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An examination of the association between traumatic brain injury and sleep disruptions among athletes in contact and non-contact sports

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AN EXAMINATION OF THE ASSOCIATION BETWEEN TRAUMATIC BRAIN INJURY AND SLEEP DISRUPTIONS AMONG ATHLETES IN CONTACT AND NON-CONTACT SPORTS

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For Nate.
Without your constant support and encouragement,
this would not have been possible.

Abstract

Traumatic brain injury (TBI) is a serious public health problem within the U.S. and accounts for a substantial proportion of deaths and disability in the U.S. population (Centers for Disease Control, 2016). Focus on TBI, which refers to a disruption of the normal functions of the brain due to a blow or jolt to the head, has risen dramatically due to the increased awareness of its high prevalence, particularly among individuals engaged in contact sports. There are many health implications of a TBI, one being that TBI increases the risk of a sleep disturbance in 30-70% of individuals (Viola-Saltzman, 2012). The current study examined the association between TBI among 176 collegiate and professional athletes (former and current) and their overall sleep patterns (i.e., overall sleep quality, sleep quantity, sleep apnea, insomnia, and narcolepsy). Specifically, we focused on the comparison of sleep patterns among athletes in contact sports (N = 132) versus those in non-contact sports (N = 44). Findings indicate strong associations between TBI and insomnia, sleepiness, apnea, and poor sleep quality, while contact sports were associated with sleep apnea. While TBI had a significant main effect on insomnia, sleepiness, and overall sleep quality, being in a contact sport had a significant main effect on the STOP-BANG measure of sleep apnea. However, there were no interaction effects between TBI and contact sports in the prediction of sleep patterns. These findings have implications for both professional and collegiate athletic programs, as well for health professionals who treat individuals with sleep disorders or a TBI.

Keywords: traumatic brain injury, sleep disturbances, athletes, contact sports

Introduction

Traumatic brain injury (TBI) accounts for a substantial proportion of deaths and disability in the U.S. population, contributing to approximately 30% of all injury-related deaths, and is among the serious public health problems in the U.S. (CDC, 2016). As defined by the Centers for Disease Control and Prevention (CDC), a TBI is a disruption of the normal functions of the brain due to a blow or jolt to the head. In recent years, the attention on TBI has risen dramatically due to the increased awareness of its prevalence, particularly among athletes, specifically accounting for 2.5 million hospitalizations, emergency visits, and deaths in the U.S. each year (CDC, 2016).

Tyler Sash was a 27-year old talented football player who died from an accidental pain medication overdose in September of 2015 (Pennington, 2016). Sash was playing for the University of Iowa throughout his college years and continuing to play the game at the professional level for the NFL team, the New York Giants. In 2011, Sash was suspended from the NFL for taking Adderall, which is a stimulant used to treat ADHD, as well as the sleep disorder narcolepsy (Youngmisuk, 2012). In the months before his death, he had reported to his mother that he was having difficulty sleeping. After his passing, an autopsy reported that he had been suffering from Chronic Traumatic Encephalopathy (CTE), a disease caused by repetitive traumatic brain injuries (Pennington, 2016; Yi, Padalino, Chin, Montenegro, & Cantu, 2013). As more and more cases like this emerge into the public eye, the attention on the effects of TBI increases as well. Researchers continue to look for more information on how to identify CTE in TBI patients, and more importantly how to help them. The effects of TBI can impair an individual’s quality of life and functioning in cognitive, physical, behavioral, social and occupational areas (CDC, 2016). Given the cognitive disruptions and other physical symptoms such as headaches and fatigue, it seems reasonable to expect individuals to have an increased risk for sleep disturbances (CDC, 2016).

In the current study, we examine the associations between TBI and overall sleep patterns among athletes. Specifically, we focus on the comparison of sleep patterns among athletes in contact sports versus those in non-contact sports, addressing a gap in the literature on TBI and sleep disturbances, especially the sparse literature on brain injury and specific sleep disturbances among an athlete population. This study would inform future researchers who seek to create specifically targeted intervention programs for college and professional athletes with differing classifications of TBI severity based on their specific sleep diagnosis.

Literature Review

Brain Injury Terminology

Injury to the brain can be classified in a multitude of ways, with each classification approach referring to a specific type of injury and the symptoms related to that injury. McKinlay, Bishop, and McLellan (2011) found that the terminology regarding brain injury is often inaccurately used, leading to a lack of public knowledge on the topic. Therefore, it is important to clarify terminology and criteria prior to an investigation on the subject.

As mentioned previously, the CDC defines a TBI as a disruption of the normal functions of the brain due to a blow or jolt to the head (CDC, 2016). There are various symptoms associated with TBI, and the type of symptoms a person shows and how long the symptoms last usually depend on the severity of the TBI. The CDC lists three classifications of TBI severity: mild, moderate, and severe (CDC, 2016). Most commonly, severity is initially classified using the Glasgow Coma Scale (Maas, Stocchetti, & Bullock, 2008), and depending on the severity, certain terminology can be used to describe the injury. In the case of a mild TBI, the term "concussion", as well as "minor head injury" or "minor brain injury" are typically used (McKinlay et al., 2011, p. 762).

Two additional terms that are commonly used when referring to brain injury are the DSM-5 diagnoses that often follow a TBI, namely "minor neurocognitive disorder" and "major neurocognitive disorder" (Simpson, 2014, p. 160). The term minor neurocognitive disorder refers to a *modest* decline from former cognitive abilities, enough to bring a concern to the individual or a clinician, but not enough to seriously impede the individual's everyday independence. In contrast, the term major neurocognitive disorder refers to a *significant* decline in cognitive abilities from the level the individual was previously at, enough to take away their independence (Simpson, 2014). Lastly, another classification of brain injury is Chronic Traumatic Encephalopathy (CTE). This term refers to a neurodegenerative disease resulting from multiple traumas to the brain, showing effects similar to that of various dementias. Symptoms include memory loss, difficulties with speech and motor tasks, as well as changes in behavior (Yi et al., 2013).

Prevalence of TBI

As noted earlier, there has been an increased focus on TBI in both the research and public populations in recent years (CDC, 2016). Of the discussions on TBI, the tie between contact sports and TBI has been a major focal point, especially after the recent publicity surrounding the neurodegenerative disease Chronic Traumatic Encephalopathy (CTE). The discovery of CTE resulted in negative publicity in the form of pushback from organizations such as the National Football League, as depicted in the 2015 film *Concussion*, as well as a public statement regarding CTE made by President Barack Obama in which he said, "I would not let my son play pro football" (Breech, 2014, p. 1). Gilchrist and colleagues (2011) further examined the connection between TBI and sports, finding that as more people continue to be involved in youth sports, the prevalence of TBI has increased as well. The CDC (2016) reported that in 2015, between 3.2 million and 5.3 million people had a disability due to a TBI in the United States alone. These injuries can result from an array of occurrences. Coronado and colleagues (2012) found that the majority of fatal TBIs in the United States are due to falls, motor crashes, or suicides. Of the TBIs that are non-fatal, Faul, Xu, Wald, and Coronado (2010) found that 35% are due to falls, 17% are due to motor accidents, and 17% result from a strike or blow to the head, for instance, those that occur in sport related injuries. Of the TBIs related to sports injuries, whether or not the sport is a contact sport plays a significant role in the occurrence of a TBI, with a higher rate of TBI seen in those who play contact compared to non-contact sports (Powell & Barber-Foss, 1999). With the high rates of TBI, it is important that the health consequences of TBI are examined and understood thoroughly.

Health Consequences of TBI

The types of problems experienced by TBI patients varies from person to person (Daneshvar et al., 2011). The health of the individual prior to TBI, the severity of symptoms experienced, and the patient's overall quality of life play a significant role in the problems that result from the TBI (Ulfarsson, Lundgren-Nilsson, Blomstrand, & Nilsson, 2014). The age at which a TBI occurs is also a determining factor in the short and long-term effects experienced. A TBI experienced earlier in life likely results in highly detrimental, lifelong problems for the individual, specifically affecting their intellectual abilities (Ewing-Cobbs et al., 2006). As one ages through adulthood, the outcomes of TBI worsen (Hukkelhoven et al., 2003).

Short-term effects. After experiencing a TBI, there are multiple symptoms that may be experienced by the individual, some of which are more frequently reported than others (Roberts & Roberts, 2011). Of these common symptoms, there are those that are psychological and those that are physical. For instance, a TBI patient may experience irritability, problems in concentration, difficulty in recalling memories, or changes in emotion, all of which are considered psychological symptoms. In addition to these symptoms, the individual may experience the physical symptoms of fatigue, a headache, dizziness, and problems sleeping (Roberts & Roberts, 2011). Although in most cases, people only have to endure these problems for days or weeks, there are instances where the symptoms may persist for months, or even years (Daneshvar et al., 2011).

Long-term effects. As described earlier, a TBI is classified as either mild, moderate, or severe, based on the symptoms expressed by the individual (CDC, 2016). In both moderate and severe TBI, there is an increased possibility that the symptoms can last for longer periods of time, sometimes resulting in permanent problems. In some cases, long-term problems are also seen in mild TBI (Dean & Sterr, 2013). Even in instances when a TBI was never diagnosed, long-lasting cognitive and health impairments are still seen in those who participate in contact sports, likely due to multiple minor traumas (Killam, Cautin, & Santucci, 2005). These enduring complications can have a major impact on the quality of life for the person affected, regardless of the type of TBI that was the source.

Like the short-term symptoms of TBI, long-term symptoms can be divided into psychological and physical, both of which may affect the other (Sarafino & Smith, 2014). Of those who experience long-term complications from a TBI, the development of psychological or neurological disorders is commonly reported by individuals and clinicians (CDC, 2016). Past research has also revealed that based on how the TBI impacts the frontal lobes of the brain, social and occupational functioning can be depleted (Rassovsky et al., 2006). Furthermore, in those with moderate and severe TBI, the frontal lobe damage is also linked to long-term deficits in memory, in particular, the ability to retrieve information (Vakil, 2005). Although long-term symptoms are typically seen in patients with moderate and severe TBI, specific symptoms that are associated with mild TBI, such as anxiety and decreased quality of sleep, are correlated with lasting cognitive deficits following the TBI (Dean & Sterr, 2013). In addition to these psychological symptoms, some commonly experienced long-term physical problems associated with TBI include motor problems, such as post-traumatic epilepsy, and sleep disturbances (CDC, 2016).

Sleep Disruption as a Symptom and Consequence of Health Problems

Sleep is one of the most important biological functions of the human body, playing a significant role in the overall health of the individual, contributing to the development of obesity (Spielgel, Tasali, Leproult, & Van Cauter, 2009), diabetes (Cappuccio, D'Elia, Strazzullo, & Miller, 2010), and even cancer (Blask, 2008). Recent studies have even gone as far as to label sleep patterns as a possible precursor to Alzheimer's disease (Lim, Gerstner, & Holtzman, 2014). Sleep is also very important in regards to mental health, considerably affecting learning and memory (Fowler, Sullivan, & Ekstrand, 1973). Furthermore, lack of sleep has been identified as both contributing to and being a consequence of various mental health problems, such as paranoia and hallucinations (Freeman et al., 2015), depression (Rosenstrom et al., 2012), and anxiety (Magee & Carmin, 2010). In 2010, sleep disturbances were reported by approximately one-third of the population in industrialized nations (Pigeon, 2010). Therefore, given the detrimental effects that sleep can have on one's physical and mental health and its prevalence, identifying and treating specific sleep disruptions is of upmost importance.

There are various types of sleep disruptions, each of which fits into a different category of sleep disorders. These categories include disorders falling and staying asleep (insomnia), difficulty staying awake (narcolepsy), difficulty breathing during sleep (apnea), and disruptive behaviors during sleep (nightmares, sleep terrors, sleepwalking; Sateia, 2014). The disorders that fit into the first three of these categories, as well as the overall quality and quantity of one's sleep (Pilcher, Ginter, & Sadowsky, 1997), are highly related to the individual's genetics, as well as their physical health.

Insomnia. The CDC lists insomnia as one of the primary sleep disorders that people face, defining it as the inability to initiate or maintain sleep (CDC, 2016). The diagnostic criteria for insomnia includes significant distress as a result of poor sleep quality or quantity, whether that is due to difficultly falling asleep, difficulty staying asleep, or waking up too early (APA, 2013). Insomnia is highly prevalent, with an estimated 10% of those in industrialized nations experiencing it persistently (Pigeon, 2010). Insomnia can be due to a variety of causes, from caffeine intake to mental health problems, and even physical health disruptions or problems.

Apnea. Another common sleep disruption is sleep apnea, described as disrupted breathing during sleep that disrupts one's sleep, typically seen in those who snore while sleeping (CDC, 2016). However, not all those who snore have apnea (CDC, 2016). The DSM-5 diagnosis describes the disorder as including breathing disturbances while sleeping that result in insufficient sleep, often followed by fatigue and daytime sleepiness (APA, 2013). Apnea is a major health concern and is not only used to help identify those at risk of developing cardiovascular disease, but is also a contributing factor to the progression of the disease itself, along with other health problems (Somers et al., 2008). The prevalence of sleep apnea is not as high as that for insomnia, yet given the health risks and implications of this disorder, 4.0% of males and 2.0% of females in the U.S. having apnea is still quite notable (Punjabi, 2008).

Narcolepsy. While both insomnia and apnea tend to result in daytime sleepiness in the individual affected, narcolepsy is a disorder that is characterized by excessive daytime sleepiness, often resulting in “sleep attacks” that cause the affected person to fall asleep at atypical times during the day (CDC, 2016). To receive a diagnosis of narcolepsy, the individual must experience an irresistible need to sleep at least three times a week, as well as one of the following: episodes of cataplexy, involuntary grimacing, hypocretin deficiency, or low amounts of REM sleep (APA, 2013). The effects of narcolepsy can be highly detrimental, affecting not only one’s energy level during the day, but also their social abilities and even their mental health (Daniels, King, Smith, & Shneerson, 2001). Therefore, it is crucial that all of the possible causes of narcolepsy be identified in order to better treat those who may suffer from this sleep disorder. Insomnia, sleep apnea, and narcolepsy, as well other sleep disruptions, can be the result of a large variety of causes, with one of the potential causes being TBI (Baumann, Werth, Stocker, Ludwig, & Bassetti, 2007). Although many associations between TBI and sleep disruptions have been made, it was not until recently that researchers began to look at this relationship in greater depth.

Associations between TBI and Sleep

It is estimated that of those who have suffered TBI, 30-70% will, in turn, suffer a disturbance in their sleep (Viola-Saltzman, 2012). How long the individual suffers from a TBI-induced sleep disturbance may vary, but Schreiber and colleagues (2008) found problems in sleeping patterns of minor traumatic-brain injury patients for years following the TBI. The types of problems experienced often include daytime sleepiness and an increased need for sleep among those suffering a TBI (Imbach, 2015). Huang and colleagues (2015) reported that in the month following a TBI, the most commonly reported sleep disturbances had to do with deficiencies in quantity and quality.

When looking at specific sleep disorders and their prevalence in those with TBI, Webster, Bell, Hussey, Natale, and Lakshminarayan (2001) found an increased frequency of sleep apnea in those who have suffered TBI compared to the normal rate of apnea in the general population. Furthermore, Castriotta and colleagues (2007) found that approximately 23% of TBI patients were found to have sleep apnea. Given that TBI is directly affecting the brain, it is possible that the specific structures affected by a TBI result in the increased occurrence of sleep apnea in those affected. In order to gain a better understanding of this, the brain structures associated with apnea should be examined. It has been found that the white matter of the brain is highly linked to apnea, as well as the axons linking the pons, frontal, temporal, and parietal cortices, and the projections to and from the cerebellum (Macey et al., 2008). In 2009, Sullivan found that the hippocampus is a highly sensitive area of the brain when it comes to TBI, showing the most changes in brain imaging compared to other brain structures. This is noteworthy when considering the finding that damage to the neurons of the hippocampus has been found to result in apnea, specifically childhood apnea (Halbower et al., 2006).

TBI has also been linked to narcolepsy, with 6% of people developing narcolepsy after suffering a TBI (Castriotta et al., 2007). The onset of narcolepsy is a result of neural loss in the hypothalamus, resulting in the lack of the hypocretin, the neurotransmitter associated with wakefulness (Dauvilliers, Arnulf, & Mignot, 2007). Therefore, it is not surprising that significant losses of hypocretin-producing neurons have been found in individuals after experiencing a TBI (Baumann et al., 2009), making the possible connection between TBI and narcolepsy.

While it is well documented that insomnia is prevalent in individuals who have suffered a TBI, examining how the brain is influenced by both insomnia and TBI helps to understand how these factors are related (Ouellet, Beaulieu-Bonneau, & Morin, 2006). While insomnia can result from an array of causes, there is potential evidence for specific brain structures playing a role in the onset of insomnia (Riemann et al., 2007). In a pilot study, Riemann and colleagues (2007) found significantly reduced hippocampal volumes in those with primary insomnia, whereas Bumb and colleagues (2013) have also found the pineal gland volume to be less than average in insomnia patients. TBI has also been linked to hypersomnia, known as “secondary narcolepsy” or “posttraumatic hypersomnia” (Viola-Saltzman, 2012, p. 7). Baumann and colleagues (2007) also found an increased risk of hypersomnia during the 6 months following a TBI, as well as an increased likelihood of excessive daytime sleepiness (EDS) and fatigue.

Sleep and Traumatic Brain Injury among Athletes

It is estimated that over 60,000 high school sport induced traumatic brain injuries occur annually in the US, with the type of sport that the athlete is involved in being the main determinate of the rate of TBI (Powell & Barber-Foss, 1999). High-contact sports such as football, wrestling, soccer, and basketball showed higher rates than lower-contact sports such as softball/baseball, field hockey, or volleyball. However, no sport that was investigated was exempt from the occurrence of TBI (Powell & Barber-Foss, 1999). So, while there are many health benefits of being physically active, those who partake in sports have an increased risk of TBI and therefore have increased chances of experiencing more than one TBI in their lifetime.

Due to the higher rate of TBI seen in those who play contact compared to non-contact sports (Powell & Barber-Foss, 1999), it is also likely that the athletes who play contact sports will have greater sleep disturbances. There are other factors specific to being a collegiate or professional athlete that are known to affect sleep, such as diet, traveling across time zones, and anxiety (Savis, 1994; Sexton-Radek, Hernandez, & Pauley, 2013). Milewski et al. (2014) also found that in athletes, having a sports related injury correlated with getting less than eight hours of sleep. Based on what is known about the increased risk of TBI in collegiate and professional athletes and how TBI affects sleep, exposure to TBI should also be considered when assessing factors that may be affecting an athlete's sleep.

Current Research

The primary purpose of this research was to examine the association between TBI among collegiate and professional athletes and their overall sleep patterns (i.e., overall sleep quality, sleep quantity, sleep apnea, insomnia, and narcolepsy). Specifically, we focused on the comparison of sleep patterns among athletes in contact sports versus those in non-contact sports. In doing so, we gained a better understanding of the potential role TBI could be playing in the heightened risk of sleep problems reported by athletes. The implications of this research would help college and professional athletic programs to gain greater insight into the health challenges that their athletes may be facing, and could likely lead to the development of better ways of overcoming these challenges.

Hypotheses

H1: It is expected that there will be an association between TBI and disrupted sleep patterns (i.e., overall sleep quality, sleep quantity, sleep apnea, insomnia, and narcolepsy).

H2: It is expected that there will be an association between whether or not one is an athlete in a contact sport versus a non-contact sport and the prevalence of sleep disruption (i.e., overall sleep quality, sleep quantity, sleep apnea, insomnia, and narcolepsy), such that athletes in contact sports will have a greater prevalence of sleep disruption.

H3: It is expected that TBI will moderate the relationship between athletes' exposure to contact sports and their sleeping patterns, such that athletes who engage in contact sports (compared to non-contact sports) and have a TBI will have a greater risk of:

a. Deficient sleep quantity

b. Deficient sleep quality

c. Sleep apnea

d. Insomnia

e. Narcolepsy

Methodology

Participants

The sample consisted of 176 athletes (collegiate or professional), recruited using Amazon Mechanical-Turk (M-Turk), an online resource that allows researchers to request participants to complete research-based computer tasks. Of the individuals who participated, 56 (31.8%) were currently athletes, and 120 (68.1%) were formerly athletes. The average age of participants was 31.9 years (range of 18-71), and there were 95 males and 81 females, with the majority being Caucasian (72.2%). Participants were divided into two groups: athletes in contact sports (N=132) and athletes in non-contact sports (N=44). Sports were categorized as contact or noncontact using the classification created by the American Academy of Pediatrics (2016).

Procedure

The study was approved by the Institutional Review Board (IRB) at the University of Northern Iowa. Data was collected during the spring of 2017. Participants chose whether or not they would like to participate in the study after reading a short script in the Amazon M-Turk system. Those who agreed to participate, and fit the inclusion criteria of being a former or current collegiate or professional athlete, were provided an online consent form. If they consented, they could continue with the online survey. Participants completed an online questionnaire using Qualtrics, which inquired about their sleeping habits, as well as their history of traumatic brain injury. Sleep disturbances were identified through self-assessment by the participants using a variety of sleep measures in an online survey. Their responses were coded according to the design of the evaluation method and then used to identify the presence of problems in sleep quality, quantity, or specific sleep disorders (insomnia, apnea, or narcolepsy). Traumatic brain injury was also identified through self-assessment by the participants via survey questions that asked about any TBI in the individual's past. Those that completed the study were paid $1.20 for 45 minutes of participation.

Measures

Quantity of Sleep. Participants were first asked to report their sleep time on an average night. This measure was adapted from the Sleep Habits Survey, a valid measure that asks about trends over multiple nights rather than an individual night (Wolfson, Carskadon, Acebo, & Martin, 2003). Developed by Bradley Hospital/Brown University Sleep Research Lab, this portion of the survey included questions that asked about ideal bedtimes and napping habits, such as "What time do you go to bed on weekends?" (Wolfson & Carskadon, 1998). Sleep quantity was inquired by asking the participants about the number of hours they slept at night on average.

Quality of Sleep. Participants were asked 25 questions from the Sleep Habits Survey (SHS), 10 of which assessed daytime sleepiness, and 15 that assessed sleep/wake problems (Wolfson & Carskadon, 1998). This scale is a valid measure (Carskadon et al., 1991), and has high reliability (Wolfson et al., 2003). All 25 questions from the SHS refer to the last two weeks of the respondent's life. The questions for the daytime sleepiness portion of the SHS used a 4-point Likert-type Scale, providing 10 daily situations that one may experience sleepiness (Wolfson et al., 2003). For instance, "During the last two weeks have you struggled to stay awake (fought sleep) or fallen asleep during a test or when needing to focus at work?" (0 =

"Never", 3 = *"Both struggled to stay awake and fall asleep"*). The reliability of this portion of the SHS in our study was excellent (α=0.94). The questions for the sleep/wake problems portion used a 5-point Likert-type Scale to identify sleep patterns, such as problems with waking up in the morning, falling asleep at night, and staying awake during the day, over large samples (Wolfson & Carskadon, 1998; Wolfson et al., 2003). For instance, "In the last two weeks, how often have you needed more than one reminder to get up in the morning?" (4 = *"Every day/Night"*, 0 = *"Never"*). The reliability of this portion of the SHS measure in our study was also exceptional (α=0.90).

The Epworth Sleepiness Scale (ESS) was also used to assess the quality of sleep. This measure consisted of 8 items that were designed to measure the amount of daytime sleepiness a person experiences on a given day (Smyth, 2012). The ESS is an effective way to differentiate between normal daytime sleepiness and abnormal daytime sleepiness (Smyth, 2012), with a high internal consistency (α=0.88), validity (Johns, 1993), and reliability (Johns, 1992; current study: α=0.88). The 4 point Likert-type scale asked the individual to rate the likelihood of them falling asleep in a given situation, for example, "As a passenger in a car for an hour without a break" (0 = *"would* never doze," 3 = *"high chance of dozing"*). The ratings were then accumulated and scored, revealing how sleepy the person is on average during the day. A score of more than six signified that the participant is sleepy, a score of ten signified that they are very sleepy, and a score of more than 16 meant the participant is dangerously sleepy (Smyth, 2012). The average score was used as an estimate of daytime sleepiness.

The Pittsburg Sleep Quality Index was the last portion of the section of the questionnaire that was assessed for quality of sleep. The PSQI was developed to assess the overall quality of one's sleep via self-evaluation (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). When being used to measure primary insomnia specifically, the PSQI has good validity and also has high test-retest reliability (Backhaus, Junghanns, Broocks, & Riemann, 2002; current study: α=0.87). The survey began by asking questions with open answers, such as "How long (in minutes) has it taken you to fall asleep each night?" Next, the individuals were questioned about their sleeping patterns in the last month. For instance, "During the last month, how often have you had trouble sleeping because you cannot get to sleep within 30 minutes" (0 = *"Not during the past month,"* 3= *"Three of more times a week"*).

Insomnia. Insomnia was assessed using two measures, the first being the SLEEP-50 Questionnaire subscale. This measure used the DSM-IV criteria to assess the participant's sleep disruptions (Spoormaker, Verbeek, van den Bout, & Klip, 2005), and had a reliability apha of 0.91 in this study. There were 8 items, with each one including a statement about sleep patterns that the participant rates on a 4-point scale. For example, "I have difficulty falling asleep" (1 = *"Not at all"*, 4 = *"Very Much*").

The second measure of insomnia that was used in this study was the Insomnia Severity Index, a valid questionnaire that has been found to have strong reliability (α=0.91; Morin et al., 2011). This measure had a reliability alpha of 0.66 in this study. The answers were obtained via a 5-point Likert-type scale in which the definitions for the number values in this scale varied based on the question being asked. For example, "How SATISFIED/DISSATISFIED are you with your CURRENT sleep pattern?" (0 = *"Very Satisfied,"* 4 = *"Very Dissatisfied"*), or "How WORRIED/DISTRESSED are you about your current sleep problem?" (0 = *"Not at all Worried,"* 4 = *"Very Much Worried"*). The total score ranged from 0-28, with 0-7 indicating no insomnia, 8-14 indicating sub-threshold insomnia, 15-21 indicating moderate insomnia, and 88-

28 indicating severe insomnia (Morin, Belleville, Belanger, & Ivers, 2011). The average insomnia score was used in the current study.

Sleep Apnea. Apnea was assessed via two commonly used apnea questionnaires. The first of these is the STOP-BANG Sleep apnea questionnaire, which was developed as an initial measure when checking an individual for sleep apnea, having high sensitivity (Chung et al., 2008), as well as validity and reliability (Nagappa et al., 2015). The name "STOP-BANG" is an acronym for the questions that are asked. The answers were then given in yes/no form. For instance, the "S" stands for the question that assesses snoring: "Do you SNORE loudly [louder than talking or loud enough to be heard through closed doors]?").

The next ten questions were from the Berlin Questionnaire (Netzer, Stoohs, Netzer, Clark, & Strohl, 1999). Developed in Germany in 1996 (Kang et al., 2013), the Berlin Questionnaire is a reliable survey (Chung et al., 2008) that contains three categories of questions. The first category included questions having to do with snoring habits, for example "How often do you snore?". The second category involved questions about fatigue/daytime sleepiness, for instance "How often do you feel tired or fatigued after your sleep?". The final category was a question about blood pressure, asking specifically "Do you have high blood pressure?". The scoring of these three categories was then used to determine the risk of apnea in the individual. If there were two or more positive responses within one category, that category received a positive score. If two or more categories have a positive score, the person is at a high risk for apnea. This method of measuring for risk of apnea has been found have a high validity and internal consistency (α=0.92-0.96; Sharma et al., 2006; Netzer et al., 1999)

Narcolepsy. To identify narcolepsy in the participants, the Ullanlinna Narcolepsy Scale was also administered during the online survey (Hublin, Kaprio, Partinen, Koskenvue, &

Heikkila, 1994). This is a valid 11 item, 5-point Likert-type scale questionnaire that reliably differentiates narcolepsy from the other possible sleep disorders (Hublin et al., 1994; current study: α=0.84). In order to identify narcolepsy in a participant, the questions in this survey assess two main criteria: cataplexy and abnormal sleeping patterns. The first series of questions assessed cataplexy, for example: "When laughing, feeling glad or angry, or in an exciting situation, have the following symptoms occurred: Knees buckling?" (0= *"Never,"* 4= *"Daily or almost daily"*). The remaining questions identified abnormal sleeping patterns, such as: "Do you fall asleep unintentionally during the day: reading?" (0= *"Never,"* 4= *"Daily or almost daily"*).

Traumatic Brain Injury (TBI). Self-reported information was used to identify any history of TBI in the participants. This information was obtained using Part I of the Brain Injury Screening Questionnaire (BISQ; Dams-O'Connor et al., 2014). The BISQ is a reliable and valid (Topolovec-Vranic et al., 2014) 19-item survey that has 6 parts to each question. Each question provides a specific situation in which a TBI may have occurred, such as "Have you ever experienced a blow to the head in the following situations: Being assaulted or mugged?" The question then goes on to ask for details regarding periods of loss of consciousness and incidents of feeling dazed or confused (Dams-O'Connor et al., 2014). Participants who responded "no" to this first part of a question were considered a negative screen for TBI. If they responded "yes," they were considered a positive screen and the severity of their TBI was then rated based on the duration of loss of consciousness (LOC): Mild = mental change status or < 30 minutes LOC, Moderate = mental change status or 30 minutes to 6 hours LOC, Severe = mental change status or > 6 hours LOC.

Data Coding

Data collected were cleaned and checked for outliers. Participants who said they have never been a collegiate or professional athlete were removed from the data. IBM's statistical package SPSS version 24 was used to run statistical analyses (IBM, 2016). The scales were coded by the researcher based on guidelines from those who created the scales, as well as past research. TBI was coded for using the recommendations of the BISQ, using the scale of duration of loss of consciousness (LOC) to determine TBI severity. Thirty-five cases were removed from the data due to the participant indicating they have never been an athlete. Descriptive statistics were computed to gain a better understanding of the data sample, and then the study-specific analyses were computed for each hypothesis.

Plan of Analysis

T-test. For Hypothesis 1, it was expected that there would be an association between TBI and disrupted sleep patterns. An independent t-test was used for each of the 10 sleep measures and TBI. We expected that those with a TBI would have significantly higher sleep disruptions.

For Hypothesis 2, an independent t-test was also used for each of the 10 sleep measures and whether their sport was contact or non-contact. It was expected that there would be an association between whether one is an athlete in a contact or noncontact sport and the prevalence of sleep disruption. We expected that those in contact sports would have significantly higher sleep disruptions.

Analysis of Variance. For Hypothesis 3, it was expected that having a TBI would worsen the effects that being exposed to contact sports have on sleep disruptions. A 2 x 2 between-subjects factorial analysis of variance (ANOVA) was used; factor 1 was presence of

TBI (1= Yes, 0=No) and factor 2 was defined as whether they engaged in a contact sport (1=Yes, 0=No). It was expected that there would be a significant interaction effect such that those with a TBI and participating in contact sports would have the worst sleep outcomes as compared to individuals who had only one risk factor i.e., either had a TBI or engaged in a contact sport. The outcome variables were sleep disruptions.

Results

Preliminary Analysis

Descriptive analyses were conducted prior to the study-specific analyses. Table 1 shows the descriptive statistics of the key study variables. On average, participants were not exceptionally sleepy (range of 0-3, with 3 being the most sleepy; M = 1.80, SD = .91), had good overall sleep quality (M = .85, SD = .81), and slept an average of 433.80 minutes (7.23 hours) per night (SD = 82.22). Correlational analyses were also conducted and are shown in Table 1. There were significant associations between being female and several sleep measures, including insomnia (r = .17, p<.05), insomnia severity (r = .29, p<.001), narcolepsy (r = .22, p<.05), overall sleep quality (r = .20, p<.01), and the STOP-Bang measure of apnea (r = -.37, p<.001). Being whites was negatively associated with mental health (r = -.18, p<.05) and physical health (r = -.16, p<.05), and BMI was associated with sleepiness (r = -.18, p<.05) and the Berlin Questionnaire score (r = .21, p<.01). Mental health was associated with physical health (r = .91, p<.01).

Hypothesis 1: Role of TBI on Sleep Disruptions

According to Hypothesis 1, it was expected that there would be an association between TBI and disrupted sleep patterns. Specifically, those who had had a TBI would have a higher prevalence of disrupted sleep patterns (i.e., overall sleep quality, sleep quantity, sleep apnea, insomnia, and narcolepsy) than those without a TBI. Independent t-tests were used to test this hypothesis (Table 2).

On average, participants with a history of TBI reported higher levels of insomnia (*M* = 2.21, *SD* = .79) than those without a TBI (*M* = 1.78, *SD* = .79). This difference was statistically significant $t(174) = 3.59$, $p < .01$ (see Figure 1). There was not a statistically significant difference in insomnia severity between participants with a history of TBI (*M* = .94, *SD* = .70) and those without a TBI (*M* = .75, *SD* = .81) as indicated by the t test ($t(174) = 1.66$, $p > .05$). There was a significant difference ($t(174) = 2.57$, $p < .05$) in daytime sleepiness across participants who reported a TBI and those without a TBI, such that those who reported a TBI had higher levels of sleepiness (*M* = 2.00, *SD* = .89) than those without a TBI (*M* = 1.65, *SD* = .90; see Figure 3). Participants with a history of TBI were not different on sleep/wake problems (*M* = 3.64, *SD* = .72) than those without a TBI (*M* = 3.81, *SD* = .87), as indicated by the t-test ($t(174) = -1.42$, $p > .05$). On average, participants with a history of TBI scored significantly higher on the Epworth sleepiness scale ($t(174) = 3.15$, $p < .01$), indicating more sleepiness (*M* = 1.07, *SD* = .63), than those without a TBI (*M* = .74, *SD* = .71; see Figure 5).

With regard to narcolepsy, there was no difference across participants who had a history of TBI (*M* = .99, *SD* = .77) compared to those without a TBI (*M* = .84, *SD* = .80; $t(174) = 1.06$, $p > .05$). There was a significant difference ($t(174) = 2.10$, $p < .05$) in the STOP-BANG measure of sleep apnea between participants with a history of TBI (*M* = 1.79, *SD* = 1.17) and those without a TBI (*M* = 1.43, *SD* = 1.09), such that those with a TBI scored significantly higher (see Figure 7). There was a statistically significant difference ($t(174) = 2.72$, $p < .01$) in the scores of the Berlin Questionnaire measure of apnea between those with a history of TBI (*M* = .51, *SD* = .58) than those without a TBI (*M* = .28, *SD* = .55), such that those with a TBI reported higher levels of apnea (see Figure 8). On average, participants with a history of TBI reported significantly ($t(174) = 2.73$, $p < .01$) poorer sleep quality ($M = 1.04$, $SD = .81$) than those without a TBI ($M = .71$, $SD = .78$; see Figure 9). There was not a significant difference in sleep quantity ($t(172) = -1.57$, $p > .05$) across those who had a TBI ($M = 25.34$, $SD = 19.13$) as compared to those without a TBI ($M = 22.80$, $SD = 21.25$).

Hypothesis 2: Engagement in Contact Sports and Sleep Disruptions

Based on Hypothesis 2, we expected to see an association between whether one is an athlete in a contact sport versus a non-contact sport and the prevalence of sleep disruptions (i.e., overall sleep quality, sleep quantity, sleep apnea, insomnia, and narcolepsy). Specifically, we expected to see that athletes in contact sports would have a greater prevalence of sleep disruption than athletes in non-contact sports. Independent t-tests were computed to test this hypothesis.

On average, participants who were athletes in contact sports scored significantly higher ($M = 1.70$, $SD = 1.15$) in the STOP-BANG measure of sleep apnea than those who participated in non-contact sports ($M = 1.25$, $SD = 1.06$) as indicated by the significant t-test ($t(174) = 2.28$, $p < .05$; see Figure 17). There were no other significant differences between participants who were athletes in contact sports versus those who were athletes in non-contact sports across the sleep measures (Table 3).

Hypothesis 3

Lastly, according to our third hypothesis, it was expected that TBI would moderate the relationship between an athlete’s exposure to contact sports and their sleeping patterns. Specifically, we expected that athletes who engaged in contact sports (compared to non-contact sports) and had a TBI would have a greater risk of deficient sleep quantity, deficient sleep quality, sleep apnea, insomnia, and narcolepsy than all other groups. A 2 x 2 between-subjects factorial analysis of variance (ANOVA) was used to test this hypothesis (Table 4).

There was a significant main effect of TBI on insomnia F (1, 172) = 8.21, $p < .01$, $\eta^2 = .05$, however, there was no interaction effect F (1, 172) = .10, $p > .05$, $\eta^2 = .00$ (see Figure 21). TBI also had a significant main effect on daytime sleepiness F (1, 172) = 6.56, $p < .05$, $\eta^2 = .04$, with no interaction effect F (1, 172) = .69, $p > .05$, $\eta^2 = .00$ (see Figure 23). With regard to the Epworth sleepiness measure, there was a significant main effect of TBI (F (1, 172) = 8.83, $p < .01$, $\eta^2 = .05$), with no interaction effect F (1, 172) = .43, $p > .05$, $\eta^2 = .00$ (see Figure 25).

Contact had a significant main effect on the STOP-BANG measure of apnea F (1, 172) = 4.45, $p < .05$, $\eta^2 = .03$, however there was still no interaction effect F (1, 172) = .00, $p > .05$, $\eta^2 = .00$ (see Figure 27). There was a significant main effect of TBI on the Berlin questionnaire of apnea, F (1, 172) = 7.17, $p < .01$, $\eta^2 = .04$; as well as a significant main effect on overall sleep quality, F (1, 172) = 5.23, $p < .05$, $\eta^2 = .03$, however there were no interaction effects on either measure [Berlin Questionnaire: F (1, 172) = .56, $p > .05$, $\eta^2 = .00$; Sleep Quality: F (1,172) = .00, $p >.05$, $\eta^2 = .00$] (see Figures 28-29).

Discussion

Summary

Although the understanding and awareness about TBI has increased dramatically over recent years, there is still a lack of understanding when it comes to milder forms of TBI, such as concussions, and their health implications (Meany, Morrison, & Bass, 2014). Previous research has examined the effects that TBI can have on health, both short term (Roberts & Roberts, 2011) and long term (Dean & Sterr, 2013), identifying factors such as problems in concentration (Roberts & Roberts, 2011), depletions in social and occupational functioning (Rassovsky et al., 2006), and sleep disturbances (CDC, 2016). Prior studies have also examined the situations in which TBIs occur (CDC, 2016), identifying blows to the head, such as those that occur during sport related injuries, which account for 17% of non-fatal TBIs (Faul, Xu, Wald, & Coronado, 2010). The present study aimed to further understand the relationship between TBI and sleep disruptions, specifically in an athlete population where the exposure to contact could increase the prevalence of TBI, thus potentially increasing the occurrence of sleep disruptions.

Findings indicated support for the majority of the first hypothesis, which stated that there would be an association between TBI and disrupted sleep patterns. For six of the ten sleep measures, those who had experienced a TBI reported greater sleep disruptions compared to those who did not, suggesting that sleep disruptions were more prevalent in those who had a TBI. Specifically, the findings indicated that those with a TBI are more likely to have insomnia, increased sleepiness (seen in both the Sleep/Wake Problems behavior scale and Epworth sleepiness measures), sleep apnea (seen in both the STOP-BANG and Berlin measures), and poorer overall sleep quality.

The results of Hypothesis 1 were mostly consistent with past literature that has focused on relations between TBI and specific sleep disorders. For example, Baumann and colleagues (2007) found TBI to be linked to an increased risk of insomnia and sleepiness, which was consistent with our findings. In addition, our outcomes on apnea and TBI align with prior research (Castriotta et al., 2007), specifically the research of Webster, Bell, Hussey, Natale, and Lakshminarayan (2001), which found that that there was an increased frequency of sleep apnea in those who have suffered TBI. While it was expected that there would be an association between narcolepsy and TBI, our findings were somewhat inconsistent with prior literature. There has been previous research that shows a link between TBI and narcolepsy (Castriotta et al., 2007), but it was found that only 6% of TBI patients developed the disorder. Therefore, it is possible that our small sample size of 176 explains our lack of association between TBI and narcolepsy. The lack of associations between TBI and narcolepsy could also be explained by the use of subjective measures of narcolepsy as compared to the use of objective measures such as PSG or actigraphy (Sadeh et al., 1995; de Zambotti, Baker & Colrain, 2015).

Results were mostly inconsistent with our second hypothesis. While it was expected that athletes in contact sports would have a greater prevalence of sleep disruption, this was only the case for one of the ten sleep measures, the STOP-BANG measure of sleep apnea. These results suggest that whether or not one plays in a contact sport or a non-contact sport does not affect the individual’s risk of developing the majority of the examined sleep disruptions. The second hypothesis was based on prior research that found a greater occurrence of TBI among those who played contact sports compared to those who played non-contact sports (Powell & Barber-Foss, 1999). If this were the case, we would expect to see significantly more sleep disruptions in the contact sport population, as supported by the findings of our first hypothesis. However, our sample showed no significant difference in the rate of TBI between those who played contact sports (44.7% had a TBI) and those who played non-contact sports (38.6% had a TBI). Therefore, it is possible that our finding of a lack of association between contact sports and the majority of sleep disruptions is due to our sample’s absence of an effect of contact sports on rates of TBI. Once again, it is possible that our small sample size of 176 may have playing a role in the lack of associations between engagement in contact sports and sleep.

It is also possible that the lack of association between contact sports and sleep disruptions shows that exposure to contact sports is not the biggest factor in the onset of sleep problems in athletes. Prior research has found that there are many factors that can result in sleep disruptions in all types of athletes, such as diet, traveling across time zones, and anxiety (Savis, 1994; Sexton-Radek, Hernandez, & Pauley, 2013). Therefore, it is possible that these factors could be playing a larger role in sleep patterns across all types of athletes than the role that exposure to contact plays.

Results were also inconsistent with our third hypothesis, which stated that TBI would moderate the relationship between athletes' exposure to contact sports and their sleeping patterns, such that those who engage in contact sports and have TBI would have a greater risk of sleep disorders. Our results indicated that while TBI had a significant main effect on insomnia, sleepiness, and overall sleep quality, and being in a contact sport had a significant main effect on the STOP-BANG measure of sleep apnea, there were no interaction effects found in any of the results. Since there was no association between contact sports and sleep disruptions in hypothesis 2, it is expected that there was no interaction effect of TBI and contact on sleep. As mentioned previously, it is possible that our small sample size led to this inconsistency, and that a larger sample size could potentially yield different results. It is also possible that obtaining our sample from the online system MTurk could have resulted in these inconsistencies, and that a more monitored sample and survey distribution could have produced different results.

Strengths

To our knowledge, there is no prior research that has examined all three elements that were examined in the current study; the current study is a novel exploration of associations between TBI and contact versus noncontact sports in the prediction of sleep disruptions. This research targets an area within the fields of health and psychology that is not fully understood and needs more research (Meany, Morrison, & Bass, 2014). Our study helps to close this gap in the literature on TBI and sleep for an athlete population, as well as identifying areas to examine for future research. An additional strength to this study is the use of multiple measures of sleep. The multiple measure approach to evaluation has been found to increase validity and reliability, as well as decreased subjectivity (Malhotra & Grover, 1998). The current study utilized measures of general sleep quality and quantity, as well as measures of specific sleep disorders. Using multiple measures allowed researchers to obtain a better understanding of the overall sleep habits of participants.

Limitations

One limitation of this study was the sample size. Due to limited resources and time, only 176 participants were recruited for participation. The source of the sample was also a limitation. While using Amazon MTurk is convenient, it is hard to monitor the individuals who are completing the survey. Future studies with greater resources could obtain a larger sample of participants, and could also recruit participants from a more reliable source. Another limitation of the study was the use of multiple subjective measures. While these measures have been shown to have good reliability and validity (see *Measures* section), the use of subjective measures is not ideal. It has been found that subjective measures do not always correlate with objective measures, and therefore objective measures would possibly yield different results (Baker, Maloney, & Driver, 1999). While the use of multiple measures could be seen as a strength to this study, it is also possible that the length of the questionnaire could increase the likelihood of participant fatigue, and thus decreasing reliability. Future studies with greater resources and time could conduct clinical evaluations for each sleep disorder and for TBI, as well as examine the medical records of participants. In order to decrease participant fatigue, these future studies could break up the evaluations into multiple sessions.

Future Directions and Implications

While the results of this study did not show an interaction between contact sports and TBI on sleep, the results did show an association between TBI and sleep disorders in general. This information contributes to the understanding of TBI and its health effects, and could still be utilized by collegiate and professional athletic programs when assessing an athlete who has experienced a TBI. These findings could also be referenced when looking for potential causes of sleep disorders across all populations, as our results show that any history of TBI could be a contributing factor to sleep disorders, such as poor sleep quality, insomnia, increased sleepiness, and apnea. The results of this study also indicated that being in a contact sport increased one's chances of having sleep apnea. Based on these results, it is important that collegiate and professional athletic programs check their athletes for all sleep disorders, with an emphasis on apnea. Interventions should also take place in athletic programs, with the goal of trying to prevent the development of apnea and other sleep disorders in athletes. These interventions could focus on lowering the rates of TBI in athletes, as well as ensuring that any initial signs of sleep disruptions are noticed and treated promptly and properly.

Future research could further explore the relationship of TBI and sleep disorders in an athlete population by looking at larger sample sizes. A larger sample size could show more significant results, and could potentially show a greater effect of the role of the type of sport one participates in and their history of TBI. The severity of a TBI, as well as its location on the brain and the specific brain structures affected, are all factors that could and should be examined in the future, especially since prior research has shown these areas to be relevant in the study of sleep disruptions and TBI (Baumann et al., 2009; Bumb et al., 2013; Dauvilliers, Arnulf, & Mignot, 2007; Macey et al., 2008; Ouellet, Beaulieu-Bonneau, & Morin, 2006; Riemann et al., 2007; Schreiber et al., 2008; Sullivan, 2009). Further research could also examine the rates of TBI and sleep disruptions across individual sports, rather than grouping sports into the two groups of contact and non-contact.

Conclusion

TBI is a major health concern, and it can have serious implications on one’s health. While many of these health effects have been identified, there is still much to be learned. One of the specific health concerns facing those with a TBI is the development of sleep disruptions. Gaining a better understanding of the specific sleep disorders that are linked to TBI is especially important to those who are potentially at a higher risk of experiencing a TBI. It can be concluded that a TBI is associated with increased sleep disturbances, but this study provides limited support for the role that playing in a contact sport versus a non-contact sport has on sleep disruptions. There could be multiple reasons for this lack of an effect, such as our small sample size, other outside influences on sleep that athletes experience, or how the sports were grouped into two groups, and further research should be explored to look into this relationship further. Nevertheless, contact sports did appear to play a role on the occurrence of sleep apnea, and researchers should continue to examine the collegiate and professional athlete population for risk of TBI and sleep disorders.

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Table 1. *Means, SD, minimum, maximum, percentage and summary of correlations of key study variables*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Female	-															
2. White	.04	-														
3. BMI	-.19*	.12	-													
4. Mental Health	-.02	-.18*	-.07	-												
5. Physical Health	-.02	-.16*	-.09	.91**	-											
6. TBI	.05	-.02	.04	.17*	.15*	-										
7. Insomnia	.17*	-.08	-.10	.18*	.12	.26***	-									
8. Insomnia Severity	.29***	-.04	-.06	.10	.08	.13	.51***	-								
9. Sleepiness	.02	-.10	-.18*	.18*	.15	.19*	.48***	.21**	-							
10. Sleep/ Wake Problems	.02	.01	.11	-.15*	-.11	-.11	-.39***	-.21**	-.50***	-						
11. Epworth	.01	-.10	.00	.19*	.15*	.23**	.53***	.29***	.69***	-.39***	-					
12. Narcolepsy	.22*	-.10	-.12	.14	.12	.10	.36***	.31**	.36***	-.21*	.38***	-				
13. STOP-BANG	-.37***	-.00	.14	.11	.07	.16*	.33***	.20**	.40***	-.28***	.44***	.13	-			
14. Sleep Quality	.20**	-.05	.03	.34*	.27**	.20**	.56***	.56***	.26***	-.27***	.39***	.28**	.26**	-		
15. Minutes of sleep per night	-.12	.11	.09	-.13	-.16*	-.12	-.19*	-.22**	-.04	.04	-.18*	-.15	-.07	-.32***	-	
16. Final BQ	.04	-.04	.21**	.18*	.10	.20**	.31***	.32***	.29***	.22**	.37***	.27**	.52***	.33***	-.09	-
Mean/ %	46.0%[a]	72.2%	23.96	5.72	4.23	76%[b]	1.97	.83	1.80	3.73	.88	.93	1.59	.85	433.80	.38
SD	-	-	4.99	17.12	16.45	-	.82	.77	.91	.81	.70	.79	1.14	.81	82.22	.57
Minimum	-	-	.22	0	0	-	1.00	.00	1.00	1.00	.00	.00	.00	.00	20.00	.00
Maximum	-	-	45.91	30	30	-	4.00	4.00	5.00	4.80	3.00	3.00	5.00	3.00	605.00	2.00

Note. [a]Female (Female=1, male=0); Percentage reported for females; [b]Yes to TBI (Yes=1, No=0); * $p < .05$; ** $p < .01$; *** $p < .001$

Table 2. *Independent Samples T-Tests for TBI*

	TBI		No TBI			
Measure	M	SD	M	SD	*t*	Sig. (2-tailed)
Insomnia	2.21	.79	1.78	.79	3.59	.000
Insomnia Severity Index	.94	.67	.75	.81	1.66	.098
Sleepiness	2.00	.89	1.65	.90	2.57	.011
Sleep/Wake Problems	3.63	.72	3.81	.87	-1.42	.157
Epworth	1.07	.63	.74	.71	3.15	.002
Narcolepsy	1.00	.77	.84	.80	1.06	.293
STOP-BANG	1.79	1.17	1.43	1.09	2.10	.038
Sleep Quality	1.04	.81	.71	.78	2.73	.007
Minutes of sleep per night	422.59	100.56	442.30	64.26	-1.57	.118
Berlin Questionnaire	.51	.57	.28	.55	2.72	.007

Table 3. *Independent Samples T-Tests for Contact vs Non-Contact Sports*

	Contact		Non-Contact			
Measure	M	SD	M	SD	*t*	Sig. (2-tailed)
Insomnia	2.00	.83	1.85	.77	1.07	.289
Insomnia Severity Index	.78	.73	1.00	.85	-1.62	.107
Sleepiness	1.87	.94	1.59	.80	1.79	.075
Sleep/Wake Problems	3.74	.75	3.73	.97	.05	.962
Epworth	.94	.72	.72	.60	1.77	.078
Narcolepsy	.98	.82	.78	.67	1.10	.274
STOP-BANG	1.70	1.15	1.25	1.06	2.28	.024
Sleep Quality	.91	.82	.68	.77	1.62	.106
Minutes of sleep per night	432.89	84.75	436.58	74.86	-.26	.799
Berlin Questionnaire	.40	.59	.32	.52	.83	.405

Table 4. *2 x 2 between-subjects factorial analysis of variance (ANOVA)*

Variable		*Mean Square*	*Sum of Squares*	*df*	*F*	*p*	η_p^2
Insomnia	Contact	0.57	0.57	1	0.90	.343	.01
	TBI	5.16	5.16	1	8.21	.005**	.46
	Contact*TBI	0.06	0.06	1	0.10	.758	.00
	Error	0.06	108.22	172	--	--	--
Insomnia Severity Index	Contact	1.55	1.55	1	2.67	.104	.02
	TBI	1.09	1.09	1	1.87	.173	.01
	Contact*TBI	0.04	0.04	1	0.07	.793	.00
	Error	0.58	99.87	172	--	--	--
Sleepiness	Contact	1.77	1.77	1	2.21	.139	.01
	TBI	5.26	5.26	1	6.56	.011*	.04
	Contact*TBI	0.55	0.55	1	0.69	.408	.00
	Error	0.55	137.77	172	--	--	--
Sleep/Wake problems	Contact	0.07	0.07	1	0.10	.754	.00
	TBI	1.95	1.95	1	2.97	.087	.02
	Contact*TBI	0.63	0.63	1	0.96	.329	.01
	Error	0.66	112.97	172	--	--	--
Epworth Sleepiness Scale	Contact	1.02	1.02	1	2.21	.139	.01
	TBI	4.07	4.07	1	8.83	.003**	.05
	Contact*TBI	0.20	0.20	1	0.43	.512	.00
	Error	4.61	79.35	172	--	--	--
Narcolepsy	Contact	0.79	0.79	1	1.26	.263	.01
	TBI	0.73	0.73	1	1.17	.282	.01

	Contact*TBI	0.08	0.08	1	0.13	.716	.00
	Error	0.62	68.55	110	--	--	--
STOP-BANG	Contact	5.68	5.68	1	4.54	.035*	.02
	TBI	3.80	3.80	1	3.03	.083	.02
	Contact*TBI	0.00	0.00	1	0.00	.948	.00
	Error	1.25	215.15	172	--	--	--
Overall Sleep Quality	Contact	1.36	1.36	1	2.16	.144	.01
	TBI	3.28	3.28	1	5.23	.023*	.03
	Contact*TBI	0.00	0.00	1	0.00	.974	.00
	Error	0.63	108.05	172	--	--	--
Sleep Quantity (minutes per night)	Contact	345.78	345.78	1	0.05	.822	.00
	TBI	10,144.06	10,144.06	1	1.50	.223	.01
	Contact*TBI	292.52	292.52	1	0.04	.836	.00
	Error	6,779.00	1,152,430.67	170	--	--	--
Berlin Questionnaire	Contact	0.09	0.09	1	0.29	.588	.00
	TBI	2.29	2.29	1	7.17	.008**	.04
	Contact*TBI	0.18	0.18	1	0.56	.454	.00
	Error	0.32	54.81	172	--	--	--

Note. **. XXXX is significant at the 0.01 level (2-tailed).

Hypothesis 1 Figures: T-tests

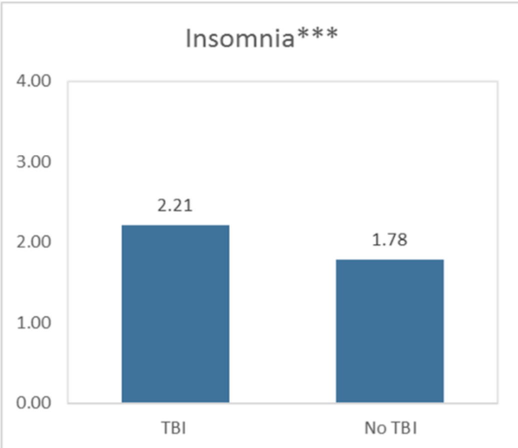


Figure 1. TBI and Insomnia
t(174) = 3.59, p < .01

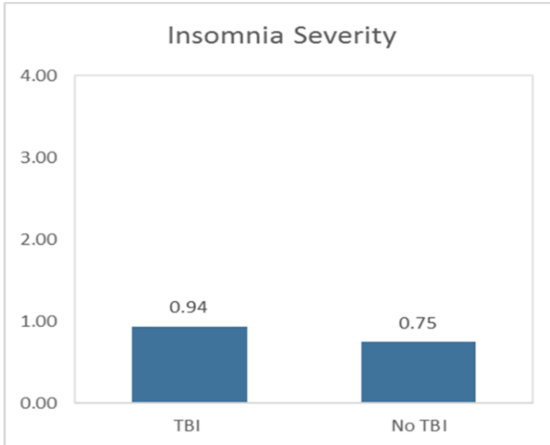


Figure 2. TBI and Insomnia Severity

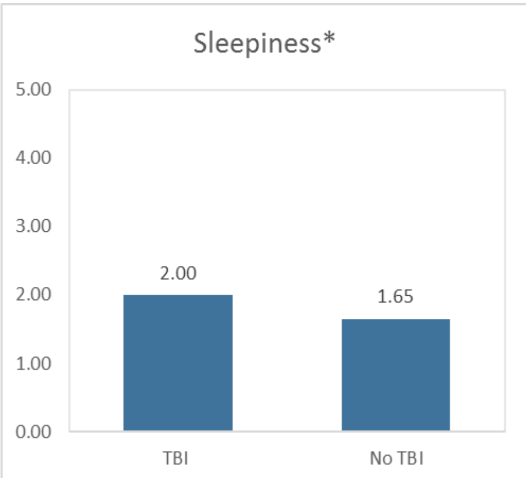


Figure 3. TBI and Sleepiness
t(174) = 2.57, p < .05

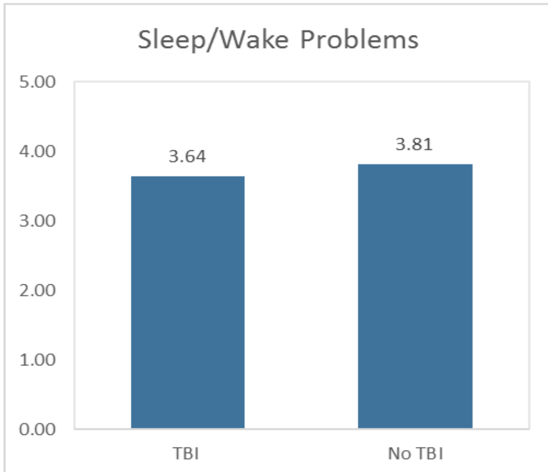


Figure 4. TBI and Sleep/Wake Problems

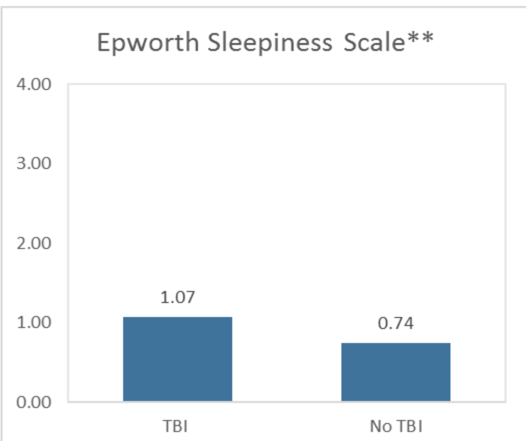


Figure 5. TBI and Epworth Sleepiness Scale
t(174) = 3.15, p < .01

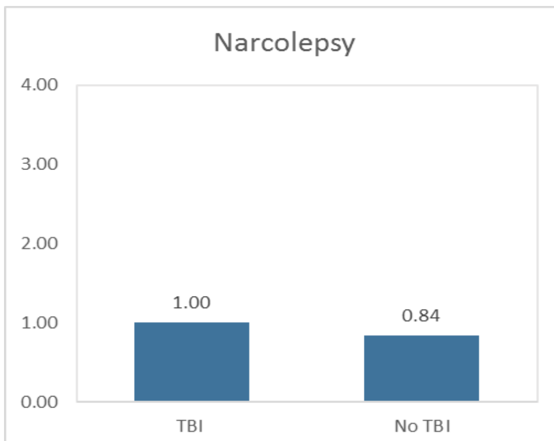


Figure 6. TBI and Narcolepsy

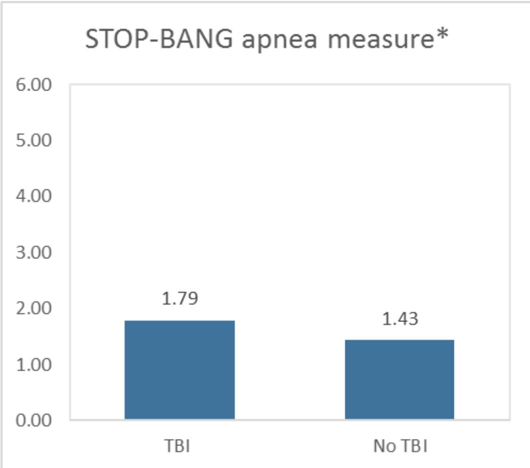


Figure 7. TBI and STOP-BANG
t(174) = 2.10, p < .05

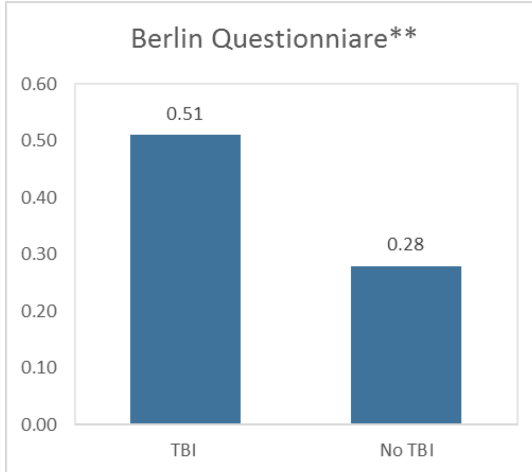


Figure 8. TBI and Berlin Questionnaire
t(174) = 2.72, p < .01

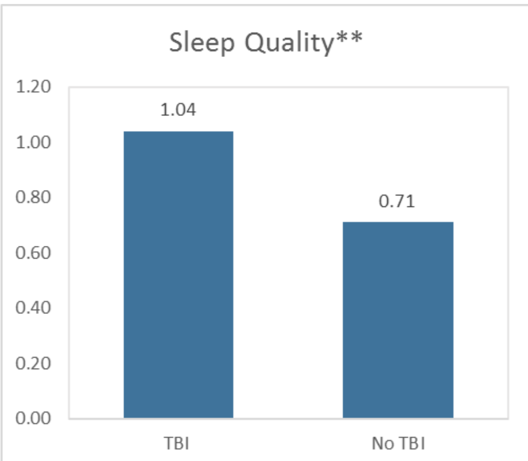


Figure 9. TBI and Sleep Quality
t(174) = 2.73, p < .01

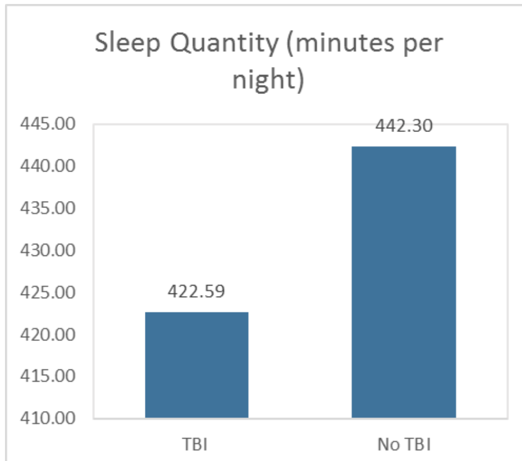


Figure 10. TBI and Sleep Quantity

Hypothesis 2 Figures: T-tests

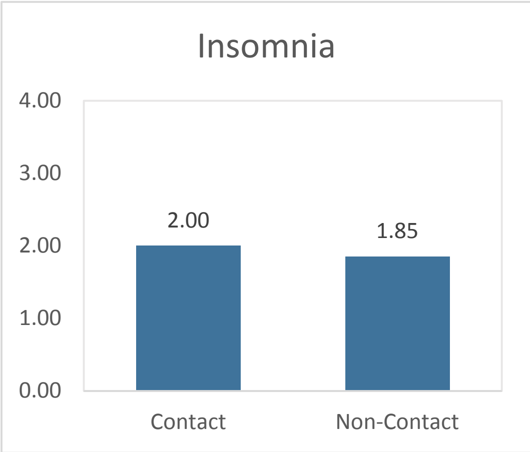


Figure 11. Contact and Insomnia

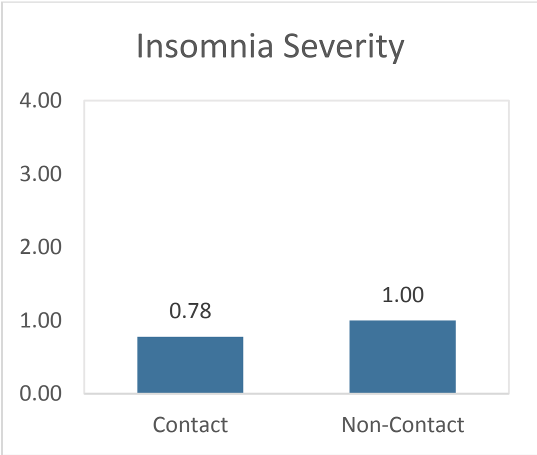


Figure 12. Contact and Insomnia Severity

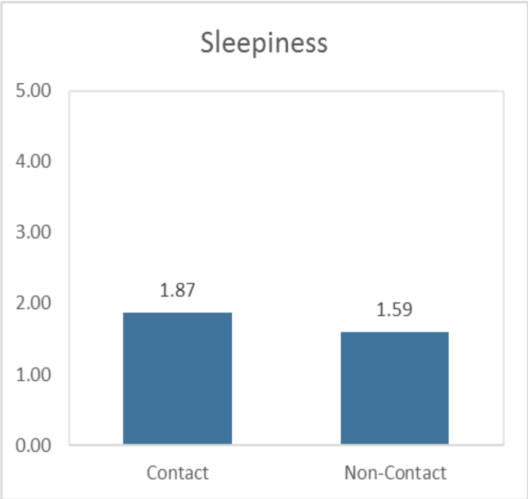


Figure 13. Contact and Sleepiness

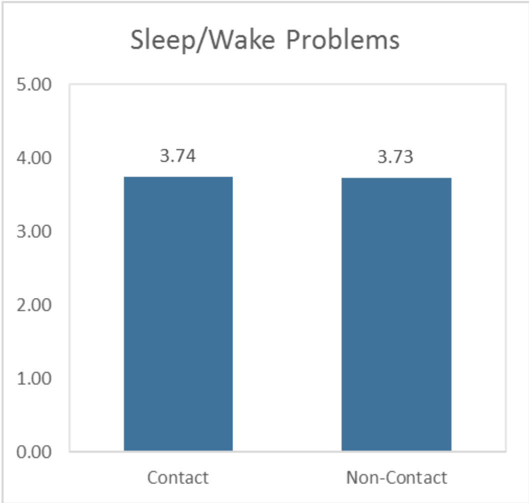


Figure 14. Contact and Sleep/Wake Problems

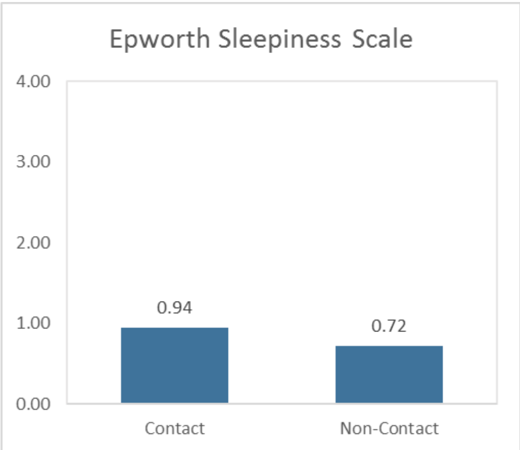


Figure 15. Contact and Epworth Sleepiness Scale

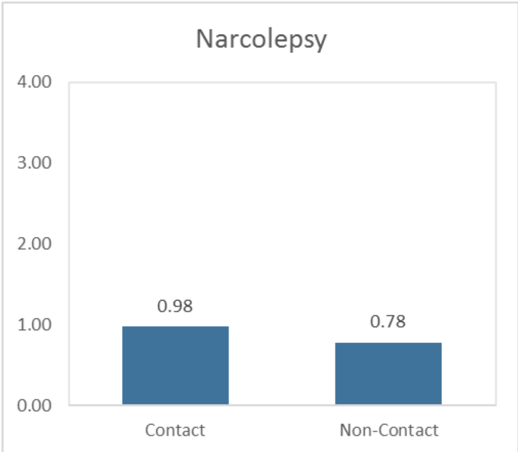


Figure 16. Contact and Narcolepsy

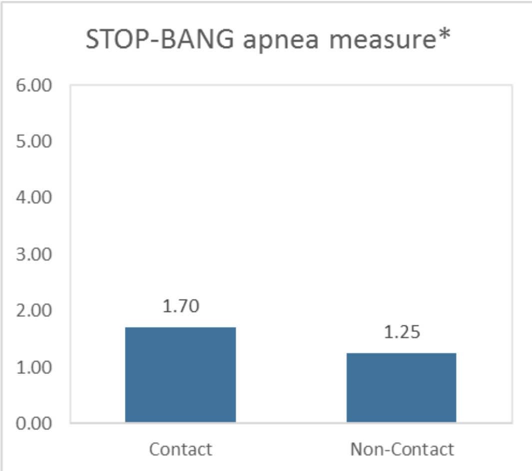


Figure 17. Contact and STOP-BANG; t(174) =2.28, p < .05

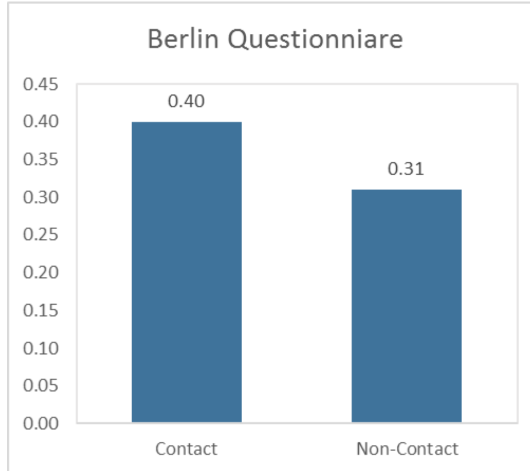


Figure 18. Contact and Berlin Questionnaire

Figure 19. Contact and Sleep Quality

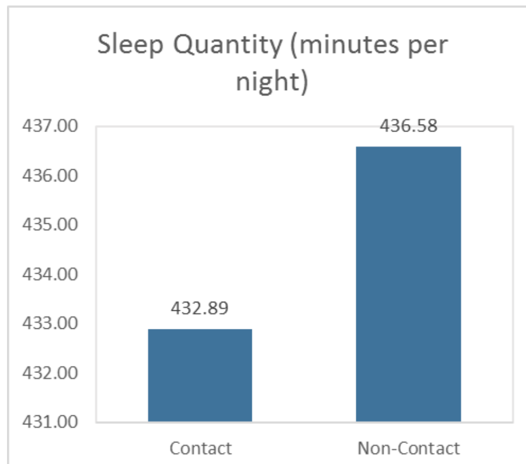


Figure 20. Contact and Sleep Quantity

Hypothesis 3 Figures: ANOVAs

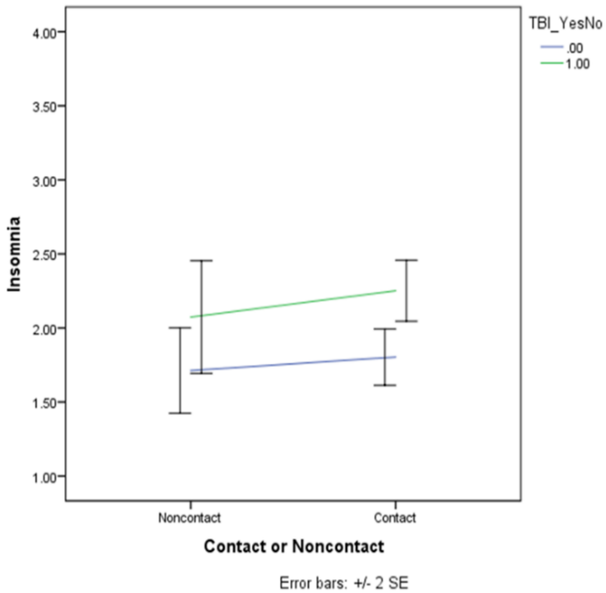


Figure 21. TBI, Contact, and Insomnia

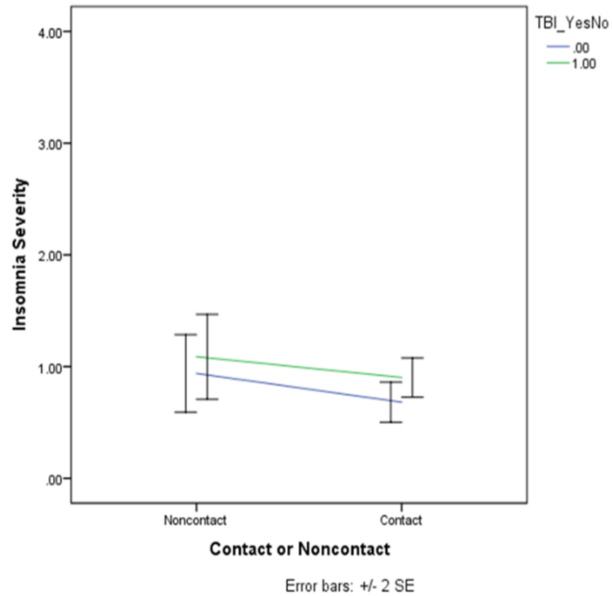


Figure 22. TBI, Contact, and Insomnia Severity

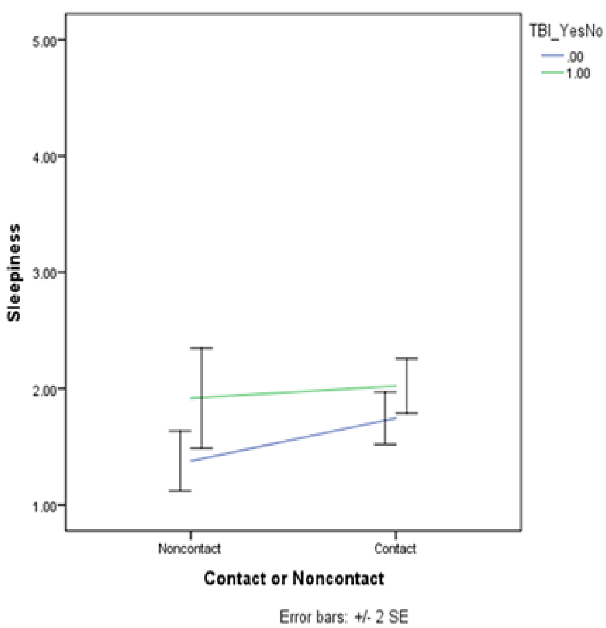


Figure 23. TBI, Contact and Sleepiness

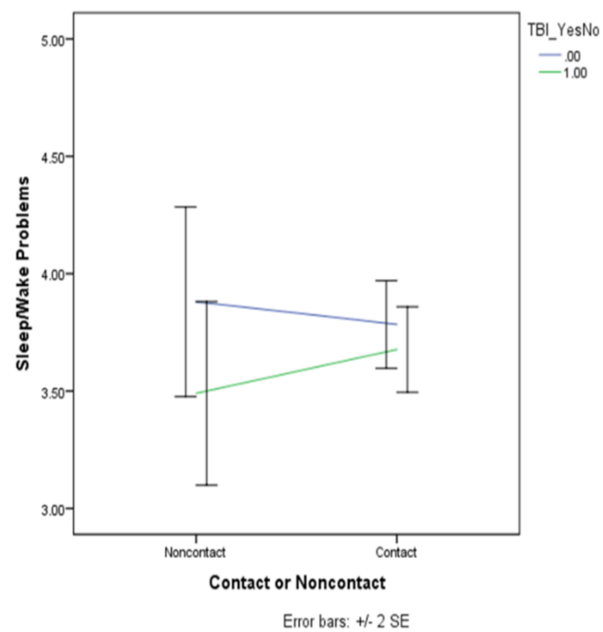


Figure 24. TBI, Contact and Sleep/Wake Problems

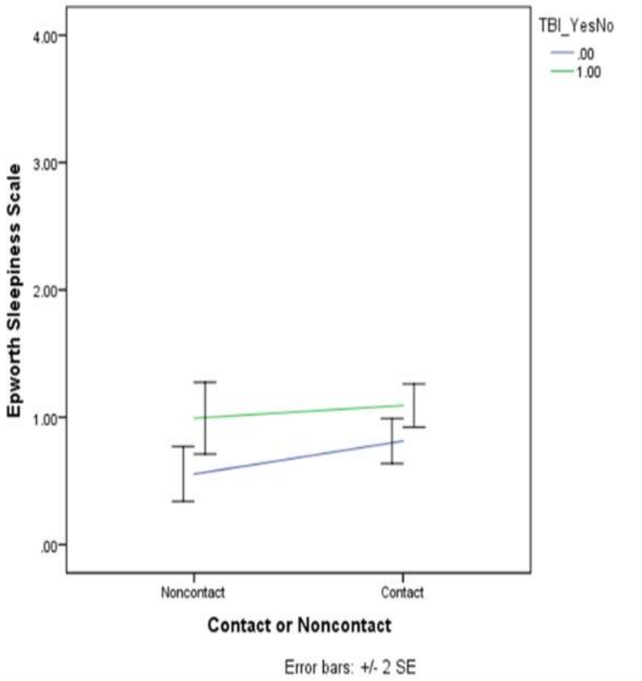


Figure 25. TBI, Contact, and Epworth Sleepiness Scale

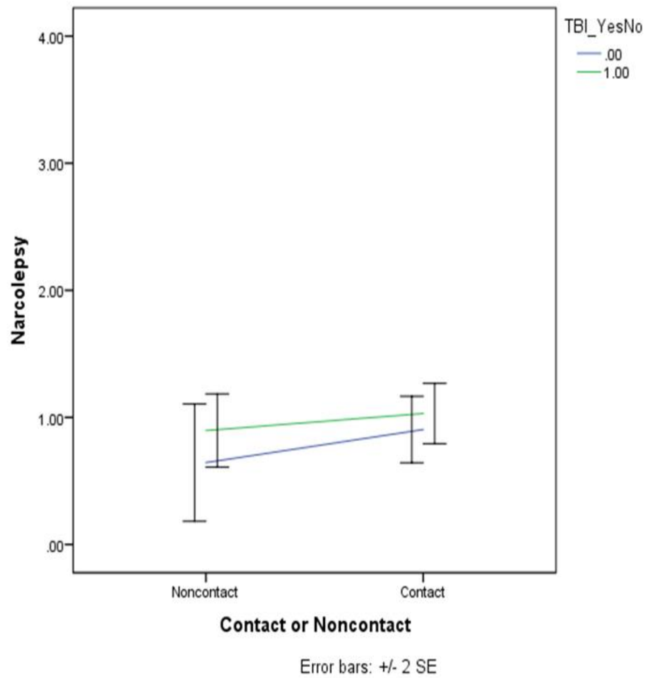


Figure 26. TBI, Contact, and Narcolepsy

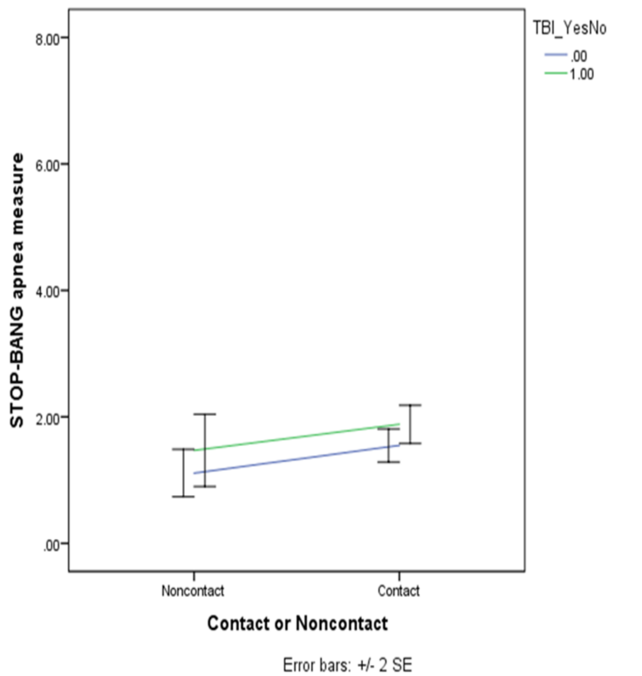


Figure 27. TBI, Contact, and STOP-BANG

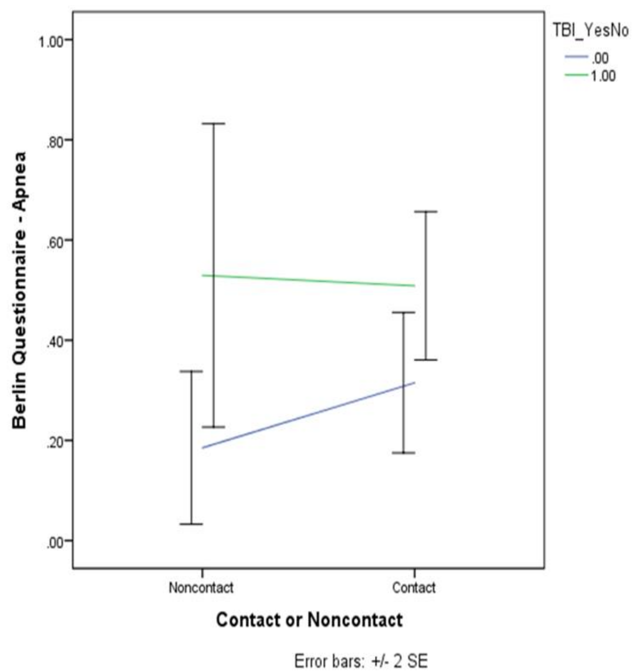
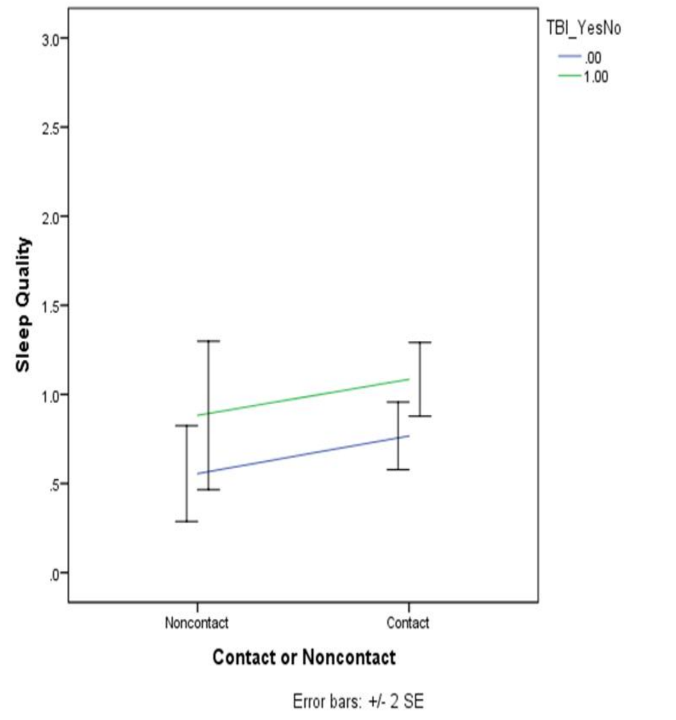


Figure 28. TBI, Contact, and Berlin Questionnaire



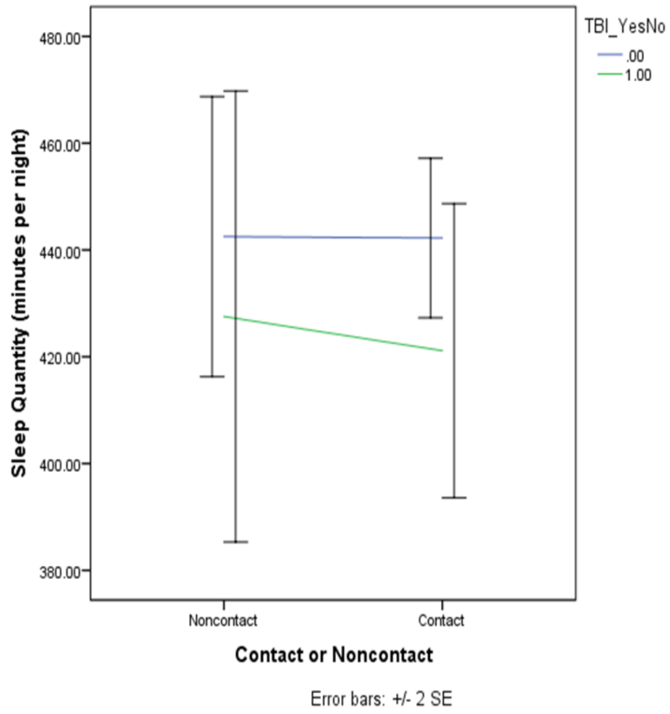


Figure 29. TBI, Contact, and Sleep Quality

Figure 30. TBI, Contact, and Sleep Quantity

Appendix

UNIVERSITY OF NORTHERN IOWA
HUMAN PARTICIPANTS REVIEW
INFORMED CONSENT

Project Title: Sleep and Participation in Physical Activity

Investigators: Olivia Rigdon and Dilbur D. Arsiwalla

Invitation to Participate: You are invited to participate in a research project conducted through the University of Northern Iowa. The following information is provided to help you made an informed decision about whether or not to participate.

Nature and Purpose: The purpose of this study is to examine the relationship between sleep and participation in physical activity among undergraduate student athletes.

Explanation of Procedure: You will be asked to complete an online survey. The survey will contain questions about your sleep habits and physical health. Participation in this study should take no more than 45 minutes.

Discomfort and Risks: There are minimal risks to your participation in this study. You may feel slightly uncomfortable answering some of the questions.

Benefits: There are no direct benefits for your participation. You will receive $1.20 on MTurk for your participation in this study.

Confidentiality: We will collect your worker ID and IP address; however, these IDs will be deleted after cleaning the data. All information and responses will be kept confidential and will not be available to anyone else. Your confidentiality will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet by any third parties. The summarized findings with no identifying information may be published in an academic journal or presented at a scholarly conference.

Right to Refuse or Withdraw: Your participation is completely voluntary. You are free to withdraw from this study, leave out any questions, or choose not to participate without any penalties.

Questions: If you have any questions, or wish to have further information about your participation in this study or further information in the study more generally, please contact Olivia Rigdon rigdono@uni.edu or Dilbur Arsiwalla <dilbur.arsiwalla@uni.edu>. You can also contact the Office of Research and Sponsored Programs, Director of Research, at 319-273-6148 for answers to questions about rights of research participants and the participant review process.

Agreement: Clicking on the Agree button below indicates that I am fully aware of the nature and extent of my participation in this project as stated above and the possible risks arising from it. I hereby agree to participate in this project. I am 18 years of age or older.

Participant Online Survey

I. Demographic Information:

Email Address: ______________________________

1) Please select the description that fits you best:
   a) I am currently a collegiate or professional athlete
   b) I was formerly a collegiate or professional athlete
   c) I have never been a collegiate or professional athlete
2) What is your age?
3) Sex:
   a) Female
   b) Male
4) Racial/ Ethnic background
   a) White/Caucasian
   b) African-American
   c) Hispanic / Latino
   d) Asian
   e) Native American
   f) Multiracial (please specify) ____
   g) Other (please specify) ____
5) Which sport are you an official collegiate athlete in? (Select all that apply)
   a) Football
   b) Soccer
   c) Wrestling
   d) Basketball
   e) Baseball
   f) Softball
   g) Volleyball
   h) Gymnastics
   i) Lacrosse
   j) Swimming
   k) Diving
   l) Track and field
   m) Cross country
   n) Tennis
   o) Golf
   p) Field hockey
   q) Rowing
   r) Other (please specify) ______________________________
6) Height ______/_______Feet/inches
7) Weight__________lbs

8) Compared to other people your age, would you say your health is:

a) Poor
b) Fair
c) Good
d) Excellent

9) Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good? _________________

10) Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good? ___________

11) During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation? ________________

12) Have you ever been told by a doctor, nurse, or healthcare professional that you have the following:

Chronic health conditions	Yes	No	Don't know/ Not Sure
High blood pressure			
High cholesterol			
Heart attack or myocardial infarction			
Angina or coronary heart disease			
Stroke			
Asthma			
Skin cancer			
Other kinds of cancer			
Chronic Obstructive Pulmonary Disease or COPD, emphysema or chronic bronchitis			
Arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?			
Depressive disorder, including depression, major depression, dysthymia, or minor depression?			
Kidney disease			
Diabetes			

13) Do you currently take any medication for ADHD or to help with concentration?

a) Yes
b) No

14) Do you have any disabilities or chronic illnesses (for example, asthma, diabetes, deafness, loss of use of a limb, etc.)?

a) Yes
b) No

15) How many days per week do you exercise for 30 minutes or more

a) 0 days
b) 1-2 days
c) 3-4 days
d) 5-7 days

II. Sleep time

For the next set of questions, choose the answer that best describes the way your sleep has been in the last two weeks.

1) What time do you go to bed on week days?___________ AM / PM
2) What time do you wake up on week days?____________AM/PM
3) On week days, after you go to bed at night, about how long does it usually take to fall asleep?____________Minutes
4) Figure out how long you usually sleep on a normal week night and fill it in. (Do not include time you spend awake in bed. Remember to mark hours and minutes even if the minutes are zero.)
Sleep time:__________hours ___________minutes.
5) What time do you go to bed on weekends?___________AM/PM
6) What time do you wake up on weekends?____________AM/PM
7) On weekends, after you go to bed at night, about how long does it usually take to fall asleep?____Minutes

8) Some people take naps in the daytime every day, others never do. Do you nap?

Yes/ No

If yes, how many hours a week do you nap?

____

9) Which of these sleep disorders have you ever been diagnosed with or treated for? (Please check all that apply)

a) Sleep apnea
b) Insomnia
c) Narcolepsy
d) Restless legs syndrome
e) Delayed sleep phase syndrome
f) None
g) Other ____

10) What is your ideal number of hours of sleep at night for you to function at an optimal level during the day? ____________________
11) After falling asleep, how many times do you typically wake up during the night? _____________
12) What is the approximate time in minutes that you are awake during these wake episodes? ______________
13) How many days out of the school/work week do you typically nap? __________________
14) How many days on weekends do you typically nap? ________________________
15) When do you nap on week days, how many hours per day are spent napping? ______________
16) When do you nap on weekends, how many hours per day are spent napping?______________

III. Sleep Habits Survey: Sleepiness Scale –Wolfson & Carskadon (1998)

During the last two weeks, have you struggled to stay awake (fought sleep) or fallen asleep in the following situations? (Mark one answer for every item.)

	Never	Struggled to stay awake	Fallen asleep	Both struggled to stay awake and fall asleep
1. In a face to face conversation with another person?	0	1	2	3
2. Travelling in a bus, train, plane, or car?	0	1	2	3
3. Attending a performance (movie, concert, play)?	0	1	2	3
4. Watching television or listening to the radio or stereo?	0	1	2	3
5. Reading, studying or doing work/homework?	0	1	2	3
6. During a test or when needing to focus at work?	0	1	2	3
7. In a class at school or a meeting at work?	0	1	2	3
8. While doing work on a computer or typewriter?	0	1	2	3
9. Playing video games?	0	1	2	3
10. Driving a car?	0	1	2	3

IV. Sleep Habits Survey: Sleep/ Wake Problems –Wolfson & Carskadon (1998)

In the last two weeks, how often have you: (Mark one answer for every item)

	Everyday/ night	Several times	Twice	Once	Never
1. Felt satisfied with your sleep?	4	3	2	1	0
2. Arrived late to class/work because you overslept?	4	3	2	1	0
3. Fallen asleep in a morning class/job?	4	3	2	1	0
4. Fallen asleep in an afternoon class/job?	4	3	2	1	0
5. Awakened too early in the morning and couldn't get back to sleep?	4	3	2	1	0
6. Stayed up until at least 3 a.m.?	4	3	2	1	0
7. Stayed up all night?	4	3	2	1	0
8. Slept in past noon?	4	3	2	1	0
9. Felt tired, dragged out, or sleepy during the day?	4	3	2	1	0
10. Needed more than one reminder to get up in the morning?	4	3	2	1	0
11. Had an extremely hard time falling asleep?	4	3	2	1	0
12. Had nightmares or bad dreams during the night?	4	3	2	1	0
13. Gone to bed because you just could not stay awake any longer?	4	3	2	1	0
14. Done dangerous things without thinking?	4	3	2	1	0
15. Had a good night's sleep?	4	3	2	1	0

V. THE 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 have not 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 = no chance of dozing
1 = slight chance of dozing
2 = moderate chance of dozing
3 = high chance of dozing

SITUATION	CHANCE OF DOZING
Sitting and reading	
Watching TV	
Sitting inactive in a public place (e.g a theater or a meeting)	
As a passenger in a car for an hour without a break	
Lying down to rest in the afternoon when circumstances permit	
Sitting and talking to someone	
Sitting quietly after a lunch without alcohol	
In a car, while stopped for a few minutes in traffic	

VI. The Pittsburg Sleep Quality Index

1. When have you usually gone to bed? ____
2. How long (in minutes) has it taken you to fall asleep each night? __________________
3. When have you usually gotten up in the morning? ______________________________
4. How many hours of actual sleep do you get at night? (This may be different than the number of hours you spend in bed) ____

5. During the past month, how often have you had trouble sleeping because you…	Not during the past month (0)	Less than one week (1)	Once or twice a week (2)	Three or more times a week (3)
Cannot get to sleep within 30 minutes				
Wake up in the middle of the night or early morning				
Have to get up to use the bathroom				
Cannot breathe comfortably				
Cough or snore loudly				
Feel too cold				

Feel too hot				
Have bad dreams				
Other reason(s), please describe, including how often you had trouble sleeping because of this reason(s):				
6. During the past month, how often have you taken sleep medication (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?				
	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)
9. During the past month, how would you rate your sleep quality overall?				

VII. Insomnia (SLEEP-50 Questionnaire)

Please respond to what extent a statement (item) has been applicable to you during the past 4 weeks.

	Not at all	Somewhat	Rather Often	Very Often
I have difficulty falling asleep				
Thoughts go through my head and keep me awake				
I worry and find it hard to relax				
I wake up during the night				
After waking up during the night, I fall asleep slowly				
I wake up early and cannot get back to sleep				

I sleep lightly				
I sleep too little				

VIII. Insomnia Severity Index

The Insomnia Severity Index has seven questions. The seven answers are added up to get a total score. When you have your total score, look at the 'Guidelines for Scoring/Interpretation' below to see where your sleep difficulty fits.

For each question, please CIRCLE the number that best describes your answer.
Please rate the CURRENT (i.e. LAST 2 WEEKS) SEVERITY of your insomnia problem(s).

Insomnia Problem	**None**	**Mild**	**Moderate**	**Severe**	**Very Severe**
1. Difficulty falling asleep	0	1	2	3	4
2. Difficulty staying asleep	0	1	2	3	4
3. Problems waking up too early	0	1	2	3	4

4. How SATISFIED/DISSATISFIED are you with your CURRENT sleep pattern?
    a. Very Satisfied
    b. Satisfied
    c. Moderately Satisfied
    d. Dissatisfied
    e. Very Dissatisfied

5. How NOTICEABLE to others do you think your sleep problem is in terms of impairing the quality of your life?
    a. Not at all Noticeable
    b. A Little
    c. Somewhat
    d. Much
    e. Very Much Noticeable

6. How WORRIED/DISTRESSED are you about your current sleep problem?
    a. Not at all Worried
    b. A Little
    c. Somewhat
    d. Much
    e. Very Much Worried

7. To what extent do you consider your sleep problem to INTERFERE with your daily functioning (e.g. daytime fatigue, mood, ability to function at work/daily chores, concentration, memory, mood, etc.) CURRENTLY?

a. Not at all Interfering
b. A Little
c. Somewhat
d. Much
e. Very Much Interfering

IX. STOP-BANG Sleep Apnea Questionnaire

Please answer the following questions with "yes" or "no".

STOP		
Do you **S**NORE loudly (louder than talking or loud enough to be heard through closed doors)?	Yes	No
Do you often feel **T**IRED, fatigued, or sleepy during daytime?	Yes	No
Has anyone **O**BSERVED you stop breathing during your sleep?	Yes	No
Do you have or are you being treated for high blood **P**RESSURE?	Yes	No

BANG		
BMI more than 35kg/m2?	Yes	No
AGE over 50 years old?	Yes	No

NECK circumference > 16 inches (40cm)?	Yes	No
GENDER: Male?	Yes	No

X. Berlin Questionnaire

1. Complete the following:
   Height:______________
   Weight:______________
   Age:________________
   Gender:_____________
2. Do you snore?
   a. Yes
   b. No
   c. Don’t know

If you snore...

3. Your snoring is?
   a. slightly louder than breathing
   b. as loud as talking
   c. louder than talking
   d. very loud. Can be heard in adjacent rooms.
4. How often do you snore?
   a. nearly every day
   b. 3-4 times a week
   c. 1-2 times a week
   d. 1-2 times a month
   e. never or nearly never
5. Has your snoring ever bothered other people?
   a. Yes
   b. No
6. Has anyone noticed that you quit breathing during your sleep?
   a. nearly every day
   b. 3-4 times a week
   c. 1-2 times a week
   d. 1-2 times a month
   e. never or nearly never
7. How often do you feel tired or fatigued after your sleep?
   a. nearly every day
   b. 3-4 times a week
   c. 1-2 times a week
   d. 1-2 times a month
   e. never or nearly never

8. During your waketime, do you feel tired, fatigued or not up to par?
    a. nearly every day
    b. 3-4 times a week
    c. 1-2 times a week
    d. 1-2 times a month
    e. never or nearly never
9. Have you ever nodded off or fallen asleep while driving a vehicle?
    a. Yes
    b. No

    If yes, how often does it occur?
        a. nearly every day
        b. 3-4 times a week
        c. 1-2 times a week
        d. 1-2 times a month
        e. never or nearly never
10. Do you have high blood pressure?
    a. Yes
    b. No
    c. Don't know

XI. Ullanlinna Narcolepsy Scale

INSTRUCTIONS

-For each item, select one answer.

-Add up your points, A total score above 14 is suggestive of narcolepsy with cataplexy.

1. When laughing, feeling glad or angry, or in an exciting situation, have the following symptoms suddenly occurred?

	Never	1-5 times during lifetime	Monthly	Weekly	Daily or almost daily
Knees buckling	0	1	2	3	4
Mouth opening	0	1	2	3	4
Head nodding	0	1	2	3	4
Falling down	0	1	2	3	4

2. How fast do you fall asleep in the evening?

>40 minutes	31-40 minutes	21-30 minutes	10-20 minutes	<10 minutes
0	1	2	3	4

3. Do you take naps during the day?

No need	I want to but cannot sleep	2 days or less a week	3-5 days a week	6-7 days a week
0	1	2	3	4

4. Do you fall asleep unintentionally during the day?

	Never	1-5 times during lifetime	Monthly	Weekly	Daily or almost daily
Reading	0	1	2	3	4
Traveling	0	1	2	3	4
Standing	0	1	2	3	4
Eating	0	1	2	3	4
Other unusual times	0	1	2	3	4

XII. TBI Definition

"TBI" stands for Traumatic Brain Injury, which occurs when an external force causes brain dysfunction, usually resulting from a violent blow to the head or body, or even an object penetrating the skull.

XIII. BISQ

For each event listed, record the number of times you experienced a blow in that type of situation.	For each blow to the head recorded in **Column A**, please answer the questions in **Column B**.																									
Column A	**Column B**																									
Have you ever experienced a blow to the head in the following situations?	Have you ever lost conciousness? (if yes, what was the longest duration?)	Don't know	< 1 min.	1-10 mins.	11-20 mins.	21-30 mins.	31-45 mins.	46-60 mins.	1 hr.-23 hrs.	1 day-1 week	1 wk-1 month	>1 month		Have you ever been dazed or confused? (is yes, what was the longest duration?)	Don't know	< 1 min.	1-10 mins.	11-20 mins.	21-30 mins.	31-45 mins.	46-60 mins.	1 hr.-23 hrs.	1 day-1 week	1 wk-1 month	>1 month	In what year(s) did this occur?
1. In a motor vehicle accident? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
2. In a motorcycle or ATV crash? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
3. As a pedestrian being hit by a vehicle? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
4.Being hit by a falling object? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	

5. Being hit by equipment? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
6.Falling down stairs? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
7.Falling from a high place? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
8.Falling during a fainting spell? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
9.Falling during a drug or alcohol blackout? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
10. Falling a way not otherwise listed? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
11.While biking, rollerblading, or skateboarding? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
12.While horseback riding? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
13.While skiing or snowboarding? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	

14.In sports (football, hockey, etc?) o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
15.While on the playground? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
16. While diving into water? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
17. Being assaulted or mugged? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
18.Being physically abused? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
19. While in combat? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	
20. Other? o No o Yes: ___ times ->	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	⇨	o No o Yes: ___ times	o	o	o	o	o	o	o	o	o	o	o	

If you believe you are having trouble with your sleep or any other health issues that maybe be associated with a TBI, please call your nearest medical center to speak with a health professional.