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The Effect of Napping on Sleep Quality and Quantity in Healthy and Concussed Collegiate Athletes

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The Effect of Napping on Sleep Quality and Quantity in Healthy and Concussed Collegiate Athletes

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Abstract

Clinicians are increasingly prescribing a regulated sleep schedule to athletes post injury; however, baseline sleep habits of collegiate athletes are unknown. Moreover, the connection between napping and sleep quality and quantity has not been studied in collegiate athletes. Therefore, the purpose of this study is to investigate napping behaviors and their effects on sleep quantity and quality in concussed and non-concussed collegiate athletes. In a sample of 233 non-concussed collegiate athletes, 74% (172/233) of participants reported napping. Napping was not significantly associated with sleep quantity (χ^2 (2) = .23, p = .64) or quality (χ^2 (1) = .42, p =.52). Due to a small sample size (n = 6) in the concussed group, the results are inconclusive. The majority of non-concussed collegiate athletes reported napping; however, it did not affect their nighttime sleep quality or quantity. Athletes are advised to regulate their sleep after injury; however, the current study provides evidence that athletes are not regulated prior to their injury. Future research should investigate if these results are congruent with those post-concussion.

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Dedication

This thesis is dedicated to my parents, Mark and Cheryl Stephenson, and my husband, Jacob Brown.

Contents

Introduction

Overview of the Problem

Sport-related concussion continues to be a major medical concern. Approximately 1.6 to 3.8 million sport and recreation related concussions occur in the United States alone (Langlois, Rutland-Brown, & Wald, 2006). Moreover, the average cost per case is $18,454 for concussion in the United States (Corso, Finkelstein, Miller, Fiebelkorn, & Zaloshnja, 2015; Faul, Xu, Wald, Coronado, & Dellinger, 2010; "Medical Expenditure Panel Survey Public Use File Details," n.d.). Signs and symptoms such as physical (e.g., dizziness, headache, nausea, vomiting), cognitive (e.g., delayed responses, confusion, fatigue, fogginess), sleep-related (e.g., trouble falling asleep, staying asleep, and drowsiness), and affective symptoms (e.g. irritability, nervousness or anxiousness) are common with concussion (National Research Council & Committee on Sports-Related Concussions in Youth, 2014); however, each injury presents with a unique combination of symptoms. The individualized signs, symptoms, and impairments associated with concussion has provided impetus for the advances in concussion assessment, management, and treatment.

Concussion assessment, management, and treatment is evolving from a one-size fits all model to a more individualized, targeted approach that considers individual differences of each athlete and their injury (Collins et al., 2016). Traditional assessment approaches included the measurement of only a few domains (e.g., cognition and symptoms) (Barth et al., 1989). However, as a result of advances in the assessment of varying clinical presentations of concussion, a thorough clinical examination followed by a multi-modal assessment of symptoms, cognition, balance, vestibular, and oculomotor function is now considered best practice (Broglio et al., 2014; McCrory et al., 2005, 2009, 2017a; McCrory, Meeuwisse, Aubry, Cantu, Dvořák, et al., 2013). With the progression of assessments, concussion management has also evolved. The management of sport related concussion to date has primarily involved a passive, assessment-based approach involving cognitive and physical rest followed by a gradual return to activity for determining return to play. Though this approach is endorsed by the majority of current consensus statements (Broglio et al., 2014; McCrory et al., 2005, 2009, 2017a; McCrory, Meeuwisse, Aubry, Cantu, Dvořák, et al., 2013), several studies highlight the deleterious effect of prescribed rest (Buckley, Munkasy, & Clouse, 2016; Thomas, Apps, Hoffmann, McCrea, & Hammeke, 2015). Thomas and colleagues (2015) reported that concussed patients prescribed a strict five days rest period reported significantly higher symptom scores compared to patients that rested for the first 24 to 48 hours followed by a stepwise return to activity protocol. Similarly, Buckley and colleagues (2016) also reported that symptoms resolved faster in patients that returned to regular daily activities when compared to those who were prescribed rest (e.g., withheld from class and activities). These findings highlight the shortcomings for prescribed physical and cognitive rest, and favor a more active, targeted approach for treating concussion (Collins et al., 2016).

The utilization of data from the multi-modal assessment approach for concussion enables the clinician to identify a predominant clinical trajectory or profile that can be targeted with specific active treatment plans (Collins, Kontos, Reynolds, Murawski, & Fu, 2014). In a recent clinical review paper, Collins and colleagues (2014) outlined six clinical profiles that include vestibular, ocular, cognitive/fatigue, migraine, anxiety/mood, and cervical- that when identified with clinical assessment data (i.e., symptom, neurocognitive, vestibular, patient history) can better characterize concussion and inform treatment. The treatments and therapies for each profile are matched to the underlying deficits, which range from therapies, rehabilitation programs, to pharmacological interventions. However, some profiles (e.g., cognitive/fatigue, migraine, and anxiety/ mood) have overlapping treatment approaches. One common treatment approach that fits more than one clinical profile is behavioral regulation, which is often a conservative, low cost approach to treating concussion (Collins et al., 2014).

Clinicians, Dr. Womble and Dr. Collins described behavioral regulation as the maintenance of a healthy and consistent sleeping, diet, hydration, physical activity, and stress management schedule (Womble & Collins, 2016), and the "dysregulation" of these components in college students is well documented in the literature. For example, sleep disturbances are reported in 70% of college students (Buboltz, Brown, & Soper, 2001). In addition to impaired sleep, several researchers report poor nutrition and hydration habits in college-aged athletic populations (Johnson, Powers, & Dick, 1999; Shriver, Betts, & Wollenberg, 2013). Shriver and colleagues (2013) reported that 75% of female athletes failed to meet the minimum amount of carbohydrate intake that is nutritionally recommended for their activity level. Similarly, Hinton and colleagues (2004) reported that only 26% of college athletes had adequate protein intake and merely 15% had adequate carbohydrate consumption (Hinton, Sanford, Davidson, Yakushko, & Beck, 2004). Moreover, collegiate athletes experience higher levels of stress than typical college students (Humphrey, Yow, & Bowden, 2000; Wilson & Pritchard, 2005). Specifically, athletes reported higher stress related to different domains (e.g., strain with social and family relationships, not having enough time for sleep, and heavy demands for extracurricular activities) than their non-athlete counterparts (Wilson & Pritchard, 2005). Overall, it seems that many college-aged athletes have poor behavioral regulation, which may play a role in recovery from concussion.

The improvement of behavioral regulation components (i.e., drinking more water, proper diet, getting adequate, regulated sleep and exercise, managing stress) is reported to be efficacious in patients with migraine (Calhoun & Ford, 2007), insomnia (Smitherman et al., 2016), anxiety, and depression (Alvaro, Roberts, & Harris, 2013; Howland, 2011). All of which can co-morbidly occur with concussion (Junn, Bell, Shenouda, & Hoffman, 2015; Sufrinko, McAllister-Deitrick, Elbin, Collins, & Kontos, 2018; Yang, Peek-Asa, Covassin, & Torner, 2015). More specifically, migraine patients, that improved their sleep habits (e.g., prescribed 8 hours of sleep at night, eliminate sleep distractors in bed, discontinued naps) reported reduced migraine frequency of 28% within a month after intervention when compared to sham interventions (Calhoun & Ford, 2007). Other researchers reported that behavioral regulation reduced insomnia symptoms and increased total sleep time, sleep efficiency and improved self-reported insomnia severity (Smitherman et al., 2016). Components of behavioral regulation such as regular exercise and stress management have been found to be advantageous for treating anxiety (Byrne & Byrne, 1993). Exercise is just as effective as pharmaceutical interventions for depression when used as stand-alone treatments (Blumenthal et al., 1999). Behavioral regulation is also associated with improvements in treatment adherence, and an overall reduction in medical expenditures (Singer, Buse, & Seng, 2015).

Significance of the Problem

Sleep is often impaired following concussion (Parcell, Ponsford, Rajaratnam, & Redman, 2006a), and is essential to recovery from the injury. Several researchers have highlighted the deleterious influence that poor sleep has on concussion symptoms (Mihalik et al., 2013), neurocognitive function (Durmer & Dinges, 2005), oculomotor function (Russo et al., 2003), and postural stability (Degache et al., 2016). Sufrinko and colleagues (2016) reported a dose response relationship between less sleep and concussion symptoms and neurocognitive performance (Sufrinko, Johnson, & Henry, 2016). Specifically, adolescent athletes endorsed higher symptom reports on the Post-Concussion Symptom Scale as well as lower neurocognitive performance. Similarly, (Beebe, Field, Milller, Miller, & LeBlond, 2017) reported that healthy, non-concussed high school athletes who were mildly sleep deprived (e.g., 6.5 hours of sleep for 5 nights) reported significantly more symptoms and demonstrated lower verbal memory performance compared to a control group that was prescribed “healthy sleep” (e.g., 9.5 hours per night in bed). Russo and colleagues (2003) also reported a consistent decrease in oculomotor function with restricted sleep on measures such as saccadic velocity, initial pupil diameter, latency to pupil constriction and constriction amplitude (Russo et al., 2003), and Degache and colleagues (2016) reported that poor sleep was correlated with poor postural control the afternoon after a sleep study (Degache et al., 2016). Overall, poor sleep quality and quantity negatively affect many of the same factors seen with concussion (e.g., self-reported symptoms, neurocognitive function, oculomotor function and postural stability).

In contrast to the negative effects of sleep dysregulation, improving sleep as a treatment approach are efficacious in several comorbid disorders with concussion that include migraine (Calhoun & Ford, 2007), depression (Howland, 2011), and anxiety (Alvaro et al., 2013). Ellison and colleagues (2017) reported that a sleep intervention significantly improved sleep, anxiety and depression compared to pre-therapy scores. In addition, Hovland, and colleagues (2017) found with improved sleep quality and quantity, self-report of depression symptoms were decreased significantly (Hovland et al., 2017). These findings not only support the efficacy for sleep regulation in migraine, depression, and anxiety; but could also have efficacy as a treatment for concussion. As future empirical investigations examine the relationship of sleep to concussion outcomes, one consideration that needs to be examined is behaviors that may interfere with sleep such as napping.

Napping is sleep that occurs outside of the single episode of night time sleep that is characteristic of typical human sleeping schedules, and napping is not defined by time of day, length or parts of the sleep cycle that were achieved (Morin & Espie, 2011). Napping is often referred to biphasic or polyphasic sleep in the literature. It is estimated that 51% to 75% of college-aged adults report napping (Lovato, Lack, & Wright, 2014; Ye, Hutton Johnson, Keane, Manasia, & Gregas, 2015a). Effects of napping noted in the literature, though prevalent in college-aged population, are understudied and conflicting.

The literature on the beneficial and/or negative effects of napping is mixed. Short naps (e.g., 5 to 15 minutes) have been shown to be beneficial in situations of sleep deprivation that can mimic the effects of college students pulling “all-nighters” and cramming sessions prior to exams or assignment deadlines by improving cognitive functioning for 1-3 hours post nap (Lovato & Lack, 2010). Short naps (e.g., 5-15 minutes) have been found to improve subjective alertness (Gillberg, Kecklund, Axelsson, & Akerstedt, 1996), objective alertness on EEG (Gillberg et al., 1996), reaction time (Taub, 1978) and short-term memory performance (Gillberg et al., 1996), all of these factors are also used to assess and manage mild traumatic brain injuries such as concussion. In contrast to the aforementioned positive effects, naps greater than 30 minutes have been found to have a negative effect on cognition (Lovato & Lack, 2010), and napping is reported to interfere with night time sleep quantity and quality (Buboltz et al., 2001; Lovato et al., 2014; Ye et al., 2015a). Lovato and colleagues (2014) reported that students who napped at least once per week were more likely to suffer from sleepiness and depression symptoms as well as difficulty concentrating when compared to those who did not report napping (Lovato et al., 2014). Moreover, as napping negatively influences sleep, sleep is also disrupted with concussion (Parcell, Ponsford, Rajaratnam, & Redman, 2006b). Therefore, sleep quality and quantity would likely be negatively affected if an athlete sustained a concussion and exhibited napping behaviors. However, napping prevalence has yet to be studied in collegiate athletes. College athletes have a higher demand on their time and energy expenditure than non-athlete students (Jolly, 2008); therefore, their sleep patterns may be different. More specifically, the role that napping has on sleep quality and quantity in college athletes is understudied. Moreover, some sports medicine clinicians have recommended telling patients not to nap after SRC (Womble & Collins, 2016); however, the chronic effects of napping behaviors on post-concussion sleep quantity and quality is also unknown, and the effects of napping behavior on concussion recovery time is unclear.

Purpose of the Study

The purpose of this study is to investigate napping behaviors and their effects on sleep quantity, quality, and concussion recovery outcomes in collegiate athletes.

Study Aims and Hypotheses

Aim 1: To describe napping behaviors in collegiate athletes.

Aim 2: To examine the relationship between napping and sleep quality and quantity in collegiate athletes.

> **Hypothesis 1**: Napping behavior will be negatively related to sleep quantity in non-concussed collegiate athletes.
>
> **Hypothesis 2**: Napping behavior will be negatively related to sleep quality in non-concussed collegiate athletes.

Exploratory Question

Exploratory Question: What is the frequency of post-concussion napping behavior in college athletes with concussion?

Operational Definitions

Concussion: a biomechanical injury induced by a blow to the head, neck, or body that transmits an impulsive force to the head. The injury presents as signs, symptoms and impairments (e.g., headache, nausea, vomiting, balance problems, dizziness, fatigue, blurred or double vision, sensitivity to light or sound, difficulty concentrating, confusion, feeling more emotional, nervous or anxious, sleep disturbances, delayed responses, loss of consciousness, amnesia and cognitive impairments) that spontaneously resolve in most cases, but may persist (McCrory et al., 2017a).

Sleep: the state where voluntary motor activity is decreased, while one is also less sensitive to stimuli, and physically has a stereotypic posture. Sleep is distinguishable from other forms of unconsciousness such as a coma by the fact that it is easily reversible and self-regulating. Sleep is comprised of two phases, non-rapid eye movement and rapid eye movement (Morin & Espie, 2011).

Sleep quantity: duration of sleep in hours and minutes (Pilcher, Ginter, & Sadowsky, 1997).

Sleep quality: is a "complex phenomenon that is difficult to define and measure objectively" (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989. P. 194). It is subjectively defined as tiredness upon waking and throughout the day, as well as feeling rested and restored on waking and the number of times the subject awoke throughout the night (Harvey, Stinson, Whitaker, Moskovitz, & Virk, 2008).

Nap: sleep that occurs during the day, or outside of the normal habitual sleeping times as part of a polyphasic sleep schedule (Morin & Espie, 2011).

Assumptions

It will be assumed that the participants report their sleep and napping behaviors accurately and honestly. It will be assumed that all concussions are accurately diagnosed by a medical professional.

Review of Literature

Prevalence of the injury

Concussion is a prevalent issue in the United States. Langlois and colleagues (2006) reported that between 1.8 and 3.8 million sport related concussions occur each year (Langlois et al., 2006). Moreover, overall incidence rates per 1000 athletic exposures have been reported at 0.23 for high school (Gessel, Fields, Collins, Dick, & Comstock, 2007a), and 0.38 for college sports (Covassin, Swanik, & Sachs, 2003). Age and competition level may play a role in in concussion prevalence/incidence rates. Similarly, different sports may have different prevalence and incidence rates of concussion.

Different characteristics of sports, such as competition level, sex, and level of contact (e.g., non-contact and contact sports), are associated with higher concussion rates. Women had higher incidence rates of concussion at 0.36 cases per 1000 athletic exposures, compared to men at 0.22 cases per 1000 athletic exposure (Gessel et al., 2007a). Furthermore, a previous study by Guskiewicz and colleagues (2000) reported that high school football had a higher rate of concussion at 5.6%, followed by division III college football at 5.5%, division II at 4.5% and division I at 4.4%, suggesting that level of competition may play a role in risk of concussion (Guskiewicz, Weaver, Padua, & Garrett, 2000). A different study over various collegiate and high school sports reported approximately 35% of concussions occurred during practice and 65% occurred during games (Gessel, Fields, Collins, Dick, & Comstock, 2007b). Sport may also play a role in risk of injury. American football (40.5%) has been found to have higher concussion rates compared to girls' soccer (21.5%), boys' soccer (15.4%), and girls' basketball (9.5%) (Gessel et al., 2007a). Prevalence of concussion is hard to estimate for various reasons. McCrea and colleagues conducted a study utilizing an anonymous survey given to high school football players at the end of season. Only 47.3% of athletes who sustained a suspected concussion reported their injury (McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004). Limitations for prevalence and incidence studies include reliance on self-report and honesty of the athletes, as well as the assumption that all are using the same definition and diagnosis criteria for concussion.

Definition of Concussion

An accurate and uniform definition of sport-related concussion (SRC) is a necessary endeavor in sports medicine. As of the 2017 consensus statement, concussion is defined as a biomechanical injury induced by a blow to the head or body that transmits an impulsive force to the head (McCrory et al., 2017a). Concussions typically result in acute neurologic impairment, as well as signs and symptoms that may appear within seconds to hours after the initial injury. Resolution of the signs, symptoms and impairments may follow a consecutive course; however, some athletes may experience a protracted recovery (McCrory et al., 2017b). Imaging (e.g., CT and MRI) cannot be used to diagnose concussion because this injury is comprised of functional disturbances rather than structural damage. Therefore, concussion is often diagnosed by clinical signs (e.g., loss of consciousness or vomiting), symptoms (e.g., dizziness, fatigue, nausea, and visual disturbances), and impairments (e.g., neurocognitive or motor) which cannot be attributed to drug (prescribed or not), alcohol use, or other pre-existing or co-existing medical conditions (McCrory et al., 2017a).

As researchers and clinicians have begun to better understand concussion, the classifications have changed. The injury is no longer classified as mild, moderate or severe (Aubry et al., 2002; Guskiewicz et al., 2004), but rather by clinical presentation into one or more clinical presentations (Collins et al., 2014). Concussion is further classified by biomechanical mechanism.

Biomechanics of Concussion

The biomechanical forces that are associated with SRC are described and categorized by direction, force and location of the force. The human brain is suspended in cerebrospinal fluid within the skull. A concussion occurs when the brain makes contact with the inside of the skull due to the head striking a stationary object or being struck by an object while stationary (Gurdjian & Volis, 1966). This could be due to contact or inertial forces. Contact forces are associated with when the head is directly his by an object; furthermore, inertial forces are associated with the lack of the head striking an object, and causing an impulsive motion (i.e., whiplash) (Meaney & Smith, 2011). This could be a result in coup or contrecoup injury. Coup injuries occur at the site of impact, and contrecoup injuries occur when the injury to the brain occurs on the opposite side of where the head was hit, such as in whiplash injuries (Zhang, Yang & King, 2004). Forces may also be further classified as linear or rotational. Linear forces are forces that act in a straight line, where rotational forces may act in a spiral motion. In theoretical models, it has been theorized that rotational forces would lead to the greatest neurobehavioral impairments (Barth, Freeman, Broshek, & Varney, 2001). This is thought to be due to the rotational forces inducing shear-inducing tissue damage (Adams, Graham, Murray, & Scott, 1982; Gennarelli et al., 1982; Unterharnscheidt & Higgins, 1969). Some studies have found that rotational forces may result in loss of consciousness more often than linear forces (Ommaya & Gennarelli, 1974). Similarly, the magnitude of the force may also play a role in the injury occurrence and presentation as well.

To date there is no empirical consensus on a biomechanical threshold that is associated with SRC. In a small sample of concussed high school football players, Broglio and colleagues (2010) reported that a concussion was more likely to occur when a linear force that is 96.1g or greater when paired with rotational acceleration that exceeded 5582 rad/s2, and the impact occurred on the front, side or top of the helmet (Broglio et al., 2010). However, no absolute threshold has been identified and this finding is only useful in identifying those who are at a risk of concussion due to a high magnitude impact (Eckner, Sabin, Kutcher, & Broglio, 2011). The aforementioned forces lead to pathophysiological changes at the molecular level inside the brain.

Pathophysiology of Concussion

The biomechanical mechanism of concussion leads to a cascade of neurometabolic events. It should be noted that the majority if studies investigating the pathophysiology of concussion have been done in animal models. Though they provide a likely comparison, it is a limitation to this research. Firstly, the initial impact initiates an ionic flux and glutamate release. As potassium leaves the neurons, sodium and calcium inter the cell due to mechanoporation of lipid membranes (Katayama, Becker, Tamura, & Hovda, 1990; Takahashi, Manaka, & Sano, 1981). This leads to the depolarization of the neurons. The depolarization causes the active transportation pumps to work overtime to restore homeostasis after the initial ionic flux (Yoshino, Hovda, Kawamata, Katayama, & Becker, 1991). During this time, cerebral blood flow is decreased. Because active transportation pumps utilize adenosine triphosphate (ATP) to move the ions, the demand for energy is high, while supply is low. Calcium influx may persist longer than sodium and potassium flux, which leads to a buildup of calcium in the cells. High levels of calcium around the mitochondria leads to mitochondrial dysfunction, which further exacerbates the energy crisis.

The biomechanical forces also have negative effects on the microstructural components (e.g., dendritic arbors, axons, and astrocytic processes). Calcium influx in axons leads to the phosphorylation of side arms and loss of structural integrity of the axons (Pettus & Povlishock, 1996), as well as proteolytic damage to the subaxolemmal spectrin and other cytoskeletal components (Büki & Povlishock, 2006). Microtubule disruption due to the axonal stretching may lead to decreased bidirectional axon transportation and even disconnection (Büki & Povlishock, 2006).

Axons are vulnerable to biomechanical stretching, which leads to permeability of the axon (Pettus, Christman, Giebel, & Povlishock, 1994). Disconnection can follow damage to the neurofilaments and microtubules; however, disconnection does not always cause death of the cell. Shrinkage and atrophy are typical, leading to a loss of functionality of the cell (Singleton, Zhu, Stone, & Povlishock, 2002). Unmyelinated axons are particularly vulnerable to these forces. Myelination is an ongoing maturational process in developing brains (Reeves, Phillips, & Povlishock, 2005). This may a possible mechanism for why youth are more susceptible to concussions; however, this is only conjecture and further evidence is needed to attribute lack of myelination to the source of susceptibility.

The injury is also known to alter neurotransmission. Changes in the glutamate receptors (NMDAR) lead to changes in activation of CaMKII, ERK, CREB, and BDNF (Atkins, Falo, Alonso, Bramlett, & Dietrich, 2009; Griesbach, Gómez-Pinilla, & Hovda, 2007). More importantly to the current study, the excitatory/inhibitory balance of GABA is disrupted post-injury (Lowenstein, Thomas, Smith, & McIntosh, 1992; Zanier, Lee, Vespa, Giza, & Hovda, 2003). GABA is a neurotransmitter that plays an important role in sleep cycles.

In both more severe and mild cases of traumatic brain, the injury has been found to upregulate cytokines and inflammatory genes in some studies (Giza & Prins, 2006; Li, Lee, Cai, Sutton, & Hovda, 2004). Researches coined the term “immunoexcitotoxicity” after theorizing that glutamate release was related to the activation of immune receptors to oxidative stress and hypothetical later cell injury (Blaylock & Maroon, 2011).

Models show that cellular death after concussion is rare (Gurkoff, Giza, & Hovda, 2006; Lyeth et al., 1990; Prins, Hales, Reger, Giza, & Hovda, 2010); however, it is theoretically possible that there is a higher risk for cell death after subsequent concussions (Giza & Hovda, 2014). Functional impairment has been well documented to be more significant after subsequent injuries (DeFord et al., 2002; Longhi et al., 2005; Prins et al., 2010). The aforementioned neurometabolic events present as a multitude of signs, symptoms, and impairments.

Signs and Symptoms

Concussions present differently and uniquely in each individual. Therefore, researchers and clinicians have developed different methods of classification to encompass different presentations of symptoms. Researchers conducted statistical analyses to cluster 20 of the 22 symptoms listed in the post-concussion symptom scale into four main factors. The groups include cognitive-migraine-fatigue (e.g., headache, dizziness, fatigue, drowsiness, sensitivity to light, sensitivity to noise, fogginess, feeling slowed down, difficulty concentrating, and difficulty remembering), affective (e.g., feeling sad, nervous, and more emotional), somatic (e.g., vomiting and numbness), and sleep (e.g., trouble falling asleep and sleeping less than usual) (Kontos et al., 2012). Physical signs of concussion, such as loss of consciousness and amnesia, are often mistaken as diagnosis criteria for concussion but are frequently absent in the injury (McCrory et al., 2017a). In conjunction with the signs and symptoms, concussed athletes also experience impairments. Impairments often noted with concussion include neurocognitive function, vestibular, ocular motor impairment (Ellemberg, Leclerc, Couture, & Daigle, 2007; Ellis et al., 2015).

Concussion Assessment

Many of the recent consensus statement propose using a multimodal approach to assess concussion, rather than only assessing symptoms (McCrory et al., 2009, 2017b; McCrory, Meeuwisse, Aubry, Cantu, Dvorak, et al., 2013). The multimodal approach includes utilizing multiple assessments that capture multiple aspects of the injury (e.g., vestibular/oculomotor, balance, neurocognitive, signs and symptoms). One important component of a multimodal assessment of concussion is neurocognitive function. Neurocognitive assessments offer a way to quantify deficits (Schatz & Zillmer, 2003).

Many neurocognitive assessments were created to offer a more objective measure of cognitive impairments (e.g., Stroop Color Word Test, Trails A and B, Controlled Oral Word Association, Wechsler Letter Number Sequencing, Wechsler Digit Span: digits forward and digits backwards, Symbol Digit Modalities Test, Paced Auditory Serial Addition Test). Historically, neurocognitive assessments were administered via paper and pencil; however, computerized neurocognitive assessments eliminate inter-rater and intra-rater reliability concerns (Aubry et al., 2002). Moreover, CNT may provide a less time-consuming option compared to paper and pencil neurocognitive assessments (Schatz & Zillmer, 2003). Broglio and colleagues (2007) compared a brief paper and pencil and computerized neurocognitive assessments (e.g., Immediate Post-Concussion Assessment, HeadMinder Concussion Resolution Index) and reported that the computerized neurocognitive tests were most sensitive at detecting concussion compared to the paper and pencil test (Broglio, Macciocchi, & Ferrara, 2007). Computerized neurocognitive assessments offer components such as attention span, working memory, sustained and selective attention time, non-verbal problem solving and reaction time (“About | Concussion Management | ImPACT Applications Inc.,” n.d.). These assessments offer a more objective measure for sports medicine professionals to assess and manage the injury.

Concussion Management and Treatment

Currently, the recommended approach for concussion management includes a multidisciplinary team. The multidisciplinary team may include a physician or neuropsychologist, physical therapist, vestibular therapist, athletic trainer, optometrist or ophthalmologist, speech or language pathologist, clinical or sport psychology professional, and occupational therapist, depending on the clinical needs of the athlete (Collins et al., 2014). The team works together to implement a treatment plan that is created by the neuropsychologist. Each member focuses on their own domain of the recovery, for example, the vestibular therapist would focus on impairments to the vestibular system by working on balance, and an optometrist might focus on ocular dysfunctions with tandem eye movement.

Due to the heterogeneity of the injury, Dr. Michael Collins, a clinician in the field, has outlined clinical trajectories to better classify the presentations, and to assist in creating treatment plans that are catered to the individual needs of the athlete (Collins et al., 2014). These clinical trajectories include vestibular, ocular, cognitive, migraine, anxiety/mood, and cervical (Collins et al., 2014). Dr. Collins and colleagues also provide suggested treatment of each trajectory based on clinical experience. For example, vestibular therapy as treatment for concussed athletes that present with vestibular impairments. Vestibular therapy may involve physical therapy with balance and stabilization. Ocular therapy may focus on tandem eye movement and tracking. Therapies that address cognitive fatigue include reducing cognitive and physical loads. Treatment for both anxiety/mood and migraines post-injury include increasing physical activity, and prescription medications that target symptoms (Collins et al., 2014). Patients that present with neck pain and headaches fit the cervical clinical trajectory and call for treatments such as range of motion exercises, traction, cervical and thoracic mobilization, and pain management

(Collins et al., 2014). One easy, free, global treatment for virtually all clinical trajectories is behavioral regulation.

Behavioral Regulation and Concussion

Recently, clinicians have suggested prescribing behavioral regulation upon concussion diagnosis (Collins et al., 2014). Behavioral regulation is the concept of a set daily schedule, covering 5 domains: nutrition, hydration, stress, exercise, and sleep (Womble & Collins, 2016). Aspects of behavioral regulation have been found to improve other disorders and symptoms that are often comorbid with concussion (e.g., migraine, depression and sleep disorders) (Alvaro et al., 2013; Calhoun & Ford, 2007; Smitherman et al., 2016). Prescribed sleep regulation outlines a sleep schedule (7-9 hours of sleep per night) with good sleep hygiene and no napping (Collins et al., 2014). However, sleep is often negatively affected after injury (Parcell et al., 2006a), and the regulation prescription does not take into account athletes' preexisting napping behaviors. Furthermore, there is currently no evidence that a regulation prescription is advantageous for concussion recovery.

Sleep and Napping

Sleep is defined as the state where voluntary motor activity is decreased, while one is also less sensitive to stimuli, and physically has a stereotypic posture. Sleep is distinguishable from other forms of unconsciousness such as a coma by the fact that it is easily reversible and self-regulating (Fuller, Gooley, & Saper, 2006). Sleep consists of four stages. Stage 1 includes the fading of conscious awareness, as the individual consequently becomes less aware of external environment. The electroencephalogram (EEG) slows with presence of oscillations typically 4-7 Hz in the theta range. Stage 2 is dictated by the complete loss of conscious awareness. Sleep spindles and k-complexes are present on EEG in stage 2. Stage 3 still has spindles; however, it also has high-voltage activity that is deemed "deep sleep" and the presence of delta waves on

EEG. Stage 4, the final stage of sleep, no longer has the presence of spindles on EEG, but does still retain the slow delta waves (Fuller et al., 2006). The average length of time spent in each stage of sleep is dependent on the age of the individual amongst other factors (Ohayon, Carskadon, Guilleminault, & Vitiello, 2004).

There are many conflicting reports of how much sleep is necessary per individual. Overall recommendations vary from 7-9 hours of sleep per night for young adults, ages 18-25 years, though 6-11 hours maybe appropriate depending on the individual ("National Sleep Foundation Recommends New Sleep Times," n.d.; Ohayon et al., 2004). Sleep is a complex process that involves multiple regions of the brain and neurotransmitters.

The sleep/wake cycle is controlled by multiple mechanisms and stimuli. The anterior hypothalamus houses the ventrolateral per-optic nucleus (Yaremchuk & Wardrop, 2011). The ventral posterior nucleus of the hypothalamus (VPN) releases gamma-aminobutyric acid (GABA) and Galanin, which inhibit the neurons of the ascending reticular activating system (ARAS), which causes wakefulness. Therefore, VPN causes sleepiness by inhibiting ARAS, an arousal inducing neurotransmitters (e.g., serotonin, adenosine, and prostaglandin) (Yaremchuk & Wardrop, 2011).

Circadian rhythm controls the sleep/wake cycle. Circadian rhythm is organized by the suprachiasmatic nucleus or nuclei, a small region of the brain above the optic chiasm, above the hypothalamus (Czeisler et al., 1999). Circadian rhythm is the cycle of sleep markers such as core body temperature and melatonin secretion by the pineal gland (Benloucif et al., 2005). Light and darkness influence the release of neurotransmitters that control the circadian rhythm. Ganglion cells in the retina tell the anterior hypothalamus and the suprachiasmatic nucleus (SCN) that communicate to the pineal gland, which releases melatonin. SNC also controls body temperature, cortisol, melatonin and thyroid hormone production (Yaremchuk & Wardrop, 2011). Sleep may change after sustaining a concussion.

It is evident in the literature that sleep is negatively affected post-concussion. There is overlap in the neurotransmitters effected by concussion and the neurotransmitters that affect sleep. GABA is down-regulated post-injury (Lowenstein et al., 1992; Zanier et al., 2003) and is also known as a sleep-promoting neurotransmitter (Yaremchuk & Wardrop, 2011). Problems with sleep quality and quantity have been shown in the literature to negatively affect neurocognitive function.

Sleep is a necessary process that helps the brain store short-term and long-term memory. In multiple studies, participants perform markedly worse on neurocognitive assessments, symptom report and impairments after sleep deprivation (Beebe et al., 2017; Russo et al., 2003; Sufrinko et al., 2016). Due to this effect, participants may perform poorly on measures typically used to assess concussion solely due to lack of sleep. In cases where nighttime sleep is lacking, people often sleep during the day to make up for lost time.

Napping is defined as sleep that occurs during the day, or outside of the normal habitual sleeping times as part of a polyphasic sleeping schedule (Morin & Espie, 2011). Most humans are monophasic, meaning humans habitually partake in a single episode of consolidated sleep rather than fragmented bits of sleep over 24 hours, like most other mammals (Morin & Espie, 2011). Naps that last between 5 and 15 minutes are the most cognitively beneficial, with effects lasting up to 3 hours (Lovato & Lack, 2010). In contrast, naps greater than 30 minutes have been found to have detrimental effects due to sleep inertia (a physiological state of cognitive impairment after waking that persists during the transition from sleep to wake) (Lovato & Lack, 2010). Napping has been found in numerous studies to improve subjective alertness (Gillberg et al., 1996; Hayashi, Ito, & Hori, 1999; Hayashi, Watanabe, & Hori, 1999; Tamaki, Shirota, Hayashi, & Hori, 2000; Taub, 1979), objective alertness on EEG (Gillberg et al., 1996; Hayashi, Ito, et al., 1999; Hayashi, Watanabe, et al., 1999; Tamaki et al., 2000; Taub, 1979), reaction times (Taub, 1979), and short-term memory performance (Gillberg et al., 1996; Hayashi, Watanabe, et al., 1999; Tamaki et al., 2000; Taub, 1979). In contrast, napping has also been correlated to poorer night-time sleep (Buboltz et al., 2001).

In previous studies, napping has been measured by various methods. One method used by researchers in the past has been by pairing validated sleep scales such as the Pittsburgh Sleep Quality Scale and invalidated napping self-report scales such as the Napping Behavior Scale (Ye et al., 2015a). Other sleep and napping scales include an after-nap questionnaire (three item survey that measures the length and quality of nap) and the Pictorial Sleepiness Scale (Maldonado, Bentley, & Mitchell, 2004; Smith, Kilby, Jorgensen, & Douglas, 2007). Studies utilized EEG during prescribed napping (Tamaki et al., 2000), actigraphy (Beecroft et al., 2008), bed occupancy sensor (Merilahti et al., 2007) and observation of the activity (Edwards & Schuring, 1993). Another study found that in children, sleep diaries and actigraphy were reliable to measure sleep start, sleep end and assumed sleep, but actigraphy is more reliable at measuring nocturnal wake times. Questionnaires were also reported as a reliable method of measuring sleep in children (Werner, Molinari, Guyer, & Jenni, 2008). Sleep and napping are relevant components of concussion recovery and treatment; however, they are often overlooked in the literature.

Concussion and Sleep

Sleep is negatively affected post-concussion. Kaufman and colleagues (2001) reported that in a preliminary sample, 19 adolescents reported chronic sleep disturbances after sustaining a mild head injury (Kaufman et al., 2001). Parsons and colleagues (1982) reported that in a sample of 75 adolescents and young adults (16-30 years) subjects reported significantly worse sleep quality and increased sleep complaints after sustaining a head injury (Parsons & Ver Beek, 1982). Moreover, Gosselin and colleagues (2009) reported that in a sample of athletes that had a history of multiple concussions and a sample of healthy controls, the previously concussed athletes reported significantly more symptoms and worse sleep quality. No between –group differences were found on polysomnographic variables on REM and NREM sleep quantitative EEG variables. Athletes in the concussed group showed significantly more delta activity on EEG and significantly less alpha activity during wakefulness compared to controls (Gosselin et al., 2009). The previous literature supports that sleep is negatively affected after sustaining a concussion.

Methods

Design

Two different designs were used for this study. Aim one and exploratory question one used a descriptive design. Aim two used a post-test only research design.

Participants

Participants included male and female athletes 18 – 29 years that were currently participating in varsity and/or club/intramural football, soccer, ice hockey, rugby, basketball, baseball, cheerleading, lacrosse, volleyball, or softball from 10 universities in the U.S. Inclusion criteria for Aims 1 and 2 required that the athlete was an intramural, club or varsity sport participant, in the study age range, and provide consent to participate. Exclusion criteria for Aims 1 and 2 included athletes that did not speak English. Inclusion criteria for Exploratory Question 1 consisted of sustaining a medically diagnosed sport-related concussion (i.e., by a certified athletic trainer or physician) and exclusion criteria included a history brain surgery, neurologic disorder, substance abuse, psychiatric disorder, and/or positive brain imaging findings. Athletes who self-report a history of sleeping disorders (e.g., insomnia, obstructive sleep apnea, narcolepsy, etc.) will be excluded from this study.

Measures/Instrumentation

Demographic Intake form. A short 10-item demographic intake form was created to make sure all participants meet inclusion and exclusion criteria for this study. Athletes were asked their age, sex, English speaking, caffeine intake, history of brain surgery, neurologic disorders, substance abuse, psychiatric disorder, positive brain imaging findings and sleep disorders (See Appendix A).

Pittsburgh Sleep Quality Index (PSQI). The PSQI is a validated 19-item questionnaire specifically designed to retrospectively measure sleep quality and quantity in clinical populations. It has a sensitivity of 89.6% and a specificity of 86.5% (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). This measure is scored on different components such as subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Each component is based on answers to different questions. A global score is used to identify overall sleep quality. If the global score is five or above, sleep quality is considered poor. This measure was recently used in studies on similar populations (Cheng et al., 2012; Taylor, Bramoweth, Grieser, Tatum & Roane, 2013). (See Appendix B).

The Short Napping Behavior Scale (SNBS). The SNBS is a 6-item napping behavior questionnaire designed to assess napping behavior among (Lovato, Lack & Wright, 2014). The short napping behavior scale includes items regarding the characteristics of naps such as frequency, duration, time of day when any naps are taken and the reason for napping (Lovato, Lack & Wright, 2014). This measure has previously been used in college students, ages 18-22 (Lovato, Lack & Wright, 2014) (See Appendix C).

Post-Concussion Symptom Scale (PCSS). The PCSS is a 22-item survey, that can be found as a component of the Sport Concussion Assessment Tool, a validated assessment that is widely endorsed by concussion consensus papers (McCrory et al., 2005; McCrory, et al., 2009; McCrory, et al., 2013; McCrory et al., 2017). The PCSS allows athletes to rate current concussion-related symptoms on a Likert scale from 0 to 6 (See Appendix D).

Patient Health Questionnaire- 9 (PHQ-9). The PHQ-9 is a 9-item questionnaire that has been validated to assess depression in adult populations. It has a sensitivity of 98% and specificity of 80% (Löwe et al., 2004) (See Appendix E).

Generalized Anxiety Disorder-7 (GAD-7). The GAD-7 is a 7-item questionnaire that has been validated to assess anxiety in adult populations. It has a sensitivity of 89% and specificity of 82% (Spitzer, Kroenke, Williams, & Löwe, 2006)(See Appendix F).

Procedures

Institutional Review Board (IRB) permission was obtained prior to any research activity. Permission from the participating school administrators, coaches, and athletic trainers was obtained prior to data collection. After obtaining permission, the researcher used one of two approaches. For universities within driving distance, the researcher arranged for a meeting with each varsity and/or club/intramural team and discuss study participation with the athletes. For universities that were too far to meet in person, the athletes received a link to a recruitment video and the online survey through their school email. Athletes were given the opportunity to provide consent. Athletes were then instructed to complete the demographic intake form to determine study eligibility. Athletes who do not meet inclusion/exclusion criteria were excluded from the study. Athletes were also given the PSQI (~3 minutes) and the SNBS (~1 minute). Athletes that sustained a medically diagnosed sport-related concussion during the season were asked by the athletic trainer if they could be contacted by the researcher. If they provided permission and their contact information, they were contacted by the researcher and recruited for participation in part two of the study. For part two, athletes filled out the demographic intake form, and were given the SNBS and Post-Concussion Symptom Scale either over the phone or in person one-week post injury (+/- 2 days). This period was chosen in order to assess napping during active injury. The athletes' time to recovery was recorded based on information provided by the medical professional making RTP decisions.

Statistical Analysis

Inspection of data for accuracy and completeness. Two researchers inspected fifteen percent of the sample, chosen at random, to verify accuracy and completeness. Data was analyzed utilizing SPSS version 24. Statistical significance was set at ($p \leq .05$).

Evaluation of Aims and Hypotheses

Aim 1: To describe napping behaviors in collegiate athletes. Aim one was addressed using descriptive statistics (e.g., means, standard deviations, frequencies, and percentages). All participant responses to each of the items on the SNBS was described and responses was also categorized across different demographic variables (e.g., sex) if available.

Aim 2: To examine the relationship between napping and sleep quality and quantity in collegiate athletes.

Hypothesis 1: Napping behavior will be negatively related to sleep quantity in non-concussed collegiate athletes. A chi-square test of independence was conducted to examine the association between napping behavior (non-nappers, nappers) and sleep quantity (below or at/above recommend quantity). Statistical significance was set at ($p \leq .05$).

Hypothesis 2: Napping behavior will be negatively related to sleep quality in non-concussed collegiate athletes. A chi-square test of independence was conducted to examine the association between napping behavior (non-nappers, nappers) and sleep quality ($\leq$ 4 on PSQI and $\geq$5 on PSQI). Statistical significance was set at ($p \leq .05$).

Exploratory Question

Exploratory Question 1: What is the frequency of post-concussion napping behavior in college athletes with concussion? Exploratory question 1 was addressed using descriptive statistics (e.g., means, standard deviations, frequencies, and percentages). All participant responses to each of the items on the SNBS was described and responses were also categorized by subject.

Results

Study Recruitment

Fifty-one colleges were contacted by the researcher about participating in the study. Twenty-two universities responded, and 12 signed the IRB authorization agreement. However, ten universities distributed the survey. In an effort to calculate a response rate, the researcher obtained varsity athlete rosters from each of the ten participating universities' athletic department websites. The researchers assumed that the online rosters were up to date and that all athletes were emailed the survey. Based on these calculations, 1,460 collegiate athletes were emailed the survey. A total of 281 responses were collected, yielding a 19% (281/1460) response rate. Approximately 17% (48/281) of the sample was excluded from the study based on exclusion criteria or incomplete survey responses. In an effort to gather data for Exploratory Question 1, eight of the universities agreed to refer concussed athletes for post-concussion data collection.

Demographics of the Non-Concussed Sample

The final sample included 233 non-concussed college athletes. The sample was comprised of 42.1% (98/233) males and 57.9% (135/233) females. Average age was 19.93 years (± 1.40; Range = 18-26). These athletes were current participants in basketball (10.3%), football (2.2%), soccer (21.6%), baseball (1.7%), rugby (3.9%), field hockey (7.8%), cross country (12.1%), track and field (15.9%), lacrosse (5.2%), volleyball (12.5%), and "other" (6.9%). Mean age of nappers was 19.7 (± 1.32), and the mean age of non-nappers was 20.4 (± 1.49).

Evaluation of Aim 1: To describe napping behaviors in collegiate athletes.

One hundred percent (233/233) of participants in the sample completed the SNBS. Seventy-four percent (172/233) of healthy collegiate athletes reported napping (i.e., Do you ever nap during the day?). Eighty-one percent (109/135) of females reported napping and 64% (63/98) of males reported napping. Females were 2.3 times more likely to report napping than

males (χ^2 (1) = 7.96, *p* = .005, 95% CI = 1.29 – 4.22). Sex was not a significant risk factor for sleep quality (χ^2 (1) = 2.46, *p* = .62) or sleep quantity (χ^2 (2) = .25, *p* = .12). The majority of nappers (51%, 86/170) reported napping one to two days per week, and 61% (104/171) of the sample reported napping between the hours of 2:00-4:00 P.M. The majority of the napping sample reported taking naps for approximately 45-60 minutes (52/168). None of the participants reported napping less than 15 minutes for a single nap. Approximately 66% (113/171) of the sample indicated that the top reason for napping was "feeling sleeping during the day."
A complete description of participant responses for the SNBS is presented in Table 1.

Table 1. Percentage of Responses for Napping Frequency, Time of Day, and Length in non-concussed collegiate athletes.

		n	%
Napping frequency (days/week) (*n* = 170)			
	< 1	19	11%
	1-2	86	51%
	3-4	42	25%
	5-6	16	9%
	>6	7	4%
Time of nap (*n* = 171)			
	8-10 AM	10	6%
	11-1 PM	45	26%
	2-4 PM	104	61%
	5-7 PM	11	6%
	8-10 PM	1	1%
Nap Length (minutes) (*n* = 168)			
	<15	0	0%
	15-30	31	18%
	30-45	42	25%
	45-60	52	31%
	>60	43	26%

Ninety four percent (219/233) of the respondents completed the PSQI. Only 32% (70/219) of participants reported "good" sleep quality (PSQI scores > 5). Twenty four percent (36/149) of athletes that reported good sleep quality also reported napping behavior on the SNBS. Furthermore, 33% (77/236) of the sample failed to meet the minimum 7 hours of sleep recommended for this age group, and 2% (6/236) slept more than the maximum recommended 9 hours of sleep.

Evaluation of Aim 2

Hypothesis 1- Napping behavior will be negatively related to sleep quantity in non-concussed collegiate athletes. The results of a chi-square test of independence revealed no association between napping behavior (non-nappers, nappers) and sleep quantity (below or at/above recommend quantity) (χ^2 (2) = .23, p = .64) (See Table 2).

Table 2. Napping and sleep quantity in the healthy sample (*n*= 236).

	< 7 hours of sleep	≥7 hours of sleep	Total
Nappers	59	117	176
Non-nappers	18	42	60
Total	77	159	236

Hypothesis 2- Napping behavior will be negatively related to sleep quality in non-concussed collegiate athletes. The results of a chi square test of independence analysis revealed no association between napping and sleep quality (good quality or bad quality per the PSQI) (χ^2 (1) = .42, p =.52) (See Table 3).

Table 3. Napping and sleep quality in the non-concussed sample (*n* = 214).

	Poor Sleep Quality	Good Sleep Quality	Total
Nappers	109	49	158
Non-nappers	36	20	56
Total	145	69	214

Evaluation of Exploratory Question 1: To describe napping behavior in the concussed sample.

Nine concussions occurred during the study and six concussed athletes agreed to participate a successfully recruited and met inclusion criteria. Sports medicine professionals that managed these injuries did not advise against napping. Four of the six athletes reported napping during the first week following concussion. Athletes that napped, all reported napping at least 30 minutes in length. Average days to recovery from concussion was 15.67 days (± 7.71) (see Table 4).

Table 4. Napping behaviors and symptom scores throughout seven days post injury in a concussed sample and days to recovery (*n*=6).

	Nap	Nap frequency	Nap Length (minutes)	Sleep symptom score out of 12	Overall symptom severity score (out of 132)	Recovery length (days)
Subject 1	Yes	5-6 days	<60	3	31	22
Subject 2	Yes	1-2 days	45-60	0	2	15
Subject 3	Yes	1-2 days	30-45	0	16	24
Subject 4	No	0	n/a	9	42	20
Subject 5	No	0	n/a	6	9	6
Subject 6	Yes	3-4 days	45-60	4	42	7

Discussion

General Discussion of the Results

This study examined napping behaviors and sleep quality and quantity in collegiate athletes. The primary finding of this study is that higher napping frequency was not correlated with worse sleep quality scores. This finding suggests that athletes may not need to avoid napping in fear of negative effects on nighttime sleep. A secondary finding of this study was that napping behaviors were not correlated with sleep quantity. Post-concussion findings were not conclusive due to a small sample size.

Examining Sleep and Napping

Napping prevalence appears to differ across differ in the literature. In the present study, 73.8% of the sample reported napping. This is within the percentages that have previously been reported in similar studies that ranged from 54%- 75% (Lovato, Lack, & Wright, 2014; Ye, Hutton Johnson, Keane, Manasia, & Gregas, 2015b). Lovato and colleagues (2014) examined napping in Australian college students and reported that only 54% of their sample napped at least 1-2 times per week. They also reported that there was no significance between napping and subjective nighttime sleep quality; however, they did not use a validated sleep quality measure like the present study, but rather asked participants to report the occurrence of a good quality nighttime sleep (e.g., never, sometimes, often, usually, or always). The present study addressed this limitation by utilizing the PSQI.

Sleep quality has been measured in various ways in the literature. The PSQI in particular has been used in previous studies and in similar populations. In the current study, healthy collegiate athletes that reported napping did not also have poor nighttime sleep quality or quantity, which did not support hypotheses 1 and 2. These finding are not in concordance with other researchers that also reported similar findings for individuals that engage in napping. Tsai and Li (2004) reported that longer naps were correlated with poor nighttime sleep quality and increased awakenings at night (Tsai & Li, 2004). Another previous study by Ye and colleagues (2015) reported that sleep quality significantly differed among napping frequency and nap length (Ye et al., 2015b). Some causes for the variation in findings are that they are different age groups, populations, and cultures. Due to small sample size, findings for post-concussion napping patterns are not conclusive. Previous literature supports that sleep is commonly disturbed post-concussion (Sandsmark, Elliott, & Lim, 2017; Singh, Morse, Tkachenko, & Kothare, 2016). There is a lack of literature over napping behaviors in concussed samples; however, it could be assumed that napping rates would be similar or higher to that of baseline rates in cases where athletes were not advised to avoid napping by sports medicine professionals.

Implications

Anecdotally, sports medicine professionals may advise non-concussed and concussed athletes not to nap. The results of this study suggest that napping has no effect on nighttime sleep quality or quality; therefore, clinicians may consider the athletes normal napping behaviors prior to advising them not to nap post-concussion.

Limitations

There are several limitations to this study. First, all of the measures used in this study relied on retrospective self-report of measures of sleep and napping behaviors. It is assumed that athletes reported accurately and honestly on all self-report measures. Lastly, the sample size for Exploratory Question 1 was small. After running an A priori power analysis to determine an appropriate sample size for hypothesis 4, a sample size of 104 is needed. Relationships established between variables cannot be inferred as causal due to the nature of the study.

Future Research

Future research should continue to explore the effects of napping on post-injury sleep. An increase in sample size is needed to further understand these relationships. In addition, utilizing objective methods (e.g., EEG and actigraphy) of obtaining sleep and napping behaviors would be preferred over self-reported measures. Lastly, future research should investigate the effect of daytime napping post injury on recovery times.

Conclusions

The results of this study did not support the hypotheses that napping negatively affected nighttime sleep quality and quantity. The results of the current study suggest that sports medicine professionals may consider allowing athletes to nap without concern of negative effects on nighttime sleep quality and quantity.

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Supplemental Analyses

Generalized Anxiety Disorder-7 assessment and findings. The mean GAD-7 score for athletes was 4.21 (± 4.27). Athletes that scored a 10 or higher on the GAD-7 were 5.39 times more likely to have poor sleep quality (χ^2 (2) = 6.03, *p* = .01, 95% CI = 1.22-23.88). The results of a chi-square test of independence revealed no association between napping behavior (non-nappers, nappers) and anxiety (GAD-7 score of >9) (χ^2 (2) = .47, *p* = .49).

Patient Health Questionnaire-9 assessment and findings. The mean PHQ-9 score for non-concussed athletes was 5.11 (± 4.68). Athletes that scored a 5 or higher on the PHQ-9 were 6.65 times more likely to have poor sleep quality (χ^2 (2) = 25.07, *p* = .00, 95% CI = 3.00-14.73). The results of a chi-square test of independence revealed no association between napping behavior (non-nappers, nappers) and depression (PHQ-9 score of ≥ 5) (χ^2 (2) = 1.53, *p* = .22).

A priori power analysis. *A priori* power analyses were conducted for the Spearman's Rho correlation in the original hypotheses 1, 2 and 3, and the logistic regression analysis in hypothesis 4 (listed below) to determine sample sizes required to achieve adequate statistical power. The effect sizes for interactions were used to calculate sample size using G-Power (F. Faul, Erdfelder, Buchner, & Lang, 2009) statistical software. Specifically, the effect sizes for *p* = 0.01 and *p* = 0.05 were calculated. The results of this power analysis can be found in Table 6.

Table 6.* A priori *power analyses.

Analysis	*p*	N
Hypothesis 1	.01	112
	.05	83
Hypothesis 2	.01	112
	.05	83
Hypothesis 3	.01	112
	.05	83
Hypothesis 4	.01	146
	.05	104

Original Aims and Hypotheses

Aim 1: *To describe napping behaviors in collegiate athletes.* Aim one was explored using descriptive statistics (e.g., means, standard deviations, frequencies, and percentages). All participant responses to each of the items on the SNBS was described and responses will also be categorized across different demographic variables (e.g., sex) if available.

***Aim 2*:** To examine the relationship between napping and sleep quality and quantity in collegiate athletes.

H1: Napping behavior will be negatively related to sleep quantity in non-concussed collegiate athletes. A Spearman's Rho correlation between average weekly napping frequency (0, 1-2, 3-4, 5-6, more than 6) and sleep quantity was not significant ($r_s(231) = -.095$, $p = .152$). Statistical significance was set at ($p \leq .05$).

H2: Napping behavior will be negatively related to sleep quality in non-concussed collegiate athletes. A Spearman's Rho correlation between average weekly napping frequency (0, 1-2, 3-4, 5-6, more than 6) was significantly correlated with sleep quality (PSQI score) significant ($r_s(221) = .14$, $p = .018$). However, when sleep quality was explored using a multiple regression model to control for depression and anxiety scores, napping was no longer a significant predictor of sleep quality (β =.142, *p*= .281), and independently explained very little of the variance in sleep quality (squared semi partial correlation = .004).

Aim 3: To investigate the effects of napping behaviors on sleep following concussion in college athletes.

*H3***:** Post-concussion napping behaviors will be negatively related to sleep quantity, in collegiate athletes with concussion. Due to a small sample size, this hypothesis could not be explored. In the future, with a larger sample, Spearman's rho correlation would be conducted to examine the association between post-concussion napping behavior (non-nappers, nappers) and sleep quantity (below recommended amount, at the recommended amount, and over the recommended amount). Statistical significance was set at ($p \leq .05$).

*H4***:** Post-concussion napping behaviors will be positively related to sleep-related symptoms in collegiate athletes with concussion. Due to a small sample size, this hypothesis could not be explored. In the future, with a larger sample, a logistic regression could be performed to examine the relationship between post-concussion napping (nappers, non-nappers) and post-concussion total symptom scores on the PCSS and the sleep-symptom cluster (e.g., trouble falling asleep and sleeping less). Statistical significance was set at ($p \leq .05$).

Exploratory Questions.

EQ1**:** Is pre-injury napping related to post-concussion napping behaviors?

EQ2: Does post-concussion napping influence clinical recovery outcomes in college athletes with sport-related concussion?

Due to a small sample size, original exploratory questions 1 and 2 were not assessed. Future research should investigate these variables with a larger sample size both at baseline and post-concussion.

Appendices

Appendix A: Demographics Page.

Name: ___________________________________Date: _______________ DOB: ____________

School: ________________________ Sport: ____________________ Age: _______ Sex: ______

Please Circle One:

Baseline Post-injury (if post-injury: DOI: _________)

1. Have you ever had brain surgery? Yes/No
2. Have you ever had positive brain imaging done (e.g. CT, X-ray, and MRI)? Yes/No
3. Have you ever been diagnosed with a neurologic disorder? Yes/No
4. Do you have a history or current substance abuse? Yes/No
5. Have you ever been diagnosed with a psychiatric disorder? Yes/No
6. Have you ever been diagnosed with a sleeping disorder (e.g., insomnia, obstructive sleep apnea, narcolepsy, etc.)? Yes/No
7. How often do you typically drink caffeine (e.g. energy drink, coffee, etc.)?
    a. More than once daily
    b. Once daily
    c. A couple of times a week
    d. Once a week
    e. Never
8. Specifically, in the past week how often have you had caffeine?
    a. More than once daily
    b. Once daily
    c. A couple of times a week
    d. Once a week
    e. Never
9. Have you ever been told by an Athletic Trainer or a medical professional not to nap? Yes/No

Appendix B: Pittsburgh Sleep Quality Index.

Name____ Date__________

Sleep Quality Assessment (PSQI)

What is PSQI, and what is it measuring?

The Pittsburgh Sleep Quality Index (PSQI) is an effective instrument used to measure the quality and patterns of sleep in adults. It differentiates "poor" from "good" sleep quality by measuring seven areas (components): subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month.

INSTRUCTIONS:

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

During the past month,

1. When have you usually gone to bed? ____________________
2. How long (in minutes) has it taken you to fall asleep each night? ____________________
3. What time have you usually gotten up in the morning? ____________________
4. A. How many hours of actual sleep did you get at night? ____________________
   B. How many hours were you in bed? ____________________

5. During the past month, how often have you had trouble sleeping because you	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
A. Cannot get to sleep within 30 minutes				
B. Wake up in the middle of the night or early morning				
C. Have to get up to use the bathroom				
D. Cannot breathe comfortably				
E. Cough or snore loudly				
F. Feel too cold				
G. Feel too hot				
H. Have bad dreams				
I. Have pain				
J. Other reason (s), please describe, including how often you have had trouble sleeping because of this reason (s):				
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				
9. During the past month, how would you rate your sleep quality overall?	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)

Scoring

Component 1	#9 Score	C1 ________
Component 2	#2 Score (<15min (0), 16-30min (1), 31-60 min (2), >60min (3)) + #5a Score (if sum is equal 0=0; 1-2=1; 3-4=2; 5-6=3)	C2 ________
Component 3	#4 Score (>7(0), 6-7 (1), 5-6 (2), <5 (3)	C3 ________
Component 4	(total # of hours asleep) / (total # of hours in bed) x 100 >85%=0, 75%-84%=!, 65%-74%=2, <65%=3	C4 ________
Component 5	# sum of scores 5b to 5j (0=0; 1-9=1; 10-18=2; 19-27=3)	C5 ________
Component 6	#6 Score	C6 ________
Component 7	#7 Score + #8 score (0=0; 1-2=1; 3-4=2; 5-6=3)	C7 ________

Add the seven component scores together ______________ *Global PSQI* ____________

A total score of "5" or greater is indicative of poor sleep quality.

If you scored "5" or more it is suggested that you discuss your sleep habits with a healthcare provider

Appendix C: Short Napping Behavior Scale.

A nap is a time during the day when you may doze or sleep regardless of whether you have planned to or not. A nap includes instances when you might fall asleep for a short while when watching TV or even reading a book.

1. Do you ever nap during the day? (Circle appropriate answer) YES/NO

If YES,

a) Across a typical week, on average how many days do you usually nap? (Circle the best answer)

Less than 1 1-2 3-4 5-6 More than 6

b) Are the naps usually planned in advance or are they usually spontaneous in that you usually take them on the "spur of the moment"? (Please circle just one)

1	2	3
Mostly planned	Some planned/Some spontaneous	Mostly spontaneous

c) What **time** does your nap(s) usually occur? (Please circle the most appropriate answer)

8am-10am 11am-1pm 2-4pm 5-7pm 8-10pm

d) About **how long** is your typical nap? (Please circle the most appropriate answer)

Less than 15minutes 15-30mins 30-45mins 45-60mins more than 60 mins

d) Do your naps usually end spontaneously or do you set an alarm to end the nap? (Circle one)

1	2
Spontaneously	Use alarm

f) Why do you usually nap? (Please circle the most appropriate answer)

- I feel sleepy during the day
- The nap refreshes me
- I have spare time
- To avoid feeling sleepy later in the day
- Other (Please specify below)

....

2. Do you feel that you get an adequate amount of night time sleep? (Circle one)

1	2	3	4	5
Never	Sometimes	Often	Usually	Always

Appendix D: Post-Concussion Symptom Scale

	None	Mild		Moderate		Severe	
Headache	0	1	2	3	4	5	6
“Pressure in head”	0	1	2	3	4	5	6
Neck pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
More emotional than usual	0	1	2	3	4	5	6
irritable	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or anxious	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Feeling like “in a fog”	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
“Don’t feel right”	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6

Appendix E: Patient Health Questionnaire-9.

PATIENT HEALTH QUESTIONNAIRE (PHQ-9)

NAME:______________________ DATE:____________

Over the last *2 weeks*, how often have you been bothered by any of the following problems?
(use "✓" to indicate your answer)

	Not at all	Several days	More than half the days	Nearly every day
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself—or that you are a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed. Or the opposite — being so figety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead, or of hurting youself	0	1	2	3
add columns		+	+	

(Healthcare professional: For interpretation of TOTAL, please refer to accompanying scoring card.) TOTAL:

10. If you checked off *any problems*, how *difficult* have these problems made it for you to do your work, take care of things at home, or get along with other people?	Not difficult at all	______
	Somewhat difficult	______
	Very difficult	______
	Extremely difficult	______

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Appendix F: Generalized Anxiety Disorder-7.

Over the last 2 weeks, how often have you been bothered by the following problems?	Not at all sure	Several days	Over half the days	Nearly every day
1. Feeling nervous, anxious, or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it's hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid as if something awful might happen	0	1	2	3
Add the score for each column	+	+	+	
Total Score *(add your column scores)* =				

Appendix G. Institutional Review Board Expedited Approval Letter.

UNIVERSITY OF ARKANSAS

To:	Robert J Elbin HPER 321-X
From:	Douglas James Adams, Chair IRB Committee
Date:	12/19/2017
Action:	**Expedited Approval**
Action Date:	12/19/2017
Protocol #:	1711084551
Study Title:	The Effect of Napping on Sleep Quality and Quantity in Healthy and Concussed Collegiate Athletes
Expiration Date:	12/14/2018
Last Approval Date:	

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

cc: Katie L Stephenson, Key Personnel
Mallory K McElroy, Key Personnel
Samantha Mohler Mohler, Key Personnel