Adult Sleep-Wake Scale

The Adult Sleep-Wake Scale (ADSWS; Fortunato, LeBourgeois, & Harsh, 2008) is a 25-item self-report questionnaire developed to measure sleep quality in adults during the past week (Appendix E). The ADSWS consists of five behavioral dimensions: going to bed, falling asleep, maintaining sleep, reinitiating sleep, and returning to wakefulness. The Going to Bed dimension includes the transitions from wakefulness to sleep and the transition from sleep to wakefulness is the Returning to Wakefulness dimension. The sleep initiation at the beginning of the sleep period is the Falling Asleep dimension and the Maintaining Sleep dimension is the maintenance of sleep. The Reinitiating Sleep dimension is when an individual returns to sleep after an awakening during the sleep period.

The ADSWS has participants rate how frequently certain sleep-related behaviors occurred on a 6-point Likert scale, with the following response options: Never (has not happened), Once in a while (happened 20% of the time), Sometimes (happened 40% of the time), Quite Often (happened 60% of the time), Frequently, if not always (happened 80% of the time), and Always (happened 100% of the time). On the going to bed scale, a sample item includes: “When it is time to go to bed, I want to stay up and do other things.” A sample item on the falling asleep scale is: “When I’m in bed and it is time to fall asleep, I am not sleepy.” The following is a sample item on the maintaining sleep scale: “After I fall asleep, during the night I toss and turn in bed.” A sample item on the reinitiating sleep scale is: “After waking up during the night, I have a hard time going
back to sleep.” On the returning to wakefulness scale, a sample item includes: “In the morning, I wake up and feel ready to get up for the day.” A total score was calculated for the ADSWS by summing the scores of the subscales and conducting a median split. The individuals above the median were put in the good sleep quality group and individuals below the median were put in the poor sleep quality group. The ADSWS was divided into good sleep quality and poor sleep quality for analysis. Participants were categorized as having good sleep quality if they had an ADSWS total score of 105 and above, and they were labeled as having poor sleep quality if they had an ADSWS score of 104 and below. The means for good sleep quality ($M = 119.92, SD = 10.28$) and poor sleep quality ($M = 88.40, SD = 11.87$) do not overlap.

The ADSWS has a high level of internal consistency with an alpha of 0.83 to 0.90 (Fortunato et al., 2008). Test-retest reliability coefficients range from .67 to .82. The coefficient alpha estimates of reliability for each of the five behavioral dimensions are as follows: going to bed = .83; falling asleep = .84; maintaining sleep = .83; reinitiating sleep = .89; and returning to wakefulness = .90. The ADSWS was established to have valid indicators of sleep wake patterns (Fortunato et al., 2008).

**Sleep Habits Questionnaire**

The Sleep Habits Questionnaire (SHQ; Buboltz et al., 2001) is a 9-item questionnaire used to measure sleep habits and sleep length (Appendix F). The SHQ is based on the instrument designed by Lack (1986). The items are open-ended for indicating wake-up times, bedtimes, usual amount of sleep, and other sleep-wake habits for the week and weekend (Buboltz et al., 2001). Sample items include “On the average, what time during the week do you go to bed,” “On the average, what time during the
weekend do you wake up,” and “On the average, how many hours of sleep do you get
during the week.” Individuals who slept less than six hours per night were put in the short
sleep group, individuals who slept 6-9 hours per night were put in the average sleep
group, and individuals who slept more than nine hours per night were placed in the long
sleep group. The means for the short sleep group (M = 4.93, SD = 1.03), average sleep
group (M = 7.72, SD = 1.12), and long sleep group (M = 9.79, SD = 0.63) do not overlap.

**Epworth Sleepiness Scale**

The Epworth Sleepiness Scale (ESS; Johns, 1991) is an 8-item self-report
questionnaire used to assess daytime sleepiness in adults (Appendix G). Participants
indicate how likely they are to doze off or fall asleep in different situations using a 4-
point Likert scale with ratings of 0 (would never doze) to three (high chance of dozing).
A score of 0 = no chance of dozing, 1 = slight chance of dozing, 2 = moderate chance of
dozing, and 3 = high chance of dozing. A total score of 0-10 means the person is within
the normal range for sleepiness, 10-12 is in the borderline range, and 12-24 is abnormal.
The average is a score of seven or 8. The ESS takes approximately three to five minutes
to complete. The ESS was divided into low, medium, and high levels of sleepiness for
analysis. Participants were categorized as having low levels of sleepiness if they had an
ESS score of 0-10, they were labeled as having medium levels of sleepiness if they had
an ESS score of 10-12, and an ESS score of 12-24 indicated high levels of sleepiness.

The ESS has a high level of internal consistency as measured by Cronbach’s alpha
of 0.88 (Johns, 1992). Correlations between the ESS total scores and sleep latency were
measured by polysomnography \[r(138)= -0.379, p<0.001\], as well as Multiple Sleep
Latency Test scores \( r(27) = -0.514, \ p<0.01 \), and demonstrate convergent construct validity.

**Karolinska Sleepiness Scale**

The Karolinska Sleepiness Scale (KSS; Akerstedt & Gillberg, 1990) is a one item scale that measures sleepiness and alertness (Appendix H). The scale is structured in a Likert format with the following response choices: 1 = extremely alert, 3 = alert, 5 = neither alert nor sleepy, 7 = sleepy, but no difficulty remaining awake, and 9 = extremely sleepy, fighting sleep. Even number responses are options as well; however, in contrast to the odd numbered responses, they do not have labels attached. Kaida et al. (2006) conducted a study where they found that the KSS was closely related to EEG and behavioral variables, indicating a high validity in measuring sleepiness. Individuals who had a score of 1-3 were placed in the low sleepiness group, scores of 4-6 represented the medium sleepiness group, and scores 7-9 indicated the high sleepiness group.

**Physical Performance Measures**

**Hand Grip Dynamometer**

A hand grip dynamometer was used to assess grip strength, which measures hand and forearm muscular strength in kilograms (kg). Hand-grip dynamometry is a useful assessment tool for multiple purposes in clinical practice, including the assessment of upper limb impairment; in evaluating work capacity for those with hand injuries and other work-related injuries; the evaluation of people with other impairments and disabilities such as rheumatoid arthritis, chronic fatigue syndrome, developmental disabilities, muscular dystrophy, and stroke; determining the efficacy of different treatments for people with a range of disabilities; part of an overall fitness assessment;
and in determining the level of effort exerted (Innes, 1999). The intra-class correlation coefficients (ICC) with the dominant hand were 0.92 during the pre-fatigue maximal contraction and 0.92 during the post-fatigue maximal contraction, indicating high reliability (Reuter, Massy-Westropp, & Evans, 2011). The muscle fatigue protocol consisted of ten 30-second sub-maximal isometric contractions. The intra-class correlation coefficients (ICC) with the non-dominant hand were 0.97 during the pre-fatigue maximal contraction and 0.95 during the post-fatigue maximal contraction, indicating high reliability (Reuter et al., 2011). Pre- and post-fatigue maximal contraction measurements using linear regression demonstrated excellent reliability (Reuter et al., 2011).

Sit-and-Reach Test

To measure flexibility, specifically in the lower back and hamstring muscles, a sit-and-reach box was utilized and measured in centimeters (cm). The sit-and-reach box is a solid box approximately 30 cm tall. It has measurement markers on the top and extends 26 cm over the front edge of the box toward the individual. The individuals removed their shoes and sat on the floor with their legs stretched out in front of them with knees straight and feet flat against the front end of the box. They lean forward at the hips in a slow steady movement and slide their hands up the measurement markers as far as they can go.

According to the American College of Sports Medicine’s (ACSM; 2006) Guidelines for Exercise Testing and Prescription, the sit-and-reach test scores for adult males are: above 34 cm = excellent flexibility, 28 to 34 cm = above average, 23 to 27 cm = average, 16 to 22 cm = below average, and below 16 cm = poor flexibility. The adult
female sit-and-reach test scores are: above 37 cm = excellent flexibility, 33 to 36 cm =
above average, 29 to 32 cm = average, 23 to 28 cm = below average, and below 23 cm =
poor flexibility.

Previous studies indicate consistently high reliability estimates (.96 < R < .99) for
the sit-and-reach test (Bravo et al., 1994; Jackson & Baker, 1986; Jackson & Langford,
1989; Shaulis, Golding, & Tandy, 1994). Studies have found moderate validity as a
measure of hamstring flexibility and relativity low validity of as a measure of lower back

**Vertec Vertical Jump Device**

The Vertec vertical jump measures vertical jump height and was used to estimate
peak power. The Vertec vertical jump measures vertical jump height in inches (in). The
Vertec is an adjustable metal pole standing upright with several horizontal vanes at the
top. The vanes are spaced a half inch apart and rotate when touched to indicate the height
reached. The correlation coefficient has been reported as 0.91, indicating good reliability
(Leard et al., 2007).

**Estimated Peak Power**

Peak power was estimated using the following formula, which was based on the
Vertical Jump Test mentioned above: 65.1 x (jump height in cm) + 25.8 x (body mass in
kg) – 1413.1 = Peak Power (Canavan & Vescovi, 2004). The estimated peak power was
measured using watts (W).

**Procedure**

The researcher obtained approval from the university’s Institutional Review
Board (IRB) prior to the start of data collection.
Recruitment of Participants

After consulting with instructors of college of education classes, announcements were made in classes regarding participation in this research. A script was read to recruit participants (Appendix I). Potential volunteers were informed of the purpose of the study and were provided with information about the location and times when they may participate. They were instructed to wear comfortable clothing that they can stretch in during the study. Participants were informed that they would receive extra credit for their participation in this project with approval from the instructor. The amount of extra credit awarded to the students was predetermined by each instructor. An alternative extra credit activity was offered by their instructor for those who chose not to participate in this study. They were reminded that participation in this project is voluntary and that no identifying information was collected. They were also informed that they would not be penalized for not volunteering and that they may stop at any time without penalty. When each participant signed up for a date and time to participate in the research study, they also provided their name, email address, and telephone number. The participants’ email addresses and phone numbers were requested for contact by the researcher the night prior to the test date to remind them about the study and to wear comfortable clothing.

Students arrived at a designated classroom in the gymnasium at the appointed time and date. Once the students were seated, a script was read to the participants regarding their participation. Participants were then asked to read the consent form. After reading the consent form, the researcher asked what questions they had, and then they were asked to sign and date the consent form. Written informed consent was then obtained from each participant, and they received a copy of the consent form. The data
and the participants' identification numbers were kept confidential. Participants were randomly assigned to either the experimental or control group.

Control Group

Once the participants signed an Informed Consent Form, they were taken from the classroom to the gymnasium where they were led through an active dynamic warm-up. Next, they completed the hand dynamometer test, the sit-and-reach test, and the vertical jump test. These measures were conducted to address practice effects, and were not used as pre-test scores. Finally, they returned to the classroom, and were instructed to read a newspaper for 10 minutes, which was provided to them. They were not allowed to sleep. Next, they were asked to complete the questionnaires about sleepiness. They were then taken from the classroom to the gymnasium where they were led through an active dynamic warm-up. Next, they completed the hand dynamometer test, the sit-and-reach test, and the vertical jump test. The scores from these measures were analyzed in the results. Finally, the participants went back to the classroom to complete the remaining questionnaires. The procedure for the active dynamic warm-up can be found in Appendix J.

Experimental Group

Once the participants signed an Informed Consent Form, they were taken from the classroom to the gymnasium where they were led through an active dynamic warm-up. Next, they completed the hand dynamometer test, the sit-and-reach test, and the vertical jump test. These measures were conducted to address practice effects, and were not used as pre-test scores. Finally, they returned to the classroom, and were instructed to get as comfortable as possible in their chairs and close their eyes while they listened to a guided
relaxation or took a nap for 10 minutes. The lights in the classroom were turned off during the guided relaxation. Next, they were asked to complete the questionnaires about sleepiness. They were then taken from the classroom to the gymnasium where they were led through an active dynamic warm-up. Next, they completed the hand dynamometer test, the sit-and-reach test, and the vertical jump test. The scores from these measures were analyzed in the results. Finally, they went back to the classroom to complete the remaining questionnaires.

**Hand Dynamometer Test Procedure**

The procedure to measure grip strength was using the Jamar hand dynamometer. The participants were seated without an armrest with their dominant arm at a 90 degree angle and used their dominant hand to apply as much grip pressure as possible on the dynamometer. The researcher used the words “Harder, harder, relax” as a standard verbal command for every participant. The researcher recorded the maximum reading (kg). The participant repeated the test three times after 20 seconds of rest between each trial. The researcher used the highest recorded value to assess the participant’s performance.

**Vertical Jump Test Procedure**

The participants did three maximum jumps using a Vertec vertical jump device. The participants began in a standing position and performed a crouching action (counter movement) before jumping for maximal height using a Vertec vertical jump device. They were given three attempts at the maximal jump with 15 seconds of rest time between jumps.
Sit-and-Reach Test Procedure

According to the American College of Sports Medicine, the sit-and-reach test procedure involves having the participant sit on the floor without shoes on, with their legs stretched out straight ahead. The soles of the feet are placed flat against the sit-and-reach box at the 26-cm mark. Both knees should be locked and pressed flat to the floor. Next, the participant slowly reaches forward along the measuring line with both hands (palms facing downwards) as far as possible. The participant keeps their hands parallel and not leading with one hand. The fingertips can be overlapped. The participant exhale and drop their head between their arms when reaching. After two practice reaches, the participant’s third reach, held for 1-2 seconds, was recorded as the participant’s score.

Once they finished completing the physical activities, the researcher had participant sign their name on the instructors’ extra credit form. The researcher returned extra credit forms to the corresponding instructor.

Risks and Benefits

Potential risks include emotional distress or discomfort associated with completing questionnaires and performing fitness activities. In attempts to minimize potential risks, participants were reassured that these questions are common in this area of research and that feelings of discomfort are not unusual. Participants were provided with a list of local mental health services, in which the participants may contact if needed. Participants were informed that any professional services sought will be at their own expense. Benefits of participation include earning extra credit and contributing to the field of psychology.
CHAPTER 3

RESULTS

Participants

Overall Sample

Participants were 98 undergraduate and graduate students at a mid-sized southern university in the United States. There were 50 female (50.5%) and 48 male (48.5%) participants. The average age of the participants was 22.5 years ($SD = 5.01$, range: 17 to 47). In terms of ethnicity, 65 were Caucasian (65.7%), 26 were African American (26.3%), 2 were Asian/Pacific Islander (2.0%), two were Hispanic (2.0%), and two indicated Other (2.0%). The sample was comprised of individuals from all academic classifications, 24.2% freshman ($n = 24$), 7.1% sophomores ($n = 7$), 18.2% juniors ($n = 18$), 28.3% seniors ($n = 28$), and 20.2% graduate students ($n = 20$).

The average weight of the participants was 165 pounds ($SD = 44.9$, range: 91 to 320). The average Body Mass Index (BMI) of the participants was 25.8 ($SD = 5.9$, range: 17.7 to 49.6). The average BMI for the male participants was 26.8 ($SD = 5.9$, range: 18.7 to 47.2) For female participants, the average BMI was 24.7 ($SD = 6.1$, range: 17.7 to 49.6) The average height of the participants was 169 cm or 5-feet - seven inches ($SD = 9.87$, range: 141 cm or 4’8” to 190.5 or 6’3”).
Control Group

The control group consisted of 19 (42.2%) females and 26 (57.8%) males with an average age of 21.4 ($SD = 4.0$; range: 17 to 37). The control group was 75.6% Caucasian, 20% African American, 2.2% Hispanic, and 2.2% Other. The control group was comprised of 37.8% freshman, 6.7% sophomores, 17.8% juniors, 24.4% seniors, and 13.3% graduate students.

In the control group, the average weight of the participants was 166.8 pounds ($SD = 36.9$, range: 106 to 261). The average Body Mass Index (BMI) of the participants was 25.5 ($SD = 4.5$, range: 18.8 to 35.9). The average height of the participants was 171 cm or 5-feet 7-inches ($SD = 9.59$, range: 155 or 5’1” to 190.5 or 6’3”).

Experimental Group

The experimental group consisted of 31 female (58.5%) and 22 male (41.5%) participants. The average age of the participants was 23.5 years ($SD = 5.59$, range: 18 to 47). The majority of the participants in the experimental group were Caucasian (58.5%), with African American (32.1%), Asian/Pacific Islander (3.8%), Hispanic (1.9%), and Other (1.9%). The experimental group was comprised of individuals from all academic classifications, 13.2% were freshman, 7.5% were sophomores, 18.9% were juniors, 32.1% were seniors, and 26.4% were graduate students.

The average weight of the participants in the experimental group was 163 pounds ($SD = 51.05$, range: 91 to 319.5). The average BMI of the participants in the experimental group was 25.9 ($SD = 6.90$, range: 17.7 to 49.6). The average height of the participants in the experimental group was 167.7 cm or 5-feet 6-inches ($SD = 9.89$, range: 141 cm or 4’8” to 190.5 cm or 3’3”).
Descriptive Statistics, Reliabilities, and \( t \)-tests for Overall Sample

Table 1 presents the overall sample's reliability coefficients, means, standard deviations, and ranges for the Adult Sleep-Wake Scale (ADWS), the Sleep Quality Index (SQI), the Sleep Habits Questionnaire (SHQ), the Epworth Sleepiness Scale (ESS), and the Karolinska Sleepiness Scale (KSS). The current sample was compared to normative samples using one-sample \( t \)-tests with adult populations.

Table 1

Descriptive Statistics, Reliabilities, and \( t \)-tests for Overall Sample

<table>
<thead>
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<th>Measures</th>
<th>( M )</th>
<th>( SD )</th>
<th>Range</th>
<th>( \alpha )</th>
<th>( t )</th>
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<td>3.27</td>
<td>0-14</td>
<td>.75</td>
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<tr>
<td>ADSWS Going to bed</td>
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<td>5.54</td>
<td>7-30</td>
<td>.87</td>
<td>3.47**</td>
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<tr>
<td>ADSWS Falling asleep</td>
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<td>4.97</td>
<td>10-30</td>
<td>.80</td>
<td>2.59**</td>
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<tr>
<td>ADSWS Maintaining sleep</td>
<td>21.92</td>
<td>5.29</td>
<td>6-30</td>
<td>.84</td>
<td>3.59**</td>
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<tr>
<td>ADSWS Reinitiating sleep</td>
<td>23.77</td>
<td>5.35</td>
<td>12-30</td>
<td>.90</td>
<td>4.01**</td>
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<tr>
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<td>16.51</td>
<td>6.43</td>
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<td>SHQ Weekday</td>
<td>7.13</td>
<td>1.76</td>
<td>2-14</td>
<td>-1.37</td>
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<td>SHQ Weekend</td>
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<tr>
<td>ESS Total</td>
<td>9.38</td>
<td>3.30</td>
<td>3-20</td>
<td>.58</td>
<td>10.44**</td>
</tr>
<tr>
<td>KSS</td>
<td>5.22</td>
<td>1.83</td>
<td>1-9</td>
<td>-2.60*</td>
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</tr>
</tbody>
</table>

*Note. SQI = Sleep Quality Index; ADSWS = Adult Sleep-Wake Scale; SHQ = Sleep Habits Questionnaire; ESS = Epworth Sleepiness Scale; KSS = Karolinska Sleepiness Scale. * \( p < .05 \) two-tailed, ** \( p < .01 \) two-tailed.

With respect to the ADSWS, a one sample \( t \)-test revealed the current sample means on the Going to Bed subscale, Falling Asleep subscale, Maintaining Sleep subscale, and Reinitiating Sleep subscale were significantly higher than the standardization sample of undergraduate college students (Fortunato et al., 2008) (See Table 1). The ESS mean of the current sample was 9.38 (\( SD = 3.30 \)), which was significantly higher than the standardization sample of adults (\( M = 5.9 \); Johns,
1991), $t(1, 97) = 10.44, p < .01$. The KSS mean was 5.22 (SD = 1.83), which was significantly higher than the standardization sample of adults ($M = 5.7$; Kaida et al., 2006), $t(1, 96) = -2.60, p < .05$.

**Descriptive Statistics, Reliabilities, and $t$-tests for Overall Sample by Gender**

Table 2 presents the overall sample's reliability coefficients, means, standard deviations, and ranges by gender for the variables in this study. With respect to the ADSWS, the means for males on the Going to Bed subscale, Falling Asleep subscale, Maintaining Sleep subscale, Reinitiating Sleep subscale, and Returning to Wakefulness subscale were significantly higher than the standardization sample of undergraduate college students (Fortunato et al., 2008) (See Table 2). The means for females on the Going to Bed subscale and Maintaining Sleep subscale were significantly higher than the standardization sample of undergraduate college students (Fortunato et al., 2008). The mean for males' and females' ESS was significantly higher than the standardization sample of adults (Johns, 1991) (See Table 2). The KSS mean for males was significantly lower than the standardization sample of adults (Kaida et al., 2006).

Vertical Jump Test means for males and females were significantly lower than another sample, which included young adult medical students and their spouses (Patterson & Peterson, 2004) (See Table 2). For estimated Peak Power, the means for males and females were significantly lower than the standardization sample, which included young adult medical students and their spouses (Patterson & Peterson, 2004).
Table 2

Descriptive Statistics, Reliabilities, and t-tests for Overall Sample by Gender

<table>
<thead>
<tr>
<th>Measures</th>
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<th>Range</th>
<th>α</th>
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</tr>
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<td>Male</td>
<td>Female</td>
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</tr>
<tr>
<td>ADSWS Falling asleep</td>
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<td>21.36</td>
<td>4.34</td>
<td>5.47</td>
<td>10-30</td>
</tr>
<tr>
<td>ADSWS Maintaining sleep</td>
<td>21.94</td>
<td>21.90</td>
<td>5.05</td>
<td>5.55</td>
<td>6-30</td>
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<td>24.96</td>
<td>22.62</td>
<td>5.00</td>
<td>5.48</td>
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</tr>
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<td>6.32</td>
<td>6.28</td>
<td>5-30</td>
</tr>
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<td>7.13</td>
<td>7.12</td>
<td>1.85</td>
<td>1.69</td>
<td>2-11</td>
</tr>
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<td>8.66</td>
<td>1.97</td>
<td>1.83</td>
<td>2-12</td>
</tr>
<tr>
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<td>10.10</td>
<td>3.09</td>
<td>3.36</td>
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<tr>
<td>Grip Strength Left Hand</td>
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<td>35.56</td>
<td>8.11</td>
<td>8.30</td>
<td>11.5-47</td>
</tr>
<tr>
<td>Vertical Jump</td>
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<td>12.79</td>
<td>4.26</td>
<td>4.32</td>
<td>7-23.5</td>
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<td>2387</td>
<td>731</td>
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</table>

Note. SQI = Sleep Quality Index; ADSWS = Adult Sleep-Wake Scale; SHQ = Sleep Habits Questionnaire; ESS = Epworth Sleepiness Scale; KSS = Karolinska Sleepiness Scale. * p < .05 two-tailed, ** p < .01 two-tailed.
The means for males’ and females’ grip strength on both the right and left hands were significantly lower than the standardization sample of adults (Mathiowetz, Kashman, Volland, Weber, Dowe, & Rogers, 1985) (See Table 2).

**Examination of Gender Differences for Overall Sample**

Table 2 presents the descriptive statistics for the control group. An analysis of variance (ANOVA) was conducted to determine which variables in the overall sample were significantly different according to gender. The following variables significantly differed based on gender: KSS Score $F(1, 95) = 6.51, p < .05$, ESS Total $F(1, 96) = 5.11, p < .05$, ADSWS Reinitiating Sleep Subscale $F(1, 96) = 4.86, p < .05$, ADSWS Returning to Wakefulness Subscale $F(1, 96) = 4.96, p < .05$, Sit-and-Reach Test $F(1, 96) = 13.63, p < .01$, Vertical Jump Test $F(1, 96) = 18.21, p < .01$, estimated Peak Power $F(1, 96) = 43.96, p < .01$, Grip Strength on the Right Hand $F(1, 93) = 195.92, p < .01$, and Grip Strength on the Left Hand $F(1, 93) = 207.23, p < .01$.

**Descriptive Statistics, Reliabilities, and $t$-tests for Control Group**

Table 3 presents the control group’s reliability coefficients, means, standard deviations, and ranges for the Adult Sleep-Wake Scale (ADWS), the Sleep Quality Index (SQI), the Sleep Habits Questionnaire (SHQ), the Epworth Sleepiness Scale (ESS), and the Karolinska Sleepiness Scale (KSS). The control group was compared to normative samples using one-sample $t$-tests.

With respect to the ADWS, a one sample $t$-test revealed the control group means on the Going to Bed subscale, Maintaining Sleep subscale, and Reinitiating Sleep subscales were significantly higher than the standardization sample (Fortunato et al., 2008) (See Table 3). The ESS mean was significantly higher than the standardization
sample (Johns, 1991). The mean of the KSS was significantly higher than the standardization sample (Kaida et al., 2006).

**Table 3**

*Descriptive Statistics, Reliabilities, and t-tests for Control Group*

<table>
<thead>
<tr>
<th>Measures</th>
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<th>SD</th>
<th>Range</th>
<th>α</th>
<th>t</th>
</tr>
</thead>
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<td>0-14</td>
<td>.78</td>
<td>-0.92</td>
</tr>
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<td>5.69</td>
<td>7-30</td>
<td>.89</td>
<td>4.23**</td>
</tr>
<tr>
<td>ADSWS Falling asleep</td>
<td>22.02</td>
<td>5.29</td>
<td>10-30</td>
<td>.87</td>
<td>1.68</td>
</tr>
<tr>
<td>ADSWS Maintaining sleep</td>
<td>21.82</td>
<td>5.10</td>
<td>11-30</td>
<td>.78</td>
<td>2.40*</td>
</tr>
<tr>
<td>ADSWS Reinitiating sleep</td>
<td>23.36</td>
<td>5.47</td>
<td>12-30</td>
<td>.90</td>
<td>2.15*</td>
</tr>
<tr>
<td>ADSWS Returning to awake</td>
<td>17.73</td>
<td>6.93</td>
<td>5-30</td>
<td>.89</td>
<td>1.68</td>
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<tr>
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<td>3.16</td>
<td>3-15</td>
<td>.57</td>
<td>6.81**</td>
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<td>1.85</td>
<td>1-9</td>
<td>-3.32**</td>
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</tr>
</tbody>
</table>

*Note.* SQI = Sleep Quality Index; ADSWS = Adult Sleep-Wake Scale; SHQ = Sleep Habits Questionnaire; ESS = Epworth Sleepiness Scale; KSS = Karolinska Sleepiness Scale.

**Descriptive Statistics, Reliabilities, and t-tests for Control Group by Gender**

Table 4 presents the overall sample's reliability coefficients, means, standard deviations, and ranges by gender for the Adult Sleep-Wake Scale (ADSWS), the Sleep Quality Index (SQI), the Sleep Habits Questionnaire (SHQ), the Epworth Sleepiness Scale (ESS), the Karolinska Sleepiness Scale (KSS), the Sit-and-Reach Test, the Vertical Jump Test, estimated Peak Power, the Grip Strength with the Right Hand, and the Grip Strength with the Left Hand.

With respect to the ADSWS, the means for males on the Going to Bed subscale, Falling Asleep subscale, Maintaining Sleep subscale, Reinitiating Sleep subscale, and Returning to Wakefulness subscale were significantly higher than the standardization sample (Fortunato et al., 2008) (See Table 2). The means for females on the Going to Bed subscale and Maintaining Sleep subscale were significantly higher than the
Table 4

Descriptive Statistics, Reliabilities, and t-tests for Control Group by Gender

<table>
<thead>
<tr>
<th>Measures</th>
<th>$M$</th>
<th>$SD$</th>
<th>Range</th>
<th>$\alpha$</th>
<th>$t$</th>
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<td>Male</td>
<td>Female</td>
<td>Male</td>
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<td>SQI Total</td>
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<td>5.26</td>
<td>3.58</td>
<td>2.94</td>
<td>0-14</td>
</tr>
<tr>
<td>ADSWS Going to bed</td>
<td>21.65</td>
<td>20.79</td>
<td>6.47</td>
<td>5.44</td>
<td>7-30</td>
</tr>
<tr>
<td>ADSWS Falling asleep</td>
<td>22.65</td>
<td>21.16</td>
<td>5.25</td>
<td>5.37</td>
<td>10-30</td>
</tr>
<tr>
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<td>21.58</td>
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<td>4.73</td>
<td>5.70</td>
<td>11-30</td>
</tr>
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<td>5.29</td>
<td>12-30</td>
</tr>
<tr>
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<td>19.92</td>
<td>14.74</td>
<td>6.65</td>
<td>6.29</td>
<td>6-30</td>
</tr>
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<td>7.36</td>
<td>1.62</td>
<td>1.55</td>
<td>2-11</td>
</tr>
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<td>3.31</td>
<td>3.01</td>
<td>3-15</td>
</tr>
<tr>
<td>KSS</td>
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<td>5.28</td>
<td>1.81</td>
<td>1.84</td>
<td>1-8</td>
</tr>
<tr>
<td>Grip Strength Right Hand</td>
<td>60.15</td>
<td>37.53</td>
<td>11.50</td>
<td>5.93</td>
<td>27-76</td>
</tr>
<tr>
<td>Grip Strength Left Hand</td>
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<td>33.84</td>
<td>10.61</td>
<td>5.27</td>
<td>24-68</td>
</tr>
<tr>
<td>Sit and Reach</td>
<td>28.94</td>
<td>35.55</td>
<td>7.76</td>
<td>7.74</td>
<td>11.5-46</td>
</tr>
<tr>
<td>Vertical Jump</td>
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<td>12.21</td>
<td>4.42</td>
<td>4.27</td>
<td>7-23.5</td>
</tr>
<tr>
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<td>2260</td>
<td>750</td>
<td>753</td>
<td>1880-4729</td>
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Note. SQI = Sleep Quality Index; ADSWS = Adult Sleep-Wake Scale; SHQ = Sleep Habits Questionnaire; ESS = Epworth Sleepiness Scale; KSS = Karolinska Sleepiness Scale. * $p < .05$ two-tailed, ** $p < .01$ two-tailed.
standardization sample (Fortunato et al., 2008). The mean for males’ and females’ ESS was significantly higher than the standardization sample (Johns, 1991) (See Table 4). The KSS mean for males was significantly lower than the standardization sample (Kaida et al., 2006).

Vertical Jump Test mean for males was significantly lower than another sample (Patterson & Peterson, 2004) (See Table 4). For males and females, the estimated Peak Power means were significantly lower than the standardization sample (Patterson & Peterson, 2004). The males and females, the mean Grip Strength on the right and left hands were significantly lower than the standardization sample (Mathiowetz et al., 1985).

**Examination of Gender Differences for Control Group**

Table 4 presents the descriptive statistics for the control group. An analysis of variance (ANOVA) was conducted to determine which variables in the control group were significantly different according to gender. The following variables significantly differed based on gender: ADSWS Reinitiating Sleep Subscale $F(1, 43) = 4.70, p < .05$, ADSWS Returning to Wakefulness Subscale $F(1, 43) = 6.99, p < .01$, Sit-and-Reach Test $F(1, 43) = 7.99, p < .01$, Vertical Jump Test $F(1, 43) = 11.39, p < .01$, estimated Peak Power $F(1, 43) = 30.41, p < .01$, Grip Strength on the Right Hand $F(1, 43) = 61.40, p < .01$, and Grip Strength on the Left Hand $F(1, 43) = 64.18, p < .01$.

**Descriptive Statistics, Reliabilities, and $t$-tests for Experimental Group**

Table 5 presents the experimental group’s reliability coefficients, means, standard deviations, and ranges for the Adult Sleep-Wake Scale (ADSWS), the Sleep Quality Index (SQI), the Sleep Habits Questionnaire (SHQ), the Epworth Sleepiness Scale (ESS),
and the Karolinska Sleepiness Scale (KSS). The experimental group was compared to normative samples using one-sample $t$-tests.

Table 5

Descriptive Statistics, Reliabilities, and $t$-tests for Experimental Group

<table>
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<th>Measures</th>
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<th>$\alpha$</th>
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<td>18.25</td>
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<td>10-30</td>
<td>.73</td>
<td>1.97</td>
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<tr>
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<td>5.48</td>
<td>6-30</td>
<td>.88</td>
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<tr>
<td>ADSWS Reinitiating sleep</td>
<td>24.11</td>
<td>5.27</td>
<td>12-30</td>
<td>.90</td>
<td>3.47**</td>
</tr>
<tr>
<td>ADSWS Returning to awake</td>
<td>15.47</td>
<td>5.84</td>
<td>5-27</td>
<td>.92</td>
<td>-0.66</td>
</tr>
<tr>
<td>SHQ Weekday</td>
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<td>1.92</td>
<td>3-14</td>
<td>-</td>
<td>-0.99</td>
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<td>4.5-15</td>
<td>+</td>
<td>1.43</td>
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</tbody>
</table>

*Note. SQI = Sleep Quality Index; ADSWS = Adult Sleep-Wake Scale; SHQ = Sleep Habits Questionnaire; ESS = Epworth Sleepiness Scale; KSS = Karolinska Sleepiness Scale. * $p < .05$ two-tailed, ** $p < .01$ two-tailed.

With respect to the ADSWS, a one sample $t$-test revealed the experimental group means on the Maintaining Sleep subscale and Reinitiating Sleep subscale were significantly higher than the standardization sample (Fortunato et al., 2008) (See Table 5). The ESS mean was significantly higher than the standardization sample (Johns, 1991).

Descriptive Statistics, Reliabilities, and $t$-tests for Experimental Group by Gender

Table 6 presents the experimental group’s reliability coefficients, means, standard deviations, and ranges by gender for the Adult Sleep-Wake Scale (ADSWS), the Sleep Quality Index (SQI), the Sleep Habits Questionnaire (SHQ), the Epworth Sleepiness Scale (ESS), the Karolinska Sleepiness Scale (KSS), the Sit-and-Reach Test, the Vertical Jump Test, estimated Peak Power, the Grip Strength with the Right Hand, and the Grip Strength with the Left Hand.
Table 6

Descriptive Statistics, Reliabilities, and t-tests for Experimental Group by Gender

<table>
<thead>
<tr>
<th>Measures</th>
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<th>t</th>
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<tr>
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<td>5.14</td>
<td>2.51</td>
<td>3.74</td>
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<td>Female</td>
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<td></td>
<td>17.82</td>
<td>18.55</td>
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<td>22.68</td>
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<td>3.08</td>
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</tr>
<tr>
<td></td>
<td>22.36</td>
<td>21.74</td>
<td>5.49</td>
<td>5.55</td>
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<td>4.82</td>
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<td>5.14</td>
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<td>1.78</td>
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<td>8.23</td>
<td>8.82</td>
<td>1.91</td>
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Note. SQI = Sleep Quality Index; ADSWS = Adult Sleep-Wake Scale; SHQ = Sleep Habits Questionnaire; ESS = Epworth Sleepiness Scale; KSS = Karolinska Sleepiness Scale. *p < .05 two-tailed, **p < .01 two-tailed.
With respect to the ADSWS, the means for males on the Falling Asleep subscale and Reinitiating Sleep subscale were significantly higher than the standardization sample (Fortunato et al., 2008) (See Table 6). The mean for males’ and females’ ESS were significantly higher than the standardization sample (Johns, 1991).

Vertical Jump Test mean for males was significantly lower than another sample (Patterson & Peterson, 2004) (See Table 6). For estimated Peak Power, the mean for males and females were significantly lower than the standardization sample (Patterson & Peterson, 2004). For males and females, the mean Grip Strength on both the Right and Left Hands were significantly lower than the standardization sample (Mathiowetz et al., 1985).

**Examination of Gender Differences for Experimental Group**

Table 6 presents the descriptive statistics for the experimental group. An analysis of variance (ANOVA) was conducted to determine which variables in the experimental group were significantly different by gender. The following variables significantly differed based on gender: ESS Total $F(1, 51) = 5.80, p < .05$, Sit-and-Reach Test $F(1, 51) = 5.21, p < .05$, Vertical Jump Test $F(1, 51) = 6.96, p < .05$, estimated Peak Power $F(1, 51) = 16.39, p < .01$, Grip Strength on the Right Hand $F(1, 48) = 145.78, p < .01$ and Grip Strength on the Left Hand $F(1, 48) = 158.79, p < .01$ (See Table 6).

**Homogeneity of Variance**

A Levene’s test of homogeneity of variance was conducted to examine if the groups differed significantly on any of the variables at time one. The test revealed that the group averages were not significantly different on any of the variables at time one: SQI Total, $F(1, 93) = .10, p > .05$; ADSWS Going to Bed, $F(1, 96) = .20, p > .05$; ADSWS
Falling Asleep, $F(1, 96) = .39, p > .05$; ADSWS Maintaining Sleep, $F(1, 96) = .09, p > .05$; ADSWS Reinitiating Sleep, $F(1, 96) = .00, p > .05$; ADSWS Returning to Wakefulness, $F(1, 96) = 2.06, p > .05$; SHQ Weekdays, $F(1, 95) = .73, p > .05$; SHQ Weekend, $F(1, 96) = .42, p > .05$; KSS Score, $F(1, 95) = .03, p > .05$; ESS Total $F(1, 96) = .06, p > .05$; Sit-and-Reach, $F(1, 96) = .15, p > .05$; Grip Strength Right, $F(1, 93) = .50, p > .05$; Grip Strength Left, $F(1, 93) = .08, p > .05$; Vertical Jump, $F(1, 96) = .05, p > .05$; Peak Power $F(1, 96) = .37, p > .05$.

**Correlations between Variables**

Table 7 presents the correlations between all of the study variables. The SQI total score was significantly negatively correlated with the ADSWS Going to Bed, Falling Asleep, Maintaining Sleep, Reinitiating Sleep, and Returning to Wakefulness Subscales, as well as with the SHQ during the week and on weekends.

The SHQ sleep length during the week was positively correlated with the ADSWS Reinitiating Sleep Subscale, as well as with the SHQ during the weekends. The SHQ sleep length during the weekends was positively correlated with the ADSWS Maintaining Sleep Subscale and was negatively correlated with the ADSWS Returning to Wakefulness Subscale. As would be expected, the ADSWS subscales all correlated at minimal to moderate levels.

The KSS Scale and the ESS Scale were positively correlated. The KSS Scale was negatively correlated with both the ADSWS Going to Bed and Returning to Wakefulness Subscales, as well as with both the Grip Strength Right Hand and Left. The ESS Scale was negatively correlated with the ADSWS Returning to Wakefulness Subscale, as well as with the Grip Strength Right Hand and Left Hand.
### Table 7

**Summary of Correlations, Means, and Standard Deviations for Scores on All Measures for Overall Sample**

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| $M$                    | 4.69 | 7.13 | 8.39 | 5.22 | 9.38 | 19.64 | 22.00 | 21.92 | 23.77 | 16.51 | 32.56 | 14.60 | 46.41 | 42.66 | 2929 |
| $SD$                   | 3.27 | 1.76 | 1.91 | 1.83 | 3.30 | 5.54  | 4.97  | 5.29  | 5.35  | 6.43  | 8.72  | 4.66  | 15.47 | 13.85 | 992  |

*Note: SQI = Sleep Quality Index; KSS = Karolinska Sleepiness Scale; ESS = Epworth Sleepiness Scale; ADSWS = Adult Sleep-Wake Scale (ADSWS Bed = Going to Bed Subscale; ADSWS Fall. = Falling Asleep Subscale; ADSWS Main. = Maintaining Sleep Subscale; ADSWS Rein. = Reinitiating Sleep Subscale; ADSWS Ret. = Returning to Wakefulness Subscale); Grip Strength RH = Right Hand; Grip Strength LH = Left Hand; Sleep Length W = Week; Sleep Length WE = Weekends

* $p < .05$ two-tailed, ** $p < .01$ two-tailed.
The Sit-and-Reach Score was negatively correlated with Grip Strength Right Hand, Grip Strength Left Hand, and Peak Power. The Vertical Jump Score was positively correlated with the Grip Strength Right Hand and Grip Strength Left Hand, as well as the ADSWS Reinitiating Sleep and Returning to Wakefulness Subscales. The estimated Peak Power Score was positively correlated with the ADSWS Reinitiating Sleep Subscale, Vertical Jump score, Grip Strength Right Hand, and Grip Strength Left Hand.

**Correlations between Variables with Males**

Table 8 presents the correlations between all of the study variables with males. The males’ SQI total score was significantly negatively correlated with the SHQ (Weekdays), SHQ (Weekends), Sit-and-Reach Test, as well as the ADSWS Falling Asleep, Maintaining Sleep, and Reinitiating Sleep Subscales. The males’ SHQ (Weekdays) was significantly positively correlated with SHQ (Weekends) and the ADSWS Reinitiating Sleep Subscale. The males’ SHQ (Weekends) was significantly negatively correlated with the ADSWS Returning to Wakefulness Subscale. As would be expected, the ADSWS subscales all correlated at minimal to moderate levels.

The males’ KSS Scale and the ESS Scale were significantly positively correlated. The males’ KSS Scale was significantly negatively correlated with both the ADSWS Falling Asleep and Returning to Wakefulness Subscales. The males’ ESS Scale was significantly negatively correlated to the ADSWS Falling Asleep Subscale.

Males’ Grip Strength with the Right Hand was significantly positively correlated with Grip Strength with the Left Hand. The males’ Vertical Jump Score was significantly positively correlated with estimated Peak Power.
Table 8

Summary of Correlations, Means, and Standard Deviations for Scores on All Measures for Overall Sample with Males Only

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*Note.* SQI = Sleep Quality Index; SHQ = Sleep Habits Questionnaire; KSS = Karolinska Sleepiness Scale; ESS = Epworth Sleepiness Scale; ADSWS = Adult Sleep-Wake Scale (ADSWS Bed = Going to Bed Subscale; ADSWS Fall. = Falling Asleep Subscale; ADSWS Main. = Maintaining Sleep Subscale; ADSWS Rein. = Reinitiating Sleep Subscale; ADSWS Ret. = Returning to Wakefulness Subscale); Grip Strength RH = Right Hand; Grip Strength LH = Left Hand. *p < .05 two-tailed, **p < .01 two-tailed.
Correlations between Variables with Females

Table 9 presents the correlations between all of the study variables with females. The females’ SQI total score was significantly negatively correlated with SHQ during the week, as well as with the ADSWS Going to Bed, Falling Asleep, Maintaining Sleep, Reinitiating Sleep, and Returning to Wakefulness Subscales. SHQ during the week was significantly positively correlated with SHQ during the weekends. The SHQ during the weekends was significantly positively correlated with the ADSWS Going to Bed, Maintaining Sleep, and Reinitiating Sleep Subscales. As would be expected, the ADSWS subscales all correlated at minimal to moderate levels. The ESS Scale was significantly negatively correlated to the ADSWS Returning to Wakefulness Subscale.

The Grip Strength with the Right Hand was significantly negatively correlated to both the ADSWS Going to Bed and Reinitiating Sleep Subscales. As would be expected, the Grip Strength with the Right Hand was significantly positively correlated to the Grip Strength with the Left Hand. The Grip Strength with the Left Hand was significantly negatively correlated to both the ADSWS Going to Bed Subscale and ADSWS Reinitiating Sleep Subscale.

In addition, the Grip Strength with the Left Hand and the estimated Peak Power were significantly positively correlated. The Vertical Jump score was positively correlated with both the ADSWS Maintaining Sleep and Reinitiating Sleep Subscales, as well as estimated Peak Power.
Table 9

Summary of Correlations, Means, and Standard Deviations for Scores on All Measures for Overall Sample with Females Only

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<tr>
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<td>6. ADSWS Bed</td>
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<td>.29*</td>
<td>-.23</td>
<td>-.06</td>
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<td>.10</td>
<td>-.06</td>
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<td>8. ADSWS Main</td>
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<td>9. ADSWS Rein</td>
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<td>-.08</td>
<td>-.11</td>
<td>-.08</td>
<td>-.36*</td>
<td>-.20</td>
<td>-.24</td>
<td>-.43**</td>
<td>-.23</td>
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<td>-.07</td>
<td>-.13</td>
<td>-.37*</td>
<td>-.21</td>
<td>-.24</td>
<td>-.41**</td>
<td>-.22</td>
<td>.10</td>
<td>.92**</td>
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<td>.09</td>
<td>.08</td>
<td>.14</td>
<td>.09</td>
<td>.31*</td>
<td>.31*</td>
<td>.12</td>
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<td>15. Peak Power</td>
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<td>.21</td>
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<td>-.03</td>
<td>.24</td>
<td>.33*</td>
<td>.851**</td>
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</table>

|SD| 3.40| 1.69| 1.83| 1.76| 3.36| 5.06| 5.47| 5.55| 5.48| 6.28| 8.30| 6.77| 5.94| 4.320| 907  |

Note. SQI = Sleep Quality Index; SHQ = Sleep Habits Questionnaire; KSS = Karolinska Sleepiness Scale; ESS = Epworth Sleepiness Scale; ADSWS = Adult Sleep-Wake Scale (ADSWS Bed = Going to Bed Subscale; ADSWS Fall = Falling Asleep Subscale; ADSWS Main = Maintaining Sleep Subscale; ADSWS Rein. = Reinitiating Sleep Subscale; ADSWS Ret. = Returning to Wakefulness Subscale); Grip Strength RH = Right Hand; Grip Strength LH = Left Hand. * p < .05 two-tailed, ** p < .01 two-tailed.
Hypothesis 1A

Hypothesis 1A stated that participants in the experimental group who took a 10-minute nap/relaxation period would have significantly higher scores on the sit-and-reach test compared to the control group. To test this hypothesis, a two-way ANOVA was performed with gender and participant group (control or experimental) as the independent variables, and the Sit-and-Reach Test as the dependent variable. This hypothesis was not supported. There was a significant main effect for gender on the Sit-and-Reach Test, $F(1, 94) = 12.75, p < .01$. There was a non-significant main effect for the participant group on the Sit-and-Reach Test, $F(1, 94) = 0.10, p > .05$. There was also a non-significant interaction effect between the participant group and gender on the Sit-and-Reach Test, $F(1, 94) = 0.10, p > .05$. Results show that males in the experimental group ($n = 22; M = 30.02$) did not have significantly higher sit-and-reach scores compared to males in the control group ($n = 26; M = 28.94$). In addition, females in the experimental group ($n = 31; M = 35.56$) did not have significantly higher sit-and-reach scores than females in the control group ($n = 19; M = 35.55$).

Hypothesis 1B

Hypothesis 1B stated that participants in the experimental group who took a 10-minute nap/relaxation period would have significantly higher scores on the hand dynamometer test on both right and left hands. Two separate two-way ANOVAs were performed. One two-way ANOVA was performed with gender and participant group (control or experimental) as the independent variables, and the Hand Dynamometer Test on the right hand as the dependent variable. Another two-way ANOVA was performed
with gender and participant group (control or experimental) as the independent variables, and the Hand Dynamometer Test on the left hand as the dependent variable.

This hypothesis was supported (with the Hand Dynamometer Test on the right hand). For the Hand Dynamometer Test on the right hand, there was a significant main effect for gender, \( F(1, 91) = 187.91, p < .01 \). In addition, there was a significant main effect for the participant group on the Hand Dynamometer Test on the right hand, \( F(1, 91) = 5.16, p < .05 \). There was a non-significant interaction effect between the participant group and gender on the Hand Dynamometer Test on the right hand, \( F(1, 91) = 1.20, p > .05 \). Results show that hand dynamometer scores on the right hand are significantly higher with males in the experimental group (\( n = 21; M = 58.05 \)) compared to males in the control group (\( n = 26; M = 60.15 \)). Females in the experimental group (\( n = 29; M = 31.48 \)) also have significantly higher hand dynamometer scores on the right hand than females in the control group (\( n = 19; M = 37.53 \)).

This hypothesis was not supported (with the Hand Dynamometer Test on the left hand). There was a significant main effect for gender on the Hand Dynamometer Test on the left hand, \( F(1, 91) = 196.55, p < .01 \). There was a non-significant main effect for the participant group on the Hand Dynamometer Test on the left hand, \( F(1, 91) = 3.58, p > .05 \). In addition, there was a non-significant interaction effect between the participant group and gender on the Hand Dynamometer Test on the left hand, \( F(1, 91) = 0.50, p > .05 \). Results show that males in the experimental group (\( n = 21; M = 53.19 \)) did not have significantly higher hand dynamometer scores on the left hand compared to males in the control group (\( n = 26; M = 55.08 \)). In addition, females in the experimental group
(n = 29; \( M = 29.67 \)) did not have significantly higher hand dynamometer scores on the left hand than females in the control group (n = 19; \( M = 33.84 \)).

**Hypothesis 1C**

Hypothesis 1C stated participants in the experimental group who took a 10-minute nap/relaxation period would have significantly higher scores on the Vertical Jump Test compared to the control group. To test this hypothesis, a two-way ANOVA was performed with gender and participant group (control or experimental) as the independent variables, and the Vertical Jump Test as the dependent variable. This hypothesis was not supported. There was a significant main effect for gender on the Vertical Jump Test, \( F(1, 94) = 18.30, p < .01 \). There was a non-significant main effect for the participant group on the Vertical Jump Test, \( F(1, 94) = 0.11, p > .05 \). In addition, there was a non-significant interaction effect between the participant group and gender on the Vertical Jump Test, \( F(1, 94) = 0.53, p > .05 \). Results show that males in the experimental group (n = 22; \( M = 16.30 \)) did not have significantly higher vertical jump scores compared to males in the control group (n = 26; \( M = 16.65 \)). Additionally, females in the experimental group (n = 31; \( M = 13.15 \)) did not have significantly higher vertical jump scores than females in the control group (n = 19; \( M = 12.21 \)).

**Hypothesis 1D**

Hypothesis 1D stated participants in the experimental group who took a 10-minute nap/relaxation period would have significantly higher scores on Estimated Peak Power. A two-way ANOVA was performed with gender and participant group (control or experimental) as the independent variables, and Estimated Peak Power as the dependent variable. This hypothesis was not supported. There was a significant main effect for
gender on Estimated Peak Power, $F(1, 94) = 43.73, p < .01$. There was a non-significant main effect for the participant group on Estimated Peak Power, $F(1, 94) = 0.24, p > .05$. Additionally, there was a non-significant interaction effect between the participant group and gender on Estimated Peak Power, $F(1, 94) = 0.50, p > .05$. Results show that males in the experimental group ($n = 22; M = 3472$) did not have significantly higher estimated peak power scores compared to males in the control group ($n = 26; M = 3510$). Females in the experimental group ($n = 31; M = 2465$) did not have significantly higher estimated peak power scores than females in the control group ($n = 19; M = 2260$).

**Hypothesis 2A**

Hypothesis 2A stated that individuals with poor sleep quality will have significantly lower scores on the Sit-and-Reach Test compared to individuals with good sleep quality (as measured by the SQI and the ADSWS). To test this hypothesis, two separate two-way ANOVAs were performed. One two-way ANOVA was performed with gender and sleep quality (SQI scores were divided into good and poor sleep quality categories) as the independent variables, and the Sit-and-Reach Test as the dependent variable. Another two-way ANOVA was performed with gender and sleep quality (ADSWS scores were divided into good and poor sleep quality categories) as the independent variables, and the Sit-and-Reach Test as the dependent variable.

The results of the two-way ANOVA did not support this hypothesis using the SQI. There was a significant main effect for gender on the Sit-and-Reach Test, $F(1, 91) = 8.39, p < .01$. There was a non-significant main effect for sleep quality (as measured by the SQI) on the Sit-and-Reach Test, $F(1, 91) = 0.81, p > .05$. There was also a non-significant interaction effect between sleep quality (as measured by the SQI) and gender.
on the Sit-and-Reach Test, $F(1, 91) = 0.08, p > .05$. Male poor sleepers ($n = 5; M = 26.80$) (as measured by the SQI) did not have significantly lower scores on the Sit-and-Reach Test compared to male good sleepers ($n = 43; M = 29.74$). Female poor sleepers ($n = 8; M = 34.75$) (as measured by the SQI) did not have significantly lower scores on the Sit-and-Reach Test than female good sleepers ($n = 39; M = 36.32$).

Additionally, the results of the two-way ANOVA did not support this hypothesis using the ADSWS. There was a significant main effect for gender on the Sit-and-Reach Test, $F(1, 94) = 13.98, p < .01$. There was a non-significant main effect for sleep quality (as measured by the ADSWS) on the Sit-and-Reach Test, $F(1, 94) = 0.73, p > .05$. In addition, there was a non-significant interaction effect between sleep quality (as measured by the ADSWS) and gender on the Sit-and-Reach Test, $F(1, 94) = 0.04, p > .05$. Male poor sleepers ($n = 22; M = 28.84$) (as measured by the ADSWS) did not have significantly lower scores on the sit-and-reach test compared to male good sleepers ($n = 26; M = 29.94$). Female poor sleepers ($n = 28; M = 34.79$) (as measured by the ADSWS) did not have significantly lower scores on the sit-and-reach test than female good sleepers ($n = 22; M = 36.55$).

**Hypothesis 2B**

Hypothesis 2B stated that the individuals with poor sleep quality will have significantly lower scores on the Hand Dynamometer Test (right and left hand). Four separate two-way ANOVAs were performed. The first ANOVA was performed with gender and sleep quality (SQI scores were divided into good and poor sleep quality categories) as the independent variables, and the Hand Dynamometer Test on the right hand as the dependent variable. The second ANOVA was performed with gender and
sleep quality (SQI scores were divided into good and poor sleep quality categories) as the independent variables, and the Hand Dynamometer Test on the left hand as the dependent variable. The third ANOVA was performed with gender and sleep quality (ADSWS scores were divided into good and poor sleep quality categories) as the independent variables, and the Hand Dynamometer Test on the right hand as the dependent variable. The fourth ANOVA was performed with gender and sleep quality (ADSWS scores were divided into good and poor sleep quality categories) as the independent variables, and the Hand Dynamometer Test on the left hand as the dependent variable.

The results of the two-way ANOVA did not support this hypothesis using the SQI and the Hand Dynamometer Test on the right hand. There was a significant main effect for gender on the Hand Dynamometer Test on the right hand, $F(1, 88) = 74.58, p < .01$. There was a non-significant main effect for sleep quality (as measured by the SQI) on the Hand Dynamometer Test on the right hand, $F(1, 88) = 0.07, p > .05$. In addition, there was a non-significant interaction effect between sleep quality (as measured by the SQI) and gender on the Hand Dynamometer Test on the right hand, $F(1, 88) = 0.96, p > .05$. Males in the Poor Sleep Group ($n = 5; M = 56.20$) (as measured by the SQI) did not have significantly lower scores on the Hand Dynamometer Test on the right hand compared to males in the Good Sleep Group ($n = 42; M = 59.57$). Females in the Poor Sleep Group ($n = 8; M = 35.25$) (as measured by the SQI) did not have significantly lower scores on the Hand Dynamometer Test on the right hand than females in the Good Sleep Group ($n = 37; M = 33.27$).

The results of the two-way ANOVA did not support this hypothesis using the SQI and the Hand Dynamometer Test on the left hand. There was a significant main effect for
gender on the Hand Dynamometer Test on the left hand, $F(1, 88) = 97.94, p < .01$. There was a non-significant main effect for sleep quality (as measured by the SQI) on the Hand Dynamometer Test on the left hand, $F(1, 88) = 0.79, p > .05$. In addition, there was a non-significant interaction effect between sleep quality (as measured by the SQI) and gender on the Hand Dynamometer Test on the left hand, $F(1, 88) = 0.05, p > .05$. Males in the Poor Sleep Group ($n = 5; M = 56.60$) (as measured by the SQI) did not have significantly lower scores on the Hand Dynamometer Test on the left hand compared to males in the Good Sleep Group ($n = 42; M = 53.95$). Females in the Poor Sleep Group ($n = 8; M = 32.38$) (as measured by the SQI) did not have significantly lower scores on the hand dynamometer on the left hand in comparison to females in the Good Sleep Group ($n = 37; M = 30.76$).

Additionally, the results of the two-way ANOVA did not support this hypothesis using the ADSWS and the Hand Dynamometer Test on the right hand. There was a significant main effect for gender on the Hand Dynamometer Test on the right hand, $F(1, 91) = 200.64, p < .01$. There was a non-significant main effect for sleep quality (as measured by the ADSWS) on the Hand Dynamometer Test on the right hand, $F(1, 91) = 0.86, p > .05$. In addition, there was a non-significant interaction effect between sleep quality (as measured by the ADSWS) and gender on the Hand Dynamometer Test on the right hand, $F(1, 91) = 2.48, p > .05$. Males in the Poor Sleep Group ($n = 22; M = 58.59$) (as measured by the ADSWS) did not have significantly lower scores on the Hand Dynamometer Test on the right hand compared to males in the Good Sleep Group ($n = 25; M = 59.76$). In addition, females in the Poor Sleep Group ($n = 27; M = 35.85$) (as measured by the ADSWS) did not have significantly lower scores on the Hand
Dynamometer Test on the right hand than females in the Good Sleep Group (n = 21; $M = 31.33$).

The results of the two-way ANOVA did not support this hypothesis using the ADSWS and the Hand Dynamometer Test on the left hand. There was a significant main effect for gender on the Hand Dynamometer Test on the left hand, $F(1, 91) = 212.86$, $p < .01$. There was a non-significant main effect for sleep quality (as measured by the ADSWS) on the Hand Dynamometer Test on the left hand, $F(1, 91) = 0.28$, $p > .05$. In addition, there was a non-significant interaction effect between sleep quality (as measured by the ADSWS) and gender on the Hand Dynamometer Test on the left hand, $F(1, 91) = 3.76$, $p > .05$. Males in the Poor Sleep Group (n = 22; $M = 53.05$) (as measured by the ADSWS) did not have significantly lower scores on the Hand Dynamometer Test on the left hand compared to males in the Good Sleep Group (n = 25; $M = 55.28$).

Additionally, females in the Poor Sleep Group (n = 27; $M = 33.04$) (as measured by the ADSWS) did not have significantly lower scores on the Hand Dynamometer Test on the left hand in comparison to females in the Good Sleep Group (n = 21; $M = 29.14$).

**Hypothesis 2C**

Hypothesis 2C stated that individuals with poor sleep quality will have significantly lower scores on the Vertical Jump Test compared to individuals with good sleep quality. Two separate two-way ANOVAs were performed. One two-way ANOVA was performed with gender and sleep quality (SQI scores were divided into good and poor sleep quality categories) as the independent variables, and the Vertical Jump Test as the dependent variable. Another two-way ANOVA was performed with gender and sleep
quality (ADSWS scores were divided into good and poor sleep quality categories) as the independent variables, and the Vertical Jump Test as the dependent variable.

The results of the two-way ANOVA did not support this hypothesis using the SQI. There was a significant main effect for gender on the Vertical Jump Test, $F(1, 91) = 14.21, p < .01$. There was a non-significant main effect for sleep quality (as measured by the SQI) on the Vertical Jump Test, $F(1, 91) = 1.77, p > .05$. There was also a non-significant interaction effect between sleep quality (as measured by the SQI) and gender on the Vertical Jump Test, $F(1, 91) = 1.80, p > .05$. The male poor sleepers ($n = 5; M = 16.50$) from the SQI did not have significantly lower scores on the Vertical Jump Test compared to male good sleepers ($n = 43; M = 16.49$). Female poor sleepers ($n = 8; M = 9.81$) from the SQI did not have significantly lower scores on the Vertical Jump Test than female good sleepers ($n = 39; M = 13.31$).

Additionally, the results of the two-way ANOVA did not support this hypothesis using the ADSWS. There was a significant main effect for gender on the Vertical Jump Test, $F(1, 94) = 16.80, p < .01$. There was a non-significant main effect for sleep quality (as measured by the ADSWS) on the Vertical Jump Test, $F(1, 94) = 2.00, p > .05$. In addition, there was a non-significant interaction effect between sleep quality (as measured by the ADSWS) and gender on the Vertical Jump Test, $F(1, 94) = 0.03, p > .05$. Male poor sleepers ($n = 22; M = 15.91$) from the ADSWS did not have significantly lower scores on the Vertical Jump Test in comparison to male good sleepers ($n = 26; M = 16.98$). Female poor sleepers ($n = 28; M = 12.18$) from the ADSWS did not have significantly lower scores on the Vertical Jump Test compared to female good sleepers ($n = 22; M = 13.57$).
Hypothesis 2D

Hypothesis 2D stated that the individuals with poor sleep quality will have significantly lower scores on estimated Peak Power compared to individuals with good sleep quality. To test this hypothesis, two separate two-way ANOVAs were performed. One two-way ANOVA was performed with gender and sleep quality (SQI scores were divided into good and poor sleep quality categories) as the independent variables, and estimated Peak Power as the dependent variable. Another two-way ANOVA was performed with gender and sleep quality (ADWS scores were divided into good and poor sleep quality categories) as the independent variables, and estimated Peak Power as the dependent variable.

The results of the two-way ANOVA did not support this hypothesis using the SQI. There was a significant main effect for gender on estimated Peak Power, $F(1, 91) = 26.26, p < .01$. There was a non-significant main effect for sleep quality (as measured by the SQI) on estimated Peak Power, $F(1, 91) = 0.00, p > .05$. In addition, there was a non-significant interaction effect between sleep quality (as measured by the SQI) and gender on estimated Peak Power, $F(1, 91) = 0.31, p > .05$. Males in the Poor Sleep Group (n = 5; $M = 3604$) from the SQI did not have significantly lower scores on Peak Power compared to males in the Good Sleep Group (n = 43; $M = 3480$). Females in the Poor Sleep Group (n = 8; $M = 2197$) from the SQI did not have significantly lower scores on Peak Power compared to females in the Good Sleep Group (n = 39; $M = 2350$).

Additionally, the results of the two-way ANOVA did not support this hypothesis using the ADWS. There was a significant main effect for gender on estimated Peak Power, $F(1, 94) = 43.03, p < .01$. There was also a non-significant main effect for sleep
quality (as measured by the ADSWS) on estimated Peak Power, $F(1, 94) = 0.05, p > .05$. There was also a non-significant interaction effect between sleep quality (as measured by the ADSWS) and gender on estimated Peak Power, $F(1, 94) = 0.11, p > .05$. Males in the Poor Sleep Group ($n = 22; M = 3483$) from the ADSWS did not have significantly lower scores on Peak Power compared to males in the Good Sleep Group ($n = 26; M = 3501$). Females in the Poor Sleep Group ($n = 28; M = 2428$) from the ADSWS did not have significantly lower scores on Peak Power than females in the Good Sleep Group ($n = 22; M = 2335$).

**Hypothesis 3A**

Hypothesis 3A stated that individuals with shorter sleep duration will have significantly lower scores on the Sit-and-Reach Test compared to individuals with longer sleep duration. To test this hypothesis, a two-way ANOVA was performed with gender and sleep duration (SHQ scores were divided into short, medium, and long sleep duration categories) as the independent variables, and the Sit-and-Reach Test as the dependent variable. The results of the two-way ANOVA did not support this hypothesis. There was a significant main effect for gender on the Sit-and-Reach Test, $F(1, 91) = 6.14, p < .05$. There was a non-significant main effect for the participant group on the Sit-and-Reach Test, $F(2, 91) = 0.47, p > .05$. There was also a non-significant interaction effect between the participant group and gender on the Sit-and-Reach Test, $F(2, 91) = 0.66, p > .05$. Male short sleepers ($n = 12; M = 29.71$) did not have significantly lower scores on the Sit-and-Reach Test in comparison to male long sleepers ($n = 7; M = 29.29$) or male medium sleepers ($n = 29; M = 29.36$). Female short sleepers ($n = 14; M = 32.64$) did not have
significantly lower scores on the Sit-and-Reach Test compared to female long sleepers 
(n = 3; M = 36.17) or female medium sleepers (n = 32; M = 36.75).

**Hypothesis 3B**

Hypothesis 3B stated that individuals with shorter sleep duration will have significantly lower scores on the Hand Dynamometer Test (right and left hand) compared to individuals with longer sleep duration. Two separate two-way ANOVAs were performed. One two-way ANOVA was performed with gender and sleep duration (SHQ scores were divided into short, medium, and long sleep duration categories) as the independent variables, and the Hand Dynamometer Test on the right hand as the dependent variable. Another two-way ANOVA was performed with gender and sleep duration (SHQ scores were divided into short, medium, and long sleep duration categories) as the independent variables, and the Hand Dynamometer Test on the left hand as the dependent variable.

The results of the two-way ANOVA did support this hypothesis on the right hand. There was a significant main effect for gender on the Hand Dynamometer Test on the right hand, F(1, 88) = 73.69, p < .01. There was a non-significant main effect for sleep duration on the Hand Dynamometer Test on the right hand, F(2, 88) = 0.01, p > .05. In addition, there was a significant interaction effect between sleep duration and gender on the Hand Dynamometer Test on the right hand, F(2, 88) = 4.22, p < .05. Male short sleepers (n = 11; M = 58.27) did not have significantly lower scores on the Hand Dynamometer Test with the right hand compared to male long sleepers (n = 7; M = 52.71) or male medium sleepers (n = 29; M = 61.14). Female short sleepers (n = 13; M = 35.62) did not have significantly lower scores on the Hand Dynamometer Test with
the right hand compared to female long sleepers (n = 3; $M = 41.67$) or female medium sleepers (n = 31; $M = 32.61$).

The results of the two-way ANOVA did not support this hypothesis on the left hand. There was a significant main effect for gender on the Hand Dynamometer Test on the left hand, $F(1, 88) = 82.52, p < .01$. There was a non-significant main effect for sleep duration on the Hand Dynamometer Test the left hand, $F(2, 88) = 0.27, p > .05$. In addition, there was a non-significant interaction effect between sleep duration and gender on the Hand Dynamometer Test on the left hand, $F(2, 88) = 2.11, p > .05$. Male short sleepers (n = 11; $M = 54.00$) did not have significantly lower scores on the Hand Dynamometer Test with the left hand compared to male long sleepers (n = 7; $M = 51.29$) or male medium sleepers (n = 29; $M = 55.03$). Additionally, female short sleepers (n = 13; $M = 32.77$) did not have significantly lower scores on the Hand Dynamometer Test with the left hand compared to female long sleepers (n = 3; $M = 38.00$) or female medium sleepers (n = 31; $M = 30.32$).

**Hypothesis 3C**

Hypothesis 3C stated that individuals with shorter sleep duration will have significantly lower scores on the Vertical Jump Test compared to individuals with longer sleep duration. To test this hypothesis, a two-way ANOVA was performed with gender and sleep duration (SHQ scores were divided into short, medium, and long sleep duration categories) as the independent variables, and the Vertical Jump Test as the dependent variable. The results of the two-way ANOVA did not support this hypothesis. There was a significant main effect for gender on the Vertical Jump Test, $F(1, 91) = 8.46, p < .01$. There was a non-significant main effect for sleep duration on the Vertical Jump Test, $F(2,
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91) = 1.61, p > .05. Additionally, there was a non-significant interaction effect between sleep duration and gender on the Vertical Jump Test, $F(2, 91) = 0.02, p > .05$. Males in the Short Sleep Group ($n = 12; M = 16.13$) did not have significantly lower scores on the Vertical Jump Test compared to males in the Long Sleep Group ($n = 7; M = 18.64$) or males in the Medium Sleep Group ($n = 29; M = 16.12$). In addition, females in the Short Sleep Group ($n = 14; M = 12.57$) did not have significantly lower scores on the Vertical Jump Test in comparison to females in the Long Sleep Group ($n = 3; M = 15.5$) or females in the Medium Sleep Group ($n = 32; M = 12.44$).

**Hypothesis 3D**

Hypothesis 3D stated that individuals with shorter sleep duration will have significantly lower scores on estimated Peak Power compared to individuals with longer sleep duration. A two-way ANOVA was performed with gender and sleep duration (SHQ scores were divided into short, medium, and long sleep duration categories) as the independent variables, and estimated Peak Power as the dependent variable. The results of the two-way ANOVA did not support this hypothesis. There was a significant main effect for gender on estimated Peak Power, $F(1, 91) = 13.85, p < .01$. There was a non-significant main effect for sleep duration on estimated Peak Power, $F(2, 91) = 2.14, p > .05$. There was also a non-significant interaction effect between sleep duration and gender on estimated Peak Power, $F(2, 91) = 1.36, p > .05$. Males in the Short Sleep Group ($n = 12; M = 3498$) did not have significantly lower scores on estimated Peak Power compared to males in the Long Sleep Group ($n = 7; M = 3594$) or males in the Medium Sleep Group ($n = 29; M = 3466$). In addition, females in the Short Sleep Group ($n = 14; M = 2596$) did not have significantly lower scores on estimated Peak Power in
comparison to females in the Long Sleep Group (n = 3; $M = 3225$) or females in the Medium Sleep Group (n = 32; $M = 2196$).

**Hypothesis 4A**

Hypothesis 4A stated that individuals with higher levels of sleepiness will have significantly lower scores on the Sit-and-Reach Test compared to individuals with lower levels of sleepiness. To test this hypothesis, two separate two-way ANOVAs were performed. One two-way ANOVA was performed with gender and sleepiness (KSS scores were divided into high, medium, and low sleepiness categories) as the independent variables, and the Sit-and-Reach Test as the dependent variable. Another two-way ANOVA was performed with gender and sleepiness (ESS scores were divided into high, medium, and low sleepiness categories) as the independent variables, and the Sit-and-Reach Test as the dependent variable.

The results of the two-way ANOVA did not support this hypothesis using the KSS. There was a significant main effect for gender on the Sit-and-Reach Test, $F(1, 91) = 10.97, p < .01$. There was a non-significant main effect for sleepiness (as measured by the KSS) on the Sit-and-Reach Test, $F(2, 91) = 0.10, p > .05$. There was also a non-significant interaction effect between sleepiness (as measured by the KSS) and gender on the Sit-and-Reach Test, $F(2, 91) = 0.28, p > .05$. Males in the KSS High Sleepiness Group (n = 12; $M = 30.58$) did not have significantly lower scores on the Sit-and-Reach Test compared to the males in the Low Sleepiness Group (n = 16; $M = 29.53$) or males in the Medium Sleepiness Group (n = 20; $M = 28.68$). In addition, females in the KSS High Sleepiness Group (n = 17; $M = 34.68$) did not have significantly lower scores on the Sit-
and-Reach Test in comparison to females in the Low Sleepiness Group (n = 8; \( M = 36.56 \)) or females in the Medium Sleepiness Group (n = 24; \( M = 35.50 \)). Additionally, the results of the two-way ANOVA did not support this hypothesis using the ESS. There was a significant main effect for gender on the Sit-and-Reach Test, \( F(1, 92) = 9.26, p < .01 \). There was a non-significant main effect for sleepiness (as measured by the ESS) on the Sit-and-Reach Test, \( F(2, 92) = 0.56, p > .05 \). In addition, there was a non-significant interaction effect between sleepiness (as measured by the ESS) and gender on the Sit-and-Reach Test, \( F(2, 92) = 0.09, p > .05 \). The ESS male High Sleepiness Group (n = 7; \( M = 29.07 \)) did not have significantly lower scores on the Sit-and-Reach Test in comparison to the male Low Sleepiness Group (n = 35; \( M = 29.29 \)) or male Medium Sleepiness Group (n = 6; \( M = 30.75 \)). The ESS female High Sleepiness Group (n = 11; \( M = 35.05 \)) did not show significantly lower scores on the Sit-and-Reach Test compared to the female Low Sleepiness Group (n = 28; \( M = 34.73 \)) or the female Medium Sleepiness Group (n = 11; \( M = 38.18 \)).

**Hypothesis 4B**

Hypothesis 4B stated that individuals with higher levels of sleepiness will have significantly lower scores on the Hand Dynamometer Test (right and left hand) compared to individuals with lower levels of sleepiness. Four separate two-way ANOVAs were performed. The first two-way ANOVA was performed with gender and sleepiness (KSS scores were divided into high, medium, and low sleepiness categories) as the independent variables, and the Hand Dynamometer Test on the right hand as the dependent variable. The second two-way ANOVA was performed with gender and sleepiness (KSS scores were divided into high, medium, and low sleepiness categories) as the independent
variables, and the Hand Dynamometer Test on the left hand as the dependent variable.

The third two-way ANOVA was performed with gender and sleepiness (ESS scores were divided into high, medium, and low sleepiness categories) as the independent variables, and the Hand Dynamometer Test on the right hand as the dependent variable. The fourth two-way ANOVA was performed with gender and sleepiness (ESS scores were divided into high, medium, and low sleepiness categories) as the independent variables, and the Hand Dynamometer Test on the left hand as the dependent variable.

The results of the two-way ANOVA did not support this hypothesis using the KSS and the Hand Dynamometer Test on the right hand. There was a significant main effect for gender on the Hand Dynamometer Test on the right hand, \( F(1, 88) = 167.20, p < .01 \). There was a non-significant main effect for sleepiness (as measured by the KSS) on the Hand Dynamometer Test on the right hand, \( F(2, 88) = 1.78, p > .05 \). Additionally, there was a non-significant interaction effect between sleepiness (as measured by the KSS) and gender on the Hand Dynamometer Test on the right hand, \( F(2, 88) = 1.79, p > .05 \). The KSS male High Sleepiness Group \( (n = 11; M = 55.45) \) did not have significantly lower scores on the Hand Dynamometer Test on the right hand compared to the male Low Sleepiness Group \( (n = 16; M = 57.44) \) or male Medium Sleepiness Group \( (n = 20; M = 62.70) \). In addition, the KSS female High Sleepiness Group \( (n = 17; M = 32.71) \) did not have significantly lower scores on the Hand Dynamometer Test on the right hand compared to the female Low Sleepiness Group \( (n = 8; M = 35.75) \) or female Medium Sleepiness Group \( (n = 22; M = 33.55) \).

The results of the two-way ANOVA did not support this hypothesis using the KSS and the Hand Dynamometer Test on the left hand. There was a significant main
effect for gender on the Hand Dynamometer Test on the left hand, $F(1, 88) = 173.34$, $p < .01$. There was a non-significant main effect for sleepiness (as measured by the KSS) on the Hand Dynamometer Test on the left hand, $F(2, 88) = 0.61$, $p > .05$. Additionally, there was a non-significant interaction effect between sleepiness (as measured by the KSS) and gender on the Hand Dynamometer Test on left hand, $F(2, 88) = 0.34$, $p > .05$. The KSS male High Sleepiness Group ($n = 11; M = 52.45$) have significantly lower scores on the left hand in comparison to the male Low Sleepiness Group ($n = 16; M = 53.50$) or male Medium Sleepiness Group ($n = 20; M = 55.80$). In addition, the KSS female High Sleepiness Group ($n = 17; M = 30.41$) have significantly lower scores on the left hand in comparison to the female Low Sleepiness Group ($n = 8; M = 32.13$) or female Medium Sleepiness Group ($n = 22; M = 31.36$).

The results of the two-way ANOVA did not support this hypothesis using the ESS and the Hand Dynamometer Test on the right hand. There was a significant main effect for gender on the Hand Dynamometer Test on the right hand, $F(1, 89) = 115.02$, $p < .01$. There was a non-significant main effect for sleepiness (as measured by the ESS) on the Hand Dynamometer Test on the right hand, $F(2, 89) = 0.86$, $p > .05$. In addition, there was a non-significant interaction effect between sleepiness (as measured by the ESS) and gender on the Hand Dynamometer Test on the right hand, $F(2, 89) = 0.01$, $p > .05$. The ESS male High Sleepiness Group ($n = 7; M = 56.29$) did not have significantly lower scores on the Hand Dynamometer Test on the right hand compared to the male Low Sleepiness Group ($n = 35; M = 59.86$) or male Medium Sleepiness Group ($n = 5; M = 58.80$). In addition, the ESS female High Sleepiness Group ($n = 10; M = 31.70$) did not have significantly lower scores on the Hand Dynamometer Test on the right hand.
compared to the female Low Sleepiness Group (n = 28; M = 34.61) or female Medium Sleepiness Group (n = 10; M = 34.00).

The results of the two-way ANOVA did not support this hypothesis using the ESS and the Hand Dynamometer Test on the left hand. There was a significant main effect for gender on the Hand Dynamometer Test on the left hand, $F(1, 89) = 125.27, p < .01$. There was a non-significant main effect for sleepiness (as measured by the ESS) on the left hand, $F(2, 89) = 0.42, p > .05$. In addition, there was a non-significant interaction effect between sleepiness (as measured by the ESS) and gender on the Hand Dynamometer Test on left hand, $F(2, 89) = 0.18, p > .05$. The ESS male High Sleepiness Group (n = 7; M = 53.57) have significantly lower scores on the left hand in comparison to the male Low Sleepiness Group (n = 35; M = 54.49) or male Medium Sleepiness Group (n = 5; M = 53.40). In addition, the ESS female High Sleepiness Group (n = 10; M = 28.90) have significantly lower scores on the left hand in comparison to the female Low Sleepiness Group (n = 28; M = 31.96) or female Medium Sleepiness Group (n = 10; M = 32.00).

Hypothesis 4C

Hypothesis 4C stated that individuals with higher levels of sleepiness will have significantly lower scores on the Vertical Jump Test compared to individuals with lower levels of sleepiness. To test this hypothesis, two separate two-way ANOVAs were performed. One two-way ANOVA was performed with gender and sleepiness (KSS scores were divided into high, medium, and low sleepiness categories) as the independent variables, and the Vertical Jump Test as the dependent variable. Another two-way ANOVA was performed with gender and sleepiness (ESS scores were divided into high,
medium, and low sleepiness categories) as the independent variables, and the Vertical Jump Test as the dependent variable.

The results of the two-way ANOVA did not support this hypothesis using the KSS. There was a significant main effect for gender on the Vertical Jump Test, \( F(1, 91) = 14.58, p < .01 \). There was a non-significant main effect for sleepiness (as measured by the KSS) on the Vertical Jump Test, \( F(2, 91) = 0.17, p > .05 \). Additionally, there was a non-significant interaction effect between sleepiness (as measured by the KSS) and gender on the Vertical Jump Test, \( F(2, 91) = 1.24, p > .05 \). The KSS male High Sleepiness Group (\( n = 12; M = 15.46 \)) did not have significantly lower scores on the Vertical Jump Test in comparison to the male Low Sleepiness Group (\( n = 16; M = 16.22 \)) or male Medium Sleepiness Group (\( n = 20; M = 17.33 \)). In addition, the KSS female High Sleepiness Group (\( n = 17; M = 13.76 \)) did not have significantly lower scores on the Vertical Jump Test in comparison to the female Low Sleepiness Group (\( n = 8; M = 12.13 \)) or female Medium Sleepiness Group (\( n = 24; M = 12.35 \)).

The results of the two-way ANOVA did not support this hypothesis using the ESS. There was a significant main effect for gender on the Vertical Jump Test, \( F(1, 92) = 9.39, p < .01 \). There was a non-significant main effect for sleepiness (as measured by the ESS) on the Vertical Jump Test, \( F(2, 92) = 0.84, p > .05 \). There was also a non-significant interaction effect between sleepiness (as measured by the ESS) and gender on the Vertical Jump Test, \( F(2, 92) = 1.02, p > .05 \). The ESS male High Sleepiness Group (\( n = 7; M = 16.64 \)) did not have significantly lower scores on the Vertical Jump Test compared to the male Low Sleepiness Group (\( n = 35; M = 16.49 \)) or the male Medium Sleepiness Group (\( n = 6; M = 16.33 \)). In addition, the ESS female High Sleepiness Group (\( n = 11; \)
$M = 12.55$) did not have significantly lower scores on the Vertical Jump Test in comparison to the female Low Sleepiness Group ($n = 28; M = 11.93$) or the female Medium Sleepiness Group ($n = 11; M = 15.23$).

**Hypothesis 4D**

Hypothesis 4D stated that individuals with higher levels of sleepiness will have significantly lower scores on estimated Peak Power compared to individuals with lower levels of sleepiness. Two separate two-way ANOVAs were performed. One two-way ANOVA was performed with gender and sleepiness (KSS scores were divided into high, medium, and low sleepiness categories) as the independent variables, and estimated Peak Power as the dependent variable. Another two-way ANOVA was performed with gender and sleepiness (ESS scores were divided into high, medium, and low sleepiness categories) as the independent variables, and estimated Peak Power as the dependent variable. The results of the two-way ANOVA did not support this hypothesis using the KSS. There was a significant main effect for gender on estimated Peak Power, $F(1, 91) = 38.38, p < .01$. There was a non-significant main effect for sleepiness (as measured by the KSS) on estimated Peak Power, $F(2, 91) = 0.74, p > .05$. In addition, there was a non-significant interaction effect between sleepiness (as measured by the KSS) and gender on estimated Peak Power, $F(2, 91) = 3.02, p > .05$. The KSS male High Sleepiness Group ($n = 12; M = 3188$) did not have significantly lower estimated Peak Power scores compared to the male Low Sleepiness Group ($n = 16; M = 3399$) or the male Medium Sleepiness Group ($n = 20; M = 3751$). In addition, the KSS female High Sleepiness Group ($n = 17; M = 2669$) did not have significantly lower estimated Peak Power scores in comparison...
to the female Low Sleepiness Group (n = 8; M = 2107) or the female Medium Sleepiness Group (n = 24; M = 2281).

Additionally, the results of the two-way ANOVA did not support this hypothesis using the ESS. There was a significant main effect for gender on estimated Peak Power, $F(1, 92) = 26.04, p < .01$. There was a non-significant main effect for sleepiness (as measured by the ESS) on estimated Peak Power, $F(2, 92) = 1.57, p > .05$. There was also a non-significant interaction effect between sleepiness (as measured by the ESS) and gender on estimated Peak Power, $F(2, 92) = 1.01, p > .05$. The ESS male High Sleepiness Group (n = 7; M = 3419) did not have significantly lower estimated Peak Power scores in comparison to the male Low Sleepiness Group (n = 35; M = 3497) or the male Medium Sleepiness Group (n = 6; M = 3553). In addition, the ESS female High Sleepiness Group (n = 11; M = 2180) did not have significantly lower estimated Peak Power scores compared to the female Low Sleepiness Group (n = 28; M = 2249) or the female Medium Sleepiness Group (n = 11; M = 2946).
CHAPTER 4

DISCUSSION

This last chapter discusses the general overview of the results, followed by a discussion of each hypothesis. The general implications for the study are also discussed, followed by the limitations of the study and future directions.

General Overview of Results

The results of this study revealed that the majority (68%) of participants experienced occasional sleep difficulties, as measured by the SQI. Only 15% of the sample reported good sleep quality and over 13% indicated that their sleep quality was poor. This means that nearly nine out of 10 participants regularly experienced moderate to poor sleep quality. An examination of item responses on the SQI revealed that over 25% of the participants experienced insomnia and 13% take sleep medication. Additionally, over half of the participants indicated that they felt tired in the morning. Almost 40% of the participants reported difficulty falling asleep and over 40% indicated disturbed sleep. In addition, 33% of participants wake up during the night and over 40% awaken too early in the morning. This may indicate that even though they are not having major sleep problems, they are still experiencing sufficient sleep problems to feel tired in the morning due to lack of sleep.
The participants slept an average of seven hours 13 minutes a day on week nights and eight hours 39 minutes on weekend nights. Of the participants, 26% slept six hours 30 minutes or less during the week, while 10% slept nine hours or more. According to the National Sleep Foundation, an adult needs from seven to nine hours of sleep per night. This indicates that 26% of the participants in this study slept less than the recommended amount. Over 35% reported experiencing sleepiness outside the normal range. Additionally, the current sample had a higher average on the ESS and KSS compared to other studies, which indicates these participants had a higher level of sleepiness. This provides further evidence suggesting that participants are experiencing sleep difficulties.

The results also revealed that the current sample had significantly lower vertical jump height, peak power, and grip strength compared to other studies. This difference in grip strength, vertical jump height, and peak power in this sample, compared to other studies, may be in part due to the sleep difficulties participants are experiencing. The results were compared to other studies with similarly aged college students and were not athletes or active Kinesiology students.

The relationship between sleep quality/sleepiness and physical performance varied. Lower grip strength was associated with increased sleepiness, as measured by both the ESS and KSS. According to the evolutionary/circadian rhythm models of sleep, sleep may have evolved to conserve energy. According to Berger and Phillips (1995), phylogenetic and ontogenetic associations between sleep and endothermy are consistent with the hypothesis that sleep evolved in conjunction with endothermy to offset the high energetic cost of endothermy. The electrophysiological and thermoregulatory continuum of slow wave sleep, circadian torpor and hibernation substantiates a primordial link
between sleep and energy conservation. Sleep constitutes a circadian and circannual rhythm of hypometabolic adaptation to biospheric energy cycles that is usually entrained through light-mediated suppression of melatonin secretion. When energy stores decline, energy is conserved by lowering body temperature (Tb) proportionally during sleep or by increasing the daily duration of sleep. Those who are not sleepy tend to have better grip strength because they conserved enough energy while they slept; therefore they were alert and had energy to perform well on the grip strength test.

Vertical jump height was positively related to returning to sleep after an awakening during the sleep period on the ADSWS. Vertical jump height was also positively related to the transition from sleep to wakefulness on the ADSWS. It may be that those who have reduced ability to reinitiate sleep following an awakening or to wake up in the morning have difficulty generating the power for vertical jump height. In addition, there was a significant positive relationship between peak power and returning to sleep after awakening. This could mean that those who have difficulty reinitiating sleep after an awakening have not slept through the proper sleep cycles, which in turn may affect peak power.

There were no significant relationships between sleep duration (as measured on the SHQ) and anaerobic performance, indicating that the length of time one sleeps may not impact immediate, short-term physical activities. It could be that the time of day the study was conducted affected physical performance. The data was collected from 8:00-10:00am and 4:00-6:00pm. Most of the data was collected in the later afternoon/early evening. Due to the time frame that most of the data was collected, the results could be impacted by the “post-lunch dip,” which would reflect 12-hour biologic cycles of
sleepiness (Hayashi, Morikawa, & Hori, 2002). It could also be that because the physical performance measures were short in duration, the participants were able to perform even though they were tired. Individuals may have been able to function well enough on the physical performance measures because they were immediate, short-term physical activities, despite their levels of sleepiness. However, it is possible that if the physical performance measures were longer in duration, individuals may not have been able to overcome the effects of sleepiness like they could in brief periods of time.

**Hypothesis One**

Hypotheses 1A through 1D posited that individuals who took a 10-minute nap/relaxation would have significantly better flexibility, grip strength, vertical jump height, and peak power than individuals in the control group. Analysis indicated that the 10-minute nap/relaxation group did significantly improve grip strength (Hypothesis 1B). However, the 10-minute nap/relaxation group did not significantly impact flexibility (Hypothesis 1A), vertical jump height (Hypothesis 1C), or peak power (Hypothesis 1D).

**Hypothesis 1A.** Hypothesis 1A stated that a 10-minute nap/relaxation would significantly improve flexibility. The results of the ANOVA did not support this hypothesis. There are numerous sports in which flexibility plays an important role. Even though a 10-minute nap/relaxation period did not significant improve flexibility, it still could benefit athletes in sports where even a small amount of increase in flexibility could assist them in performing better and perhaps even lead to winning.

The ineffectiveness of this intervention for flexibility may be due to several reasons. One reason is that there may be no effect of a nap/relaxation on flexibility. Another possible reason is the 10-minute time frame of the nap/relaxation that was used.
It is possible that a 10-minute nap/relaxation did not allow participants adequate time to sleep; therefore, not improving alertness and flexibility. The nap/relaxation may have been more effective if conducted over a longer period of time, allowing participants to have the necessary sleep/relaxation time to increase their flexibility. In addition, the sleep/relaxation may need to be monitored with an Actigraph to determine if individuals are actually sleeping for 10 minutes. It is possible that by monitoring participants with an Actigraph, it would be assured that they slept/relaxed for 10 minutes, which may have led to them experiencing changes in their flexibility. Relaxation does not mean that muscles are physically lengthening, which would result in improvements. Napping has been found to increase alertness, memory, motor skills, decision-making, and mood, which are not components in performing well on a sit-and-reach test.

**Hypothesis 1B.** Hypothesis 1B stated that a 10-minute nap/relaxation would significantly improve grip strength. The results of the ANOVA did support this hypothesis on the right hand, but not the left hand. This means that a 10-minute nap/relaxation period may improve grip strength. The 10-minute nap/relaxation period may have resulted in reduced muscle tension or increased focus, which enabled participants to feel relaxed and improve their grip strength. Short daytime naps of less than 30 minutes, which rarely contain SWS, have been shown to have positive effects on daytime alertness (Takahashi, 2003). This has been experimentally confirmed after a normal night of sleep in young adults and elderly individuals, after a restricted night of sleep, and during prolonged sustained performance (Naitoh, Kelly, & Babkoff, 1992). Tietzel and Lack (2002) found that a 10-minute brief nap had a recuperative effect, suggesting that the recuperative power of a short nap depends on stage 2 sleep, not stage
1. According to Hayashi et al. (2005), a daytime nap containing three minutes of stage 2 sleep has recuperative effects, whereas these effects are limited following only stage 1 sleep. However, these results are in contrast to Waterhouse, Atkinson, Edwards, and Reilly (2007) who found that a post-lunch nap did not improve grip strength. In the study by Waterhouse et al. (2007), there was actually a decline in grip strength. Because the researchers examined the grip strength scores individually instead of taking the best of the three scores, this decline could be explained by muscle fatigue (Waterhouse et al., 2007).

Hypothesis 1C. Hypothesis 1C stated that a 10-minute nap/relaxation would significantly improve vertical jump height. The results of the ANOVA did not support this hypothesis. The ineffectiveness of this intervention for vertical jump height may be due to several reasons. One reason is that there may be no effect of a nap/relaxation on vertical jump height. It is also important to remember that the current sample had significantly higher levels of sleepiness than the standardization groups for the ESS and KSS. This suggests that the current sample may not have been able to benefit from the 10-minute nap/relaxation, because they needed a longer nap/relaxation period to improve their vertical jump height.

Hypothesis 1D. Hypothesis 1D stated that a 10-minute nap/relaxation would significantly improve peak power. The results of the ANOVA did not support this hypothesis. The ineffectiveness of this intervention for peak power may be due to several reasons. One reason could be that there may be no effect of a nap/relaxation on peak power. It may also be possible that the 10-minute nap/relaxation may have been beneficial in different formats (e.g., Progressive Muscle Relaxation, Visual Imagery),
instead of a guided breathing relaxation. In addition, it could be possible that the 10-minute nap/relaxation would be more effective if participants would have been able to lie down. Participants may have been able to fall asleep or feel more relaxed if they felt comfortable by being able to lie down. By lying down, they may have achieved the relaxation needed for improvement in peak power. Individuals are more likely to fall asleep while lying down than sitting in a chair, because people regularly sleep lying down and their bodies are cued to become sleepy when they lay down.

**Hypothesis Two**

Hypotheses 2A through 2D posited that individuals with good sleep quality would have significantly better flexibility, grip strength, vertical jump height, and peak power than individuals with poor sleep quality. Results revealed that sleep quality did not significantly impact flexibility (Hypothesis 2A), grip strength (Hypothesis 2B), vertical jump height (Hypothesis 2C), or peak power (Hypothesis 2D).

**Hypothesis 2A.** Hypothesis 2A stated that poor sleep quality will reduce flexibility. The results of the ANOVA did not support this hypothesis. The hypothesis not being significantly supported for flexibility may be due to the possibility that flexibility is not affected by sleep quality. Sleep quality was assessed using the SQI and ADSWS, but no significant results were found using the ADSWS and flexibility. However, the participants with good sleep quality based on the SQI did have somewhat better flexibility than participants with poor sleep quality, even though it was not statistically significant. This could be an advantage to athletes in several sports in which flexibility is important. Even though sleep quality did not significantly improve flexibility, getting a
good night’s sleep could still be an advantage to athletes in sports where any increase in flexibility could influence performance.

These results are in contrast to a study conducted by Lee and Lin (2007) who found that female Taiwan college students with poor sleep quality had a significantly shorter distance for the sit-and-reach (flexibility) than females with good sleep quality. The study by Lee and Lin (2007) used the Chinese version of the Pittsburgh Sleep Quality Index (PSQI) to measure sleep quality and the current study used the SQI. It is possible that the different results are due to measurement issues as different scales were used to assess sleep quality.

**Hypothesis 2B.** Hypothesis 2B stated that poor sleep quality will reduce grip strength. The results of the ANOVA did not support this hypothesis. The hypothesis not being significantly supported for grip strength may be due to the possibility that grip strength is not affected by sleep quality. Sleep quality was assessed using the SQI and ADSWS, but no significant results were found using the ADSWS and grip strength. However, even though the results were not statistically significant, the participants with good sleep quality did have a five point improvement in grip strength compared to participants with poor sleep quality. This could mean that getting a good night’s sleep may benefit athletes in sports in which an improvement in grip strength could impact performance outcome. Dam, Ewing, Ancoli-Israel, Ensrud, Redline, and Stone (2008) found that less REM sleep appeared to be associated with weaker grip strength in older men. Therefore, another possible reason is that individuals with good sleep quality may have more REM sleep, which could have improved grip strength. In addition, studies of students have also shown that those deprived of REM sleep perform worse on academic
tests than those who were not deprived (Karni et al., 1994; Pilcher & Huffcutt, 1996; Pilcher & Ott, 1998; Pilcher & Walters, 1997; Smith & Lapp, 1991). Students who demonstrated a significant increase in REM sleep followed a period of intense learning were found to perform significantly better on an examination than students who did not show an increase in REM sleep (De Koninck et al., 1989). Therefore, it is a possibility that an increase in REM sleep could improve physical performance.

These results are also inconsistent with a study conducted by Goldman et al. (2007) who found that older women with poor sleep quality (≥1.6 hours of wake after sleep onset) had 4% weaker grip strength than participants with good sleep quality. It is possible that because physiological measures to assess sleep quality were not used, sleep quality was not accurately measured. It is also possible that individuals could have overcome the effects of poor sleep for a brief period of time and performed well enough on the hand dynamometer. In addition, older women could be more easily affected by poor sleep quality than college students, because college students may be more resilient to the effects of sleep.

**Hypothesis 2C.** Hypothesis 2C stated that individuals with poor sleep quality will have reduced vertical jump height. The results of the ANOVA did not support this hypothesis. Sleep quality was assessed using the SQI and ADSWS, but no significant results were found with vertical jump height. The hypothesis not being supported for vertical jump height may be due to several reasons. There may be no effect of sleep quality on vertical jump height. Another possible reason that this hypothesis was not supported is that participants could have been tired from the dynamic warm-up,
especially if they were not athletes. The warm-up may have tired people physically, which could have hindered their vertical jump height.

**Hypothesis 2D.** Hypothesis 2D stated that poor sleep quality will reduce peak power. The results of the ANOVA did not support this hypothesis. Sleep quality was assessed using the SQI and ADSWS, but no significant results were found with peak power. The hypothesis not being supported for peak power may be because there may be no effect of sleep quality on peak power. The time of day could impact peak power. For instance, peak power may have been better in the morning than the afternoon, because individuals may have been active all day and were tired by the time they participated in the study. In addition, because peak power was based on a brief physical performance measure and that people can overcome sleep issues for brief periods, sleep quality may not have had a significant impact on peak power.

**Hypothesis Three**

Hypotheses 3A through 3D posited that individuals with short sleep duration would have significantly reduced flexibility, grip strength, vertical jump height, and peak power compared to individuals with long sleep duration. Results revealed that sleep duration did not significantly impact flexibility (Hypothesis 3A), grip strength (Hypothesis 3B), vertical jump height (Hypothesis 3C), or peak power (Hypothesis 3D).

**Hypothesis 3A.** Hypothesis 3A stated that long or average sleep durations would significantly improve flexibility. The results of the ANOVA did not support this hypothesis. The hypothesis not being supported for flexibility may be because flexibility may not be affected by sleep duration. Another possible reason that this hypothesis was
not supported is that individuals may not require the recommended number of hours of sleep per night to let their muscles rest so that they are flexible.

**Hypothesis 3B.** Hypothesis 3B stated that longer sleep duration will significantly improve grip strength. The results of the ANOVA did not support this hypothesis. The hypothesis not being supported for grip strength may be because grip strength may not be affected by sleep duration. Another possible reason that this hypothesis was not supported is that the time of day could impact grip strength. Goh, Tong, Lim, Low, and Lee (2001) found that grip strength increased progressively during the day, but decreased during the night. Cappaert (1999) found similar results, indicating that grip strength peaked in the afternoon. Therefore, the time of day for testing could have impacted grip strength performance. The post-nap dip could account for an increase in sleepiness, which could have negatively impacted grip strength performance (Hayashi et al., 2002). Additionally, this hypothesis may not have been supported possibly due to the increased use of technology, such as typing on keyboards, which could contribute to the overuse of individuals’ muscles and therefore decrease grip strength.

**Hypothesis 3C.** Hypothesis 3C stated that longer sleep duration will significantly improve vertical jump height. The results of the ANOVA did not support this hypothesis. The hypothesis not being supported for vertical jump height may be because sleep duration does not have an effect on vertical jump height. These results are inconsistent with a study conducted by Takeuchi, Davis, Plyley, Goode, and Shephard (1985) who found that that sleep deprived males had significantly decreased vertical jump height. The study by Takeuchi and colleagues (1985) had participants undergo 64 hours of sleep deprivation. It is possible that short sleep duration (< six hours of sleep per night) does
not have the same effect as prolonged sleep deprivation. In addition, individuals may have reported what time they lay down in bed instead of when they actually fall asleep. This could mean that these individuals are not actually long sleepers and the results may not be significant.

**Hypothesis 3D.** Hypothesis 3D stated that longer sleep duration will significantly improve peak power. The results of the ANOVA did not support this hypothesis. The hypothesis not being supported for peak power may because sleep duration does not affect peak power. Another possibility is that the long sleepers may be getting more REM sleep, which could contribute to the increase in peak power. In addition, people may only need a minimum amount of sleep for their muscles to recuperate, which could mean that individuals with short sleep duration would not have a reduction in peak power. Furthermore, peak power was estimated based on vertical jump height, and they are positively correlated with each other. Is it not surprising that peak power did not significantly improve when there was not a significant improvement in vertical jump height.

**Hypothesis Four**

Hypotheses 4A through 4D posited that compared to individuals with higher levels of sleepiness, individuals with lower levels of sleepiness will have significantly better flexibility, grip strength, vertical jump height, and peak power. Results revealed that sleepiness did not significantly impact flexibility (Hypothesis 4A), grip strength (Hypothesis 4B), vertical jump height (Hypothesis 4C), or peak power (Hypothesis 4D).

**Hypothesis 4A.** Hypothesis 4A stated that higher levels of sleepiness will significantly reduce flexibility. The results of the ANOVA did not support this
hypothesis. The hypothesis not being supported for flexibility may be due to several reasons. Flexibility may not be affected by sleepiness. Another possible reason that this hypothesis was not supported is that the Sit-and-Reach Test was not long in duration. Particularly relevant to college students, Durmer and Dinges (2005) found that cognitive performance effects of sleep deprivation revealed a "fatigue effect," which became worse as time on the task increased. Furthermore, performance declined as the task duration extended. This decline in performance can include physical performance. Possibly assessing measures of flexibility that are longer in duration than a sit-and-reach test would result in a significant impact of sleepiness on flexibility. Therefore, it is possible that higher levels of sleepiness may adversely affect flexibility if assessed in an extended measure.

Hypothesis 4B. Hypothesis 4B stated that higher levels of sleepiness will significantly impair grip strength. The results of the ANOVA did not support this hypothesis. The hypothesis not being supported for grip strength may be because grip strength is not affected by sleepiness. It is also possible that due to the short time frame to complete the grip strength task, people were able to overcome sleepiness. Participants may not have been able to overcome sleepiness during a longer task, such as long-distance running. Individuals participated in the dynamic warm-up twice within a two-hour period, which may have countered the effects of sleepiness, as the warm-up increased heart rate and physiological arousal. Research has shown that the active, dynamic warm-up has demonstrated positive effects on performance. However, participants in this study were not athletes; therefore, many of them are not likely to be physically active and were not use to engaging in that type of physical activity. In
addition, many of the male participants were competitive with one another during both of the active, dynamic warm-ups. This could have led to an increase in heart rate and physiological arousal, which may have temporarily diminished the effects of sleepiness.

**Hypothesis 4C.** Hypothesis 4C stated that higher levels of sleepiness will significantly reduce vertical jump height. The results of the ANOVA did not support this hypothesis. The hypothesis not being supported for vertical jump height may be due to several reasons. There may be no effect of sleepiness on vertical jump height. Another possible reason that this hypothesis was not supported is that the Vertical Jump Test is too short and simplistic of a task to be impacted by sleepiness. In addition, sleepy individuals may have been able to turn on the motivation in order to perform for a short period of time.

**Hypothesis 4D.** Hypothesis 4D stated that higher levels of sleepiness will significantly reduce peak power. The results of the ANOVA did not support this hypothesis. The hypothesis may not be supported for peak power because there may not be a significant effect of sleepiness on peak power. It is also possible that sleepiness affects tasks which are more cognitive in nature. Because there is not much of a cognitive aspect to peak power, sleepiness may not have an impact on peak power.

**Implications**

This study has important implications for athletes. The fact that there was a significant improvement in grip strength due to a 10-minute nap/relaxation highlights the importance of sleep. These results could have an impact on sports such as baseball, basketball, football, tennis, and wrestling, in which grip strength plays an important role.
This suggests that athletes in these sports could potentially benefit from a 10-minute nap/relaxation prior to competing.

Even though a 10-minute nap/relaxation period did not significantly improve flexibility, it could still benefit athletes in several sports in which flexibility is important. This could be an advantage to athletes in sports at the professional or collegiate levels where even a small amount of difference could assist them in winning. At the professional level, winning could affect millions of dollars. College scholarships may be affected by whether or not the individual wins.

Sleep quality did improve flexibility and grip strength, even though it was not significant. Long sleepers also had an improvement in grip strength, vertical jump height, and peak power. In addition, average sleepers had an increase in flexibility and individuals who were alert had better peak power. The implication of these results is that getting a good night's sleep could be an advantage to athletes in sports where any increase in flexibility, grip strength, vertical jump height, or peak power could influence performance outcome. This also could have implications in occupational tasks which require grip strength, as well as activities of daily living, which may also have an impact on possible work outcomes.

The current study had a higher average on the ESS and KSS compared to other studies, indicating that this sample had a higher level of sleepiness than other samples. Additionally, over 35% of this sample reported experiencing sleepiness outside the normal range. Reduced sleep time has explained excessive sleepiness of several patient and nonpatient groups. For example, a sample of sleep clinic patients was identified as having excessive daytime sleepiness, which can be attributed to chronic insufficient sleep
(Roehrs, Zorick, Sicklesteel, Wittig, & Roth, 1983). These patients had objectively documented excessive sleepiness, "normal" nocturnal sleep with unusually high sleep efficiency (time asleep-time in bed), and report about two hours more sleep on each weekend day than each weekday. Regularizing bedtime and increasing time in bed produces a resolution of these symptoms and normalizes Multiple Sleep Latency Test (MSLT) results (Manber, Bootzin, Acebo, & Carskadon, 1996). Therefore, the increased sleepiness of healthy young adults can be attributed to insufficient nocturnal sleep. When the sleepiest 25% of a sample of young adults was given extended time in bed (10 hours) for as long as five to 14 consecutive nights, their sleepiness was reduced to a level resembling the general population mean (Roehrs, Shore, Papineau, Rosenthal, & Roth 1996). Therefore, reducing sleepiness can be done by regulating bedtime and extending time in bed. Lower grip strength was associated with increased sleepiness in the current study. It is possible that by reducing sleepiness, athletes may experience an increase in their grip strength.

In the current study, vertical jump height was positively related to the transition from sleep to wakefulness. It is possible that those who have reduced ability to wake up in the morning are sleepy and therefore have difficulty generating the power for vertical jump height. This could mean that by reducing sleepiness, athletes may be able to see an increase in their vertical jump height. Therefore, it may be important for athletes to regulate their bedtime and increase their time in bed in order to reduce sleepiness.

Bonnet and Arand (2005) found that a 5-minute walk immediately preceding Multiple Sleep Latency Test (MSLT) evaluations masked the impact of a 50% reduction of nocturnal sleep and continued for at least 90 minutes after the task. This indicated that
exercise before performing tasks provided a temporary reversal of some psychomotor decline resulting from sleep loss. In the current study, individuals engaged in two dynamic warm-ups (lasting 10-15 minutes each) in a two-hour time period prior to participating in the physical performance tasks. Therefore, individuals’ performance may not have shown a decrease because the psychomotor deficits were masked by participating in the dynamic warm-ups. However, athletes who are competing in an event that lasts longer than 90 minutes may not be able to mask the effects of sleep loss by exercising beforehand. This could mean that if baseball players exercised before a game, after 90 minutes, they may experience a decrease in grip strength, which could affect their swing. The implication for baseball players is to get a good night’s sleep, so they do not experience a reduction in grip strength. It is also possible that the results of the current study could have been significant if individuals did not participate in the dynamic warm-ups. It may also be that if the study tested participants several hours after the dynamic warm-ups, then they may have had a decrease in grip strength because the effects of sleep loss would not be masked by the warm-up.

**Limitations**

There are several limitations to the current study. One limitation is in regards to the generalizability of the study. The current sample consisted of 98 undergraduate and graduate students who ranged in age from 17 to 47. The sample is not representative of the general population, due to the fact that the participants are all college students. Therefore, it is not clear if the results would generalize to individuals with different levels of education. In addition, it is unclear if the results would generalize to non-current students. The participants attend a public university in the Southern United States.
Therefore, the generalizability of the results to students attending private colleges and universities, as well as universities and colleges outside the Southern United States, is questionable.

Furthermore, other limitations of the study include the small sample with unequal sample size and no pre-test was conducted to determine if groups differed beforehand, even though random assignment of participants was implemented. Regarding the unequal sample size, SPSS autocorrects the formula to calculate the sum of squares in unequal sample sizes in two-way ANOVA analyses, which was used for this study. The study was originally designed to be a within and between subjects design; however, due to the lack of participants, it resulted in a post-test only study. Pre-test measures would have been ideal to determine if the groups were different at the onset of the study. However, due to the difficulty in recruiting participants, the post-tests were only conducted. Therefore, it is difficult to determine what, if any, effects of the nap/relaxation condition had an effect on physical performance.

Another limitation of the study is that, on the SHQ, only 26.3% of the participants slept <6 hours per night, which is the number of hours used to classify an individual as having a short sleep duration. On the SHQ, only 10.1% of the participants slept less than nine hours per night, which indicates an individual as having a long sleep duration. Most of the participants (61.6%) had average sleep duration (greater than six and less than nine hours of sleep per night). The current study may not have included enough individuals in each group to determine if there was a significant change in physical performance, which could mean that there was not enough power to indicate a significant effect in the results.
An additional limitation of the current study is that all of the sleep-related data was self-reported. Therefore, the results must be interpreted under the assumption that the participants responded truthfully. Participants were told that their responses would be kept confidential. Participants were instructed to detach their consent forms from the questionnaire packet before turning it in, to ensure the confidentiality of their responses. In addition, the questionnaires with the participant’s identification number did not include any personal identifying information, which ensured that participant data was anonymous. Despite these efforts, participants may not have responded truthfully. Participants may have over-reported or under-reported their responses, because they could have been inclined to respond in a socially desirable manner. Social desirability was not controlled for in this study.

Another limitation is that participants may not have been motivated to take the appropriate time to complete the questionnaires on sleep quality, sleep duration, and sleepiness accurately. The participants may not have cared how they physically performed on the Vertical Jump test, given that the current sample did not consist of athletes and had significantly lower scores on physical performance measures than other samples. Individuals’ level of motivation for participating in the study may have affected the results as well. Due to participants being given extra credit for their participation; their motive may have been to improve their grade instead of trying their best with the physical performance measures, despite being encouraged to try their best on all measures. Participants may not have tried hard enough to see an improvement in their physical performance without the motivation to do their best.
An additional limitation is in regards to the time frame that the questionnaires inquired about for this study. All of the sleep-related data was self-reported and the questionnaires requested information over a specific period of time. Therefore, memory bias could have impacted the results. Participants in this study may not have been accurate or consistent in recalling or reporting their sleep quality, sleep length, or level of sleepiness. The SQI asked respondents to assess their sleep quality over the past three month and the ADSWS asked participants to assess their sleep quality over the past week. It could be quite difficult for an individual to remember their sleep patterns over an extended period of time.

Another limitation is that the current study was unable to use a force plate to measure peak power. Therefore, peak power was estimated using a formula based on the Vertical Jump Test. Future research should use an actual measure of peak power instead of estimating peak power. However, the equations for estimated peak power do have a high reliability.

An additional limitation is that the physical performance measures used in this study do not require psychomotor reactivity and therefore may have not been impacted by sleepiness. Blagrove and Akehurst (2001) found that adults reporting excessive sleepiness also report negative effects on psychomotor reactivity. However, flexibility, grip strength, vertical jump height, and peak power are not dependent on psychomotor abilities. A tennis return, sprint start, and karate block are dependent on psychomotor abilities and if those measures were used in this study, then they may have been significantly affected by sleepiness.
Another limitation is that the physical performance measures used in this study do not require visual-motor reaction time, critical thinking abilities, vigilance, attention to task, or reaction time; therefore, they may have not been impacted by sleep quality. Taub (1980) found that poor sleep quality adversely affects visual-motor reaction time, critical thinking abilities, vigilance, attention to task, and reaction time, which are all important in physical performance. However, flexibility, grip strength, vertical jump height, and peak power are not dependent on psychomotor abilities. A tennis return, sprint start, and karate block do require visual-motor reaction time, critical thinking abilities, vigilance, attention to task, or reaction time and if they were the measures used in this study, then they may have been significantly affected by sleep quality.

An additional limitation is that the physical performance measures used in this study do not require much cognitive skill and therefore may have not been impacted by sleep duration. Hicks and Gilliland (1981), as well as Taub and Berger (1973), found that individuals who report sleeping six hours or less have a greater incidence of cognitive difficulties. This increase in cognitive difficulties may impact physical performance. However, flexibility, grip strength, vertical jump height, and peak power are not dependent on cognitive skill. Hitting a baseball or throwing a football are more dependent on cognitive skill, and they may have been significantly affected by sleep duration if they were used in this study. It is important to note that given the limitations, the results of this study do make an important contribution to the literature.

Suggestions for Future Research

Future research should be expanded to include a sample more representative of the general population, including individuals of different educational level,
socioeconomic status, geographic region, and age. The study should also be replicated
with a larger sample size and pre-test measures to be able to determine if the sample sizes
are different prior to the experimental condition. In addition, future research should be
expanded to include individuals who are not currently students. These suggestions may
assist in improving the generalizability of study. It is also important that the effectiveness
of the 10-minute nap/relaxation be examined with a sample of more individuals
experiencing sleep difficulties. This will help ensure that the intervention has a chance to
be effective because the sample would represent equal sample sizes among the groups.

It is highly recommended that future research measure sleep quality and sleep
length using objective measures, such as an Actigraph. By using physiological measures
of sleep quality, it would greatly reduce human error, as well as the chance of memory
bias impacting the results. Physiological measures may also significantly reduce
individuals inaccurately assessing their sleep quality over time. Another way to assess
sleep length more accurately is through the use of a sleep diary. Future research should
also examine other forms of physical performance measures, such as additional anaerobic
or aerobic activities. Waterhouse and colleagues (2007) found that naps produced an
improvement in sprint performance after sleep loss during the previous night. However,
the current study did not measure sprinting, which is another anaerobic activity. Future
research could examine aerobic activity, such as long-distance running.

Future directions also could include comparing individuals who experience
anxiety to those who do not experience anxiety. Individuals who experience anxiety may
experience arousal, maladaptive behaviors, negative thoughts, and difficulty
concentrating, which could impede their physical performance. Guided imagery is often
used in relaxation procedures with athletes in order to regulate their arousal before
competition, lessen maladaptive behaviors, and balance negative thoughts as well as to
enhance concentration and focus (Peluso et al., 2005; Vempati & Telles, 2002; Watanabe
et al., 2006). Therefore, individuals who experience anxiety may benefit from guided
imagery. Finally, it is unclear if a nap would have a beneficial effect on participants who
have been partially deprived of sleep compared to this without partial sleep deprivation.
Future research could examine physical performance between individuals who are
partially sleep deprived verses those who do not suffer from partial sleep deprivation.

With additional understanding of the relationship between sleep and physical
performance, there are practical implications for athletes. Athletes in sports in which grip
strength plays an important role, such as baseball, basketball, football, tennis, and
wrestling, could potentially benefit from a 10-minute nap/relaxation prior to competing.
Getting a good night’s sleep also could be an advantage to athletes in sports where any
increase in flexibility, grip strength, vertical jump height, or peak power could influence
performance outcome.
APPENDIX A

HUMAN USE COMMITTEE

APPROVAL FORM
MEMORANDUM

TO: Ms. Rebecca Hoffmann and Dr. Walt Buboltz
FROM: Barbara Talbot, University Research
SUBJECT: HUMAN USE COMMITTEE REVIEW
DATE: December 19, 2011

In order to facilitate your project, an EXPEDITED REVIEW has been done for your proposed study entitled:

"The Relation of Sleep Length/Quality and Napping on Physical Performance"

HUC 888

The proposed study's revised procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects. The information to be collected may be personal in nature or implication. Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential. Informed consent is a critical part of the research process. The subjects must be informed that their participation is voluntary. It is important that consent materials be presented in a language understandable to every participant. If you have participants in your study whose first language is not English, be sure that informed consent materials are adequately explained or translated. Since your reviewed project appears to do no damage to the participants, the Human Use Committee grants approval of the involvement of human subjects as outlined.

Projects should be renewed annually. This approval was finalized on December 19, 2011 and this project will need to receive a continuation review by the IRB if the project, including data analysis, continues beyond December 19, 2012. Any discrepancies in procedure or changes that have been made including approved changes should be noted in the review application. Projects involving NIH funds require annual education training to be documented. For more information regarding this, contact the Office of University Research.

You are requested to maintain written records of your procedures, data collected, and subjects involved. These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study. If changes occur in recruiting of subjects, informed consent process or in your research protocol, or if unanticipated problems should arise it is the Researchers responsibility to notify the Office of Research or IRB in writing. The project should be discontinued until modifications can be reviewed and approved.

If you have any questions, please contact Dr. Mary Livingston at 257-4315.
APPENDIX B

INFORMED CONSENT FORM
HUMAN SUBJECTS CONSENT FORM

The following is a brief summary of the project in which you are asked to participate. Please read this information before signing the statement below.

TITLE OF PROJECT: The Relation of Sleep Length/Quality and Napping on Physical Performance

PURPOSE OF STUDY/PROJECT: The purpose of this study is to examine the impact of sleep quality/length and napping on physical performance.

PROCEDURE: Prior to participation, you must sign an informed consent. After consent forms are signed, you will be asked to complete two questionnaires, participate in a dynamic warm-up, complete the hand grip dynamometer test, sit-and reach test, and vertical jump and force plate test, take a nap or read a newspaper, participate in a dynamic warm-up again, complete the hand grip dynamometer test, sit-and reach test, and vertical jump and force plate test again, and complete a packet of surveys. You will be making two trips from the classroom to the gymnasium, in one two-hour block of time. The maximum your participation will take is two hours. Please answer the questions truthfully and to the best of your ability. Surveys and informed consent forms will be collected separately. At the exit, you will be provided with information regarding the availability of tutoring and counseling services and information regarding how to obtain a summary of the results of the study. Data will be analyzed to determine relationships among the variables.

INSTRUMENTS: The survey booklet includes general questions about your background and history, and specific surveys about your sleep habits, physical activity, mood, and body image.

RISKS/ALTERNATIVE TREATMENTS: The participant understands that Louisiana Tech is not able to offer financial compensation nor to absorb the costs of medical treatment should you be injured as a result of participating in this research. Participants might experience soreness, muscle/tendon strains or soreness, and ligament sprains due to maximal jumps. In case of emergency, an individual certified in First Aid and CPR will be on site during testing.

BENEFITS/COMPENSATION: Some participants may be offered extra class credit for participation. If extra credit is provided by your instructor, he/she must offer an alternative assignment for extra credit if you do not choose to participate in this study.

I, ______________________, attest with my signature that I have read and understood the following description of the study, “The Relation of Sleep Length/Quality and Napping on Physical Performance,” and its purposes and methods. I understand that my participation in this research is strictly voluntary and my participation or refusal to participate in this study will not affect my relationship with Louisiana Tech University. Further, I understand that I may withdraw at any time or refuse to answer any questions without penalty. Upon completion of the study, I understand that the results will be freely available to me upon request. I understand that the results of my survey will be confidential, accessible only to the principal investigators, myself, or a legally appointed representative. I have not been requested to waive nor do I waive any of my rights related to participating in this study.

Signature of Participant or Guardian Date

CONTACT INFORMATION: The principal experimenters listed below may be contacted to answer questions about the research, subjects’ rights, or related matters.

PROJECT DIRECTORS: Rebecca Hoffmann and Walt Buboltz, Ph.D.
EMAIL: rmr026@latech.edu; buboltz@latech.edu
PHONE: (410) 581-3835; (318) 257-4039

Members of the Human Use Committee of Louisiana Tech University may also be contacted if a problem cannot be discussed with the experimenters:
Dr. Les Guice (318) 257-3056
Dr. Mary M. Livingston (318) 257-2292 or (318) 257-4315
APPENDIX C

DEMOGRAPHICS FORM
Demographics Form

Participant #: __________

Please complete the following information.

<table>
<thead>
<tr>
<th>1. What is your gender?</th>
<th>2. What is your age? ______</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Male</td>
<td></td>
</tr>
<tr>
<td>2. Female</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. What is your race/ethnic origin? (Circle all that apply)</th>
<th>4. What are you classified as?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. African American/Black</td>
<td>1. Freshman</td>
</tr>
<tr>
<td>2. Asian/Pacific Islander</td>
<td>2. Sophomore</td>
</tr>
<tr>
<td>4. Hispanic</td>
<td>4. Senior</td>
</tr>
<tr>
<td>5. Native American</td>
<td>5. Graduate student</td>
</tr>
<tr>
<td>6. Other, please specify: ______</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. What is your height (feet/inches)? ____</th>
<th>6. What is your weight (in pounds)? ____</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>7. Are you an NCAA athlete?</th>
<th>8. If yes, then what sport do you play?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yes</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>2. No</td>
<td>--------------------------------------</td>
</tr>
</tbody>
</table>
APPENDIX D

SLEEP QUALITY INDEX
Instructions: Please answer the following questions to the best of your ability by circling the response that best fits you. If unsure, please give your best guess.

1. Time to fall asleep
   - < 10 minutes
   - 11-30 minutes
   - > 30 minutes

2. Suffered from insomnia during the past three months
   - No
   - < 3 days/week
   - 3-7 days/week

3. Difficulties falling asleep during the past 3 months
   - No
   - < 3 days/week
   - 3-7 days/week

4. Disturbed night sleep during the past 3 months
   - No
   - < 3 days/week
   - 3-7 days/week

5. Nocturnal awakening during the past 3 months
   - No
   - < 3 days/week
   - 3-7 days/week

6. Tiredness in the morning during the past 3 months
   - Very or Mostly Alert
   - Don’t Know
   - Very or Mostly Tired

7. Wake up too early in the morning during the past 3 months
   - No
   - < 3 days/week
   - 3-7 days/week

8. Use of sleeping medication during the past 3 months
   - No
   - Occasionally
   - At least once per week
APPENDIX E

ADULT SLEEP-WAKE SCALE
Adult Sleep-Wake Scale (ASWS)

**Directions:** Using the choices below, circle *how often* the following things have happened *during the past week*.

- **Never** – has not happened
- **Once in a while** – happened 20% of the time
- **Sometimes** – happened 40% of the time
- **Quite Often** – happened 60% of the time
- **Frequently, if not always** – happened 80% of the time
- **Always** – happened 100% of the time

<table>
<thead>
<tr>
<th>Questions 1 – 5 are <em>only</em> about you <em>Going to Bed</em> at bedtime.</th>
</tr>
</thead>
</table>

When it is time to go to bed...

1.) ...I want to stay up and do other things (for example: read, work, or watch TV).

- Never
- Once in a while
- Sometimes
- Quite Often
- Frequently, if not always
- Always

In general...

2.) ...I have to make myself go to bed.

- Never
- Once in a while
- Sometimes
- Quite Often
- Frequently, if not always
- Always

3.) ...It is very hard for me to go to bed on time.

- Never
- Once in a while
- Sometimes
- Quite Often
- Frequently, if not always
- Always

4.) ...I “put off” or delay going to bed.

- Never
- Once in a while
- Sometimes
- Quite Often
- Frequently, if not always
- Always

5.) How long do you usually “put off” or delay going to bed?

- (a) < 15 min
- (b) 15-30 min
- (c) 30-45 min
- (d) 45-60 min
- (e) 60-90 min
- (f) >90 min

Remember: Think about the past week.

<table>
<thead>
<tr>
<th>Questions 6 – 10 are <em>only</em> about you <em>Falling Asleep</em> after “lights out.”</th>
</tr>
</thead>
</table>

When I’m in bed and it is time to fall asleep...

6.) ...I am not sleepy.

- Never
- Once in a while
- Sometimes
- Quite Often
- Frequently, if not always
- Always

7.) ...I am unable to settle down.

- Never
- Once in a while
- Sometimes
- Quite Often
- Frequently, if not always
- Always
In general...

8.) ...I try to make myself go to sleep.
   Never  Once in a while  Sometimes  Quite Often  Frequently, if not always  Always

9.) ...I fall asleep quickly.
   Never  Once in a while  Sometimes  Quite Often  Frequently, if not always  Always

10.) How long does it usually take you to fall asleep after “lights out”?
   (a) < 15 min  (b) 15-30 min  (c) 30-45 min  (d) 45-60 min  (e) 60-90 min  (f) >90 min

Questions 11 – 15 are only about how you Sleep during the night (someone else could have told you these things).

After I fall asleep, during the night...

11.) ...I toss and turn in bed.
   Never  Once in a while  Sometimes  Quite Often  Frequently, if not always  Always

12.) ...I am very restless.
   Never  Once in a while  Sometimes  Quite Often  Frequently, if not always  Always

13.) ...I awaken more than once.
   Never  Once in a while  Sometimes  Quite Often  Frequently, if not always  Always

In general...

14.) ...I sleep without arousals or awakenings.
   Never  Once in a while  Sometimes  Quite Often  Frequently, if not always  Always

15.) How often do you usually wake up during the night?
   (a) Never  (b) Once  (c) Twice  (d) 3 times  (e) 4 times  (f) More than 4 times

Remember: Think about the past week.

Questions 16 – 20 are only about you Going back to sleep after waking up during the night.

After waking up during the night...

16.) ...I have a hard time going back to sleep.
   Never  Once in a while  Sometimes  Quite Often  Frequently, if not always  Always

17.) ...I drift off back to sleep
   Never  Once in a while  Sometimes  Quite Often  Frequently, if not always  Always
18.) ...I am calm and relaxed.

   Never   Once in a while   Sometimes   Quite Often   Frequently, if not always   Always

19.) ...I roll over and go right back to sleep.

   Never   Once in a while   Sometimes   Quite Often   Frequently, if not always   Always

20.) How long does it usually take you to go back to sleep after waking during the night?

   (a) < 5 min   (b) 5-10 min   (c) 10-15 min   (d) 15-20 min   (e) 20-30 min   (f) >30 min

Questions 21-25 are only about you Waking Up in the morning.

In the morning, I wake up...

21.) ...and feel ready to get up for the day.

   Never   Once in a while   Sometimes   Quite Often   Frequently, if not always   Always

22.) ...rested and alert.

   Never   Once in a while   Sometimes   Quite Often   Frequently, if not always   Always

23.) ...and just can't get going.

   Never   Once in a while   Sometimes   Quite Often   Frequently, if not always   Always

In general...

24.) ...I am slow-to-start in the morning.

   Never   Once in a while   Sometimes   Quite Often   Frequently, if not always   Always

25.) ...I find it difficult to get out of bed in the morning.

   Never   Once in a while   Sometimes   Quite Often   Frequently, if not always   Always
Sleep Habits Questionnaire (SHQ)

**Instructions:** Write in your answers to the following questions.

1. On the average, what time during the week do you go to bed? _________________

2. On the average, what time during the week do you wake up? _________________

3. On the average, what time during the weekend do you go to bed? _______________

4. On the average, what time during the weekend do you wake up? _________________

5. On the average, how many hours of sleep do you get during the week? _________

6. On the average, how many hours of sleep do you get on the weekend? _________

7. Ideally I would like to get _____ hours of sleep during the week each night.

8. Ideally I would like to get _____ hours of sleep on the weekend each night.

9. About how many minutes does it take you to fall asleep after lying down in bed?
   _____
APPENDIX G

EPWORTH SLEEPINESS SCALE
Epworth Sleepiness Scale

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you haven’t done some of these things recently try to work out how they would have affected you.

Use the following scale to choose the most appropriate number for each situation:

0 = would never doze

1 = slight chance of dozing

2 = moderate chance of dozing

3 = high chance of dozing

It is important that you answer each question as best you can.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Chance of Dozing (0-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting and reading</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Watching TV</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Sitting, inactive in a public place (e.g. a theatre or a meeting)</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>As a passenger in a car for an hour without a break</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Lying down to rest in the afternoon when circumstances Permit</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Sitting and talking to someone</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Sitting quietly after a lunch without alcohol</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>In a car, while stopped for a few minutes in the traffic</td>
<td>0 1 2 3</td>
</tr>
</tbody>
</table>

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APPENDIX H

KAROLINSKA SLEEPINESS SCALE
Karolinska Sleepiness Scale (KSS)

**Directions:** Please rate how sleepy you currently feel on the following scale by circling the number.

(1) Extremely alert

(2)

(3) Alert

(4)

(5) Neither alert nor sleepy

(6)

(7) Sleep – but no difficulty remaining awake

(8)

(9) Extremely sleepy – fighting sleep
APPENDIX I

SCRIPT FOR RECRUITING PARTICIPANTS
Script for Recruiting Participants

Hi, my name is Becky Hoffmann. I am a fourth year doctoral student here at Tech. I am currently conducting research for my dissertation. Part of that includes inviting students in Psychology and Kinesiology courses to participate in the research and to offer you an opportunity to earn extra credit and contribute to the field of psychology.

I will be passing around a list of dates and times that you may sign-up to participate. On the left side, please write down your name and telephone number next to the date and time you wish to participate. Then, tear off the information on the right side which lists the date and time you signed up for, as well as the location you will report to. Please wear comfortable clothing that you can stretch in. I am requesting your phone number, because you will receive a phone call the day before reminding you about the time you signed up for and to wear comfortable clothing. If you are unavailable during the dates and times listed and would still like to participate in the research, you can email me to set up an alternative time. My email address is: rmr026@latech.edu. Your participation in this study is voluntary. All information provided in this study will remain anonymous and confidential. The amount of extra credit you receive will be determined by your professor. What questions do you have? Thank you very much for signing up to participate in this study.
APPENDIX J

ACTIVE DYNAMIC WARM-UP PROCEDURE
Active Dynamic Warm-up (Pre-Practice/Game)

1. Complete Jumping Jack Series
   a. Jumping Jacks 2 x 10
   b. Split Jack Forward 2 x 10
   c. Highland Fling 2 x 10
   d. Long Striders 2 x 10
2. Neck Clock 1 x 5 each
3. Shoulder Roll forward and backward 1 x 5 each
4. Long Arm Swings 1 x 5 each
5. Arm Circle Giant forward and backwards 1 x 10 each
6. Arm Hugs 1 x 10
7. Trunk Twists 1 x 5 each
8. Prisoner Squat Arms Forward 1 x 5
9. Heel to Toe Raise 1 x 5 each
10. Lunge Forward 1 x 5 each
11. Lunge Backwards 1 x 5 each
12. Lateral Lunge 1 x 5 each
13. Inverted Toe Touch 1 x 10 yd
14. Straight Leg March 1 x 10 yd
15. Quadricep Stretch Walking 1 x 10 yd
16. Knee Hug Walking 1 x 10 yd
17. Walking Lunge Same Elbow Same Leg 1 x 10 yd
18. Walking Lunge with Twist 1 x 10 yd
19. Prone Scorpion 1 x 5 each
20. Acceleration A Skip 1 x 10 yd
21. Butt Kickers 1 x 10 yd
22. Slow Backpedal 1 x 20 yd
23. Fast Backpedal 1 x 20 yd
24. Carioca 2 x 20 yd
25. Power Skip 1 x 20 yd
REFERENCES


Prinz, P. (2004). Sleep, appetite, and obesity—What is the link? *Public Library of Science and Medicine, 1*, 186-188.


