INCIDENCE OF PERCEIVED SLEEP APNEA IN DIVISION I FOOTBALL ATHLETES USING ANTHROPOMETRIC MEASUREMENTS AND A MODIFIED BERLIN QUESTIONNAIRE

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CHAPTER 1

INTRODUCTION

As the intensity and competitiveness of sports continues to evolve and increase with each sporting season, every type of athletic team is looking for an extra advantage to get ahead. In the football world, it seems that these advantages are acquiring and developing bigger, faster, and stronger athletes. While bigger athletes can mean increased strength and improved speed, larger athletes can also experience an increase in health risks. High body weight accompanied by high body fat percentage can result in obesity, which is associated with multiple health risks including hypertension, type two diabetes, coronary heart disease, stroke, osteoarthritis, some cancers, and sleep apnea (Centers for Disease Control and Prevention [CDC], 2007b).

Sleep apnea is a disordered sleep condition that currently affects over twelve million people in the U.S. (Holten, 2004). Approximately 2% of women and 4% of men suffer from this disorder in the general population (Holten, 2004; Wieber, 2005). Most people affected by sleep apnea are males, over the age of 30, who are overweight or obese, and have a short neck with a large circumference greater than 44 cm (Caples, Gami, & Somers, 2005). Risk factors for sleep apnea also include body mass index over 25 (Caples, et al., 2005) and high body weight (Netzer, Stoohs, Netzer, Clark, & Strohl, 1999). Sleep apnea is also associated with significant medical consequences such as an increased risk of hypertension (Nieto, et al., 2000; Peppard, Young, Palta, Skatrud, 2000), coronary vascular disease (Peker, Hedner, & Norum, 2002), congestive heart failure (Kaneko, Flores, & Usui, 2003), heart arrhythmias, and impotence (Goncalves, Guilleminault, & Ramos, 2005). Sleep apnea often goes undiagnosed because many people do not realize that they have the condition. Not only is sleep apnea linked to these serious medical conditions, but it severely affects the quality of life of individuals who suffer from sleep apnea. While much research regarding sleep apnea pertains to the general population, little research has investigated the incidence of sleep apnea in an athletic population. Due to current trends in athletics that emphasize larger size, it would seem that this larger athletic population could potentially suffer from this condition.

Purpose for the Study

The purpose of this research is to investigate the risk factors associated with sleep apnea in an athletic population. Anthropometric measurements (height, weight, neck circumference, and body mass index) and the results of a modified Berlin Questionnaire are used to investigate and to determine the perceived incidence of sleep apnea in an athletic population. Using a population of football athletes, height, weight, neck circumference, and body mass index will be obtained for each subject. These measurements will be used to investigate whether there is a statistically significant difference in the values of these measures from football linemen to the remaining football positions. In addition, this research will also investigate if a correlation exists between weight (kg) and neck circumference (cm), body mass index (kg/m^2) and neck circumference (cm), neck circumference (cm) and Berlin score, and weight (kg) and Berlin score.

This research study may indicate a need to screen for sleep apnea during pre-participation physicals in athletics. Pre-participation physicals are medical exams performed by physicians that clear athletes for participation in sports. This type of exam looks for medical conditions that would be detrimental to individuals playing sports. This exam also takes a health history to determine the individual's readiness to begin athletic activity. Due to the multitude of health risk factors associated with sleep apnea as mentioned previously, there may be a need to screen for this condition in athletes. If a large number of athletes are found to present with risk factors of sleep apnea, pre-participation physicals may need to add sleep apnea screening questions.

Need for the Study

Due to the increasing size of football linemen, especially offensive linemen (Secora, Latin, Berg, & Noble, 2004), over the past several decades, it is a distinct possibility that these larger athletes could be at higher risk of having sleep apnea. It would seem that larger athletes would have increased risks of developing sleep apnea, and this study may address the need to implement screening techniques to identify at-risk individuals in athletic populations. Suffering from sleep apnea can lead to a decrease in quality of life that includes daytime sleepiness, difficulty concentrating, memory problems, mood swings, and overall sluggishness (National Heart, Blood, and Lung Institute [NHBLI], 2008b). These factors could possibly present themselves on the athletic field which could result in decreased athletic performance. Not only would identifying individuals with sleep apnea improve their individual quality of life, but it may also improve overall participation in the classroom and on the athletic field.

Hypotheses

1. Offensive and defensive linemen will have statistically significantly different values for variables of height, weight, body mass index, neck circumference, and Modified Berlin Questionnaire scores when compared to the remaining football positions (quarterbacks, wide receivers, running backs, tight ends, defensive backs, linebackers, kickers, punters, place holders, and snappers); placing the linemen at higher risk for sleep apnea.
2. There will be a positive correlation between subject weight (kg) and subject neck circumference (cm).
3. There will be a positive correlation between subject body mass index (kg/m^2) and neck circumference (cm).
4. There will be a positive correlation between subject neck circumference (cm) and Berlin score (a score of 0-2).
5. There will be a positive correlation between subject weight (kg) and Berlin score (a score of 0-2).

Delimitations

The following study was delimited to:

1. The data collected was from Division I collegiate football players who participated on the Oklahoma State University football team in the 2007-2008 school year.
2. All subjects (80 athletes) were males between 17-24 years of age.
3. Each subject completed a Modified Berlin Questionnaire.
4. The investigator obtained anthropometric measurements from each subject, including height (in inches and meters), weight (in pounds and kilograms), and neck circumference (in centimeters).
5. The investigator calculated body mass index from the current height (m) and weight (kg) measurements.
6. The Modified Berlin Questionnaire was administered in the Main Athletic Training Room, located in Gallagher-Iba Arena, Stillwater, Oklahoma, where the researcher explained the questionnaire and was available for questions.
7. Anthropometric measurements were obtained by the principle investigator on the same day and location as the subject completed the Modified Berlin Questionnaire.
8. The Modified Berlin Questionnaire was scored by one individual, the principle investigator.
9. All anthropometric measurements were measured and recorded by one individual, the principle investigator.

10. Data collection took place from January 22, 2008 – February 11, 2008.

Limitations

These limitations were recognized during the course of the study:

1. The subjects were not randomly sampled.
2. The convenience sample of Oklahoma State University football players (n = 80) may not represent all football programs.
3. The subjects were asked to recall and remember current sleep activities and current symptoms of daytime sleepiness.
4. The subjects were asked to recall if they had been told by a physician that they had high blood pressure at any point in time.
5. The electric scale used to obtain subject weight was not calibrated for each subject.

Assumptions

The following assumptions were made during the course of the study:

1. All subjects completed the Modified Berlin Questionnaire honestly and correctly.
2. The Modified Berlin Questionnaire was administered and explained in the same fashion to every subject by the principle investigator.

Definition of Terms

1. **<u>Apnea:</u>** involves upper-airway collapse and is defined as nearly complete cessation of airflow associated with oxygen desaturation or an arousal from sleep (Caples, et al., 2005).
2. **<u>Apnea/Hypopnea Index (AHI):</u>** a measure used to diagnose and determine severity of sleep apnea; it is the average number of apneas or hypopneas; an AHI greater than 10 is indicative of sleep apnea (Caples, et al., 2005).
3. **<u>Atherosclerosis:</u>** a disease in which plaque builds up along the walls of arteries and can eventually result in stroke or heart attack (NHLBI, 2007).
4. **<u>Berlin questionnaire:</u>** a sleep questionnaire that was developed from information gathered by pulmonary specialists and primary care physicians from the United States and Germany in 1996; questions are organized into subjects of daytime sleepiness, sleepiness and driving, snoring behaviors, history of high blood pressure, and body mass index (Netzer, et al., 1999).
5. **<u>Body Mass Index (BMI):</u>** A measure calculated from an individual's height and weight using the formula: weight (kg)/height $(m)^2$; this measure is considered a reliable measure for body fatness; a normal, healthy body mass index is between 18.5 – 24.9 kg/m^2 (CDC, 2007a).
6. **<u>Continuous Positive Airway Pressure (CPAP):</u>** a conservative treatment for sleep apnea; a breathing treatment that utilizes continuous pressure which acts as a pneumatic splint to keep the pharyngeal airway open (Victor, 2004).

7. **<u>Genioglossus and Hyoid Advancement:</u>** a surgical procedure used to treat sleep apnea that pulls the tongue muscles forward in the mouth to open the obstructed airway (Victor, 2004).

8. **<u>Hypopnea:</u>** associated with a partial collapse of the upper airway (Caples, et al., 2005).

9. **<u>Polysomnography:</u>** a sleep study; this study is used to diagnose sleep apnea.

10. **<u>Rapid Eye Movement (REM) sleep:</u>** the deepest, most important, and final stage of sleep (Culebras, 1996; Edelman & Santiago, 1986); individuals with sleep apnea may never progress to this stage of sleep, resulting in daytime sleepiness and drowsiness (Culebras, 1996; Edelman & Santiago, 1986).

11. **<u>Rhinoplasty:</u>** a surgical procedure used to treat sleep apnea involving reconstruction of the nose.

12. **<u>Septoplasty:</u>** a surgical procedure used to treat sleep apnea involving the correction of a deviated nasal septum.

13. **<u>Sleep apnea</u>** – a sleep disorder that results in a cessation of breathing. There are three types of sleep apnea: obstructive sleep apnea, central sleep apnea, and mixed sleep apnea.

    a. **<u>Central Sleep Apnea:</u>** a type of sleep apnea that is characterized by the cessation of respiration, which can be associated with hypoxemia (Culebras, 1996; Victor, 2004); the area of the brain that controls breathing does not send correct signals to breathing muscles (NHLBI, 2008b).

b. **<u>Mixed:</u>** a combination of obstructive sleep apnea and central sleep apnea (Culebras, 1996); mixed apneas occur in individuals with obstructive sleep apnea as their respiratory alteration may result in a central apnea (Culebras, 1996; Victor, 2004).

c. **<u>Obstructive Sleep Apnea:</u>** a type of sleep apnea that is characterized by repetitive partial (hypopnea) or complete (apnea) obstruction of airway that results in a cessation of breathing (Caples, et al., 2005).

14. **<u>Tonsillectomy:</u>** a surgical procedure used to treat sleep apnea involving the removal of tonsils.

15. **<u>Uvulopalatopharyngoplasty (UPPP):</u>** a surgical procedure used to treat sleep apnea involving the removal of the uvula and a portion of the soft palate.

CHAPTER II

LITERATURE REVIEW

As the world of collegiate athletics continues to change and evolve over time, there has been a continuing trend that involves acquiring and developing larger collegiate athletes. Larger athletes include traits such as increased height, weight, and muscle mass in conjunction with improved speed. While this trend to create and develop larger athletes may benefit the overall success of the athletic team, increased body weight can be detrimental to individual athletes. One detrimental effect of increased body weight includes sleep apnea. Sleep apnea is a breathing disorder that typically affects males, over the age of 30 who are overweight or obese, have a body mass index over 25, high body weight, and a neck circumference greater than 44 centimeters (Caples, et al., 2005; Netzer, et al., 1999). While the majority of individuals who suffer from sleep apnea are older males, it seems that active football players may also be at risk for this condition due to their increasing size over time.

Body Composition of Collegiate Football Athletes

Over the past several decades, football athletes have evolved into larger individuals, especially in offensive and defensive linemen. This is due in part to the increasing competitiveness of collegiate athletics. Athletic participation includes not only the competitive season, but also intensive strength and conditioning training that continues throughout the calendar year. While developing lean mass is the ultimate goal, weight gain during the off-season may increase unwanted body fat in addition to fat free mass. Research has noticed an on-going trend that present collegiate football athletes are larger than football athletes from decades past. Total body mass, skin-fold thicknesses, and body fat have been shown to be greater in current collegiate football players than from collegiate football players from the early 1980s to the early 1990s (Noel, VanHeest, Zaneteas, & Rodgers, 2003). Earlier studies showed that football athletes from Division I programs were stronger, faster, taller, and heavier in the 1980s as compared to the 1970s (Olson & Hunter, 1985). In a study conducted by Secora, Latin, Berg, and Noble (2004), the authors found that current offensive linemen have increased body mass, increased fat free body mass, and a higher percentage of body fat when compared to athletes from the 1980s.

Other current findings include that both offensive and defensive linemen and tight ends are presenting with higher percentages of body fat. In a study by Noel, et al. (2003), on average, offensive linemen, defensive linemen, and tight ends presented with greater than 25% body fat, the borderline for obesity in their perspective age group. Much of the fat was found to be abdominal fat which has been associated with ischemic heart disease and stroke (Noel, et al., 2003). These findings were increased values when compared to previous data (Noel, et al., 2003). However, this larger body size did not only present itself in larger players, but smaller players as well. All players were on average larger in total body mass than players of similar competitive level in the early 1980s (Noel, et al., 2003). This finding may suggest that while players are attempting to get larger, this increase in body mass may not always be an increase in fat free mass.

In some cases, collegiate football players move on to compete in professional football leagues, including the National Football League (NFL). Collegiate players that make the transition to professional football may have less body fat after playing professionally than when they began their collegiate career (Kaiser, et al., 2008). This may indicate that overall body mass increases, but that body fat percentage does not after entering professional football. While professional football players do not have diminished life expectancies, players with high body mass indexes have been estimated to be six times more likely to die from cardiovascular disease (Baron & Rinsky, 1994). This high body mass index and high body weight may also be retained after retirement from football and further increases risks of cardiovascular disease (Kaiser, et al., 2008).

Due to the overall trend that collegiate football players are continuing to get larger over time, this indicates the possibility for increased health risks associated with high body weight. The risk of sleep apnea is typically associated with older individuals with high body weight, but research has not indicated prevalence in an athletic population. Due to large body weight and body size, football players should be seen as an at-risk group for developing sleep apnea.

Sleep Apnea

There are three types of sleep apnea: obstructive sleep apnea, central sleep apnea, and mixed sleep apnea. Obstructive sleep apnea (OSA) is characterized by repetitive partial (hypopnea) or complete (apnea) obstruction of airway that results in a cessation of breathing (Caples, et al., 2005). Breathing pauses can last from a few seconds to minutes and may occur five to 30 times or more an hour (NHLBI, 2008b). Obstructions that may cause hypopneas or apneas can originate in the mouth and throat or the nose. These obstructions include enlarged tonsils, excessive soft palate tissue, an enlarged uvula, the tongue falling back into the airway, a deviated septum, inflamed turbinates and chronic sinusitis (Culebras, 1996; Caples, et al., 2005). When the airway is blocked, the lungs try to bring in more air, but inspiration is not successful due to the airway obstructions resulting in oxygen desaturation (Culebras, 1996). Eventually the central nervous system steps in to generate an inspiration great enough to open the airway (Caples, et al., 2005). Typically this results in an arousal of the individual; essentially the individual's body wakes up when he or she begins breathing again (Caples, et al., 2005; Culebras,1996; Mansoor, 2004; Victor, 2004).

Central sleep apnea (CSA) is characterized by the cessation of respiration, which can be associated with hypoxemia (Culebras, 1996; Victor, 2004). Unlike OSA, in individuals with CSA there is no respiratory effort and once breathing begins again they may gasp, choke, or grunt (Caples, et al., 2005; Culebras, 1996; Victor, 2004). The area of the brain that controls breathing does not send correct signals to breathing muscles and there is no breathing effort (NHLBI, 2008b).

Mixed sleep apnea is a combination of obstructive sleep apnea and central sleep apnea (Culebras, 1996). Mixed apneas occur in individuals with obstructive sleep apnea as their respiratory alteration may result in a central apnea (Culebras, 1996; Victor, 2004). The central apnea occurs first and results in an obstructive apnea (Victor, 2004).

Regardless of the type of apnea, individuals who have sleep apnea suffer from physical and physiological effects that greatly affect their quality of life. Signs and symptoms of sleep apnea include snoring with pauses in breathing, daytime sleepiness (especially when driving), poor judgment, inability to focus, memory loss, irritability, depression, and morning headaches (Caples, et al., 2005; Culebras, 1996; Holten, 2004). Daytime sleepiness can have a huge impact on society due to sleep apnea-related car collisions. In 2000, over 800,000 drivers were involved in sleep apnea-related car collisions and treating all drivers who have sleep apnea would save 980 lives per year (Sassani, et al., 2004).

Daytime sleepiness occurs in conjunction with sleep apnea because individuals with sleep apnea do not sleep soundly or completely through the night. Every time the individual stops breathing and restarts again, the body and central nervous system is aroused, essentially waking the person (Culebras, 1996). However, the individual does not know that he or she has awoken. Constant arousal does not allow the individual to progress through the five stages of sleep. Because these individuals cannot progress properly through all sleep stages, these individuals do not feel well rested. Their bodies constantly awaken throughout the night, but the individual is not aware that it occurs (Culebras, 1996).

Normal individuals properly progress from stage one to stage four sleep and end the sleep cycle in rapid eye movement (REM) sleep. This sleep cycle lasts about 90 minutes and repeats four to five times throughout the night (Culebras, 1996). Individuals who suffer from sleep apnea do not progress through the entire sleep cycle as effectively. They may remain in sleep stage three or four and may never progress to REM sleep, the deepest and most important stage of sleep (Culebras, 1996; Edelman & Santiago, 1986).

A change in nerve activity may also contribute to daytime sleepiness. During normal sleep, sympathetic nerve activity decreases compared to levels during the day

(Mansoor, 2004). In individuals with sleep apnea, nerve activity is greatly increased both at night and during the day (Mansoor, 2004), thus making the individual feel increasingly fatigued and tired. The exact reason for this phenomenon is unknown (Mansoor, 2004).

Health Risks of Sleep Apnea

Sleep apnea has been shown to be highly associated with hypertension. The prevalence of sleep apnea and hypertension is 22-48% in the general population (Wieber, 2005). Blood pressure in individuals with OSA is increased when the individual is asleep, due to increased respiratory effort, and this phenomenon continues when the individual is awake (Wieber, 2005; Caples, et al., 2005; Culebras, 1996). Hypertension in individuals with OSA may be a result of increased sympathetic nerve activity, but the exact reason for this connection is unknown (Mansoor, 2004). In addition to this finding, Nieto, et al., (2000) found that hypertension is highly correlated to individuals with sleep apnea who present with a high apnea/hypopnea index or sleep time below 90% oxygen saturation. The findings of this study also suggested an independent association between sleep apnea and hypertension, but no reason as to why this association may exist (Nieto, et al., 2000). This connection may also exist due to additional common traits including obesity and high body mass index (Nieto, et al., 2000). It may be that the combination of the multitude of risk factors (high body weight, body fat, body mass index, and sleep apnea) that when found together may be linked to sleep apnea (Nieto, et al., 2000). While the exact connection is uncertain, there appears to be a definite link between hypertension and sleep apnea.

Heart arrhythmias have also been associated with sleep apnea. While arrhythmias during sleep can occur in healthy individuals, individuals with sleep apnea appear to have increased arrhythmic events during sleep. These arrhythmias appear to be related to sleep apnea severity and were found to have a 58% prevalence of arrhythmias in a patient population (Hoffstein & Mateika, 1994). In connection with heart arrhythmias, vascular dysfunction has also been linked to sleep apnea and may contribute to arrhythmic events (Hoffstein & Mateika, 1994). Vascular dysfunction may result from an increase in levels of endothelin, a vasoconstrictor which is known to lead to abnormal cardiac events, and is found in individuals with obstructive sleep apnea (Caples, et al., 2005). Sleep apnea may also be linked to beginning stages of atherosclerosis (Wieber, 2005), but this link is not fully understood. Atherosclerosis is a disease in which plaque builds up along the walls of arteries and can eventually result in stroke or heart attack (NHLBI, 2007).

While research is lacking addressing the link between sleep apnea and heart failure, there seems to be an indirect link between the two conditions. At least 10% of patients with heart failure have clinically significant sleep apnea (Caples, et al., 2005). Heart failure is linked to hypertension and hypertension is linked to sleep apnea, so the two conditions together may be indirectly linked (Caples, et al., 2005).

Due to the link between sleep apnea and high body weight, metabolic processes tend to be altered in individuals with sleep apnea. It is often found that in the year before diagnosis, individuals have experienced a 10% weight gain (Caples, et al., 2005). Due to the link between high body weight and sleep apnea, those with sleep apnea have been found to have a higher prevalence of insulin resistance and diabetes mellitus (Caples, et al., 2005). Insulin resistance has been shown to be an independent determinant of hypertension (Ip, et al., 2002). Individuals with sleep apnea have also been found to have an abnormal structure of the protein leptin, an appetite suppressant (Caples, et al., 2005). This abnormal leptin structure may be a predisposing factor for obesity (Caples, et al., 2005) which then may result in sleep apnea.

Diagnosis

Typically if one is suspected to have sleep apnea, the individual visits his or her primary care physician. The physician may gather health history information as well as family history information and conduct a physical examination. If symptoms lead to sleep apnea, then the physician will recommend a sleep study. Sleep apnea is clinically diagnosed by polysomnography, also known as a sleep study. Polysomnography is typically performed over a two night period at a hospital. The first night is used to measure physiological activity of the individual without treatment and the second night is used to determine the dosage and effectiveness of Continuous Positive Airway Pressure (CPAP) treatment. CPAP is a conservative breathing treatment administered during sleep that provides relief for many individuals with sleep apnea. The study can be completed in one night, known as a split-night study, in order to save money for insurance purposes (Victor, 2004). An individual spends the night in a normal bed, but is hooked up to several electrodes that measure brain, heart, and respiratory activity.

During the study, the average number of apneas or hypopneas is found, and this is known as the apnea/hypopnea index (AHI). An AHI greater than 10 is indicative of sleep apnea (Caples, et al., 2005). Brain wave activity is monitored to observe the individual's progression through the sleep cycle. After sleep has been observed, the CPAP breathing treatment is administered to the individual. CPAP breathing treatment is administered by placing a mask on the individual's face. This mask is hooked to an airway machine. CPAP treatment begins to see if a specific pressure will decrease or eliminate the apneas. In CPAP treatment, the pressure delivered to the patient is the same for any given breath (Victor, 2004). The pressures produced by CPAP treatment act as a pneumatic splint to keep the pharyngeal airway open (Victor, 2004). If CPAP treatment is found to be successful during the sleep study, then the individual can begin nightly CPAP treatment on his or her own. Some individuals do not find relief from CPAP breathing treatment due to predisposing factors such as nasal or throat obstructions (Victor, 2004). If the CPAP breathing treatment is successful during the sleep study, then the individual must be referred to a ear nose and throat specialist for further evaluation to determine specific obstructions.

Treatment

There are multiple options for treating sleep apnea, but the correct treatment is determined by the exact cause of the apnea. If the exact cause of the apnea is not determined, then the apnea can never be corrected. A majority of individuals with sleep apnea find relief from nightly CPAP breathing treatment. CPAP treatment reduces ventricular irritability (Wieber, 2005) which helps to alleviate the apnea. It has also been found that CPAP treatment may decrease platelet activation and aggregation (Bokinsky, et al., 1995) that may be associated with sleep apnea, thereby decreasing cardiac risk (Wieber, 2005). CPAP breathing treatments are administered by a face mask that can be large, uncomfortable and hard to tolerate. These treatments are not cures and only alleviate sleep apnea when they are used (Victor, 2004). If the individual discontinues using the breathing treatment, the apnea will return. Apneas caused by nasal or throat obstructions will be unsuccessful with CPAP breathing treatments (Victor, 2004).

For those who do not have success with CPAP breathing treatments, surgery may be the next option. Often times several surgical procedures will be combined in order to effectively eliminate the obstructions. These surgical procedures include a tonsillectomy, uvulopalatopharyngoplasty (UPPP) which involves removing the uvula and a portion of the soft palate, septoplasty, rhinoplasty, and genioglossus and hyoid advancement that pulls the tongue muscles forward to open the obstructed airway (Victor, 2004). Research has shown that UPPP has a relatively low success rate when performed alone, but research has not indicated success when combined with other procedures (Caples, et al., 2005; Victor, 2004). Often times the use of CPAP breathing treatment may be needed after the surgical procedures if the sleep apnea was not successfully eliminated with surgery.

A less invasive treatment includes using a dental device. Dental devices may be used to gradually move the lower jaw forward (Holten, 2004). These appliances are fitted by a dentist and are worn at night. By pulling the jaw forward this may decrease the amount of tongue mass at the back of the throat (Holten, 2004).

Other treatments may include adopting lifestyle changes that may alleviate symptoms without the other invasive treatments mentioned above. However, these lifestyle changes may also need to be performed in conjunction with any of the above mentioned treatments as well. Some changes may include refraining from drinking alcohol or drowsy medications (NHLBI, 2008a). Alcohol and sedatives may make it more difficult for the throat to stay open during sleep (NHLBI, 2008a). Losing weight may also be recommended (NHLBI, 2008a), as this may decrease the amount of mass in the throat, decreasing the chance for an apnea to occur during sleep. Sleeping on one's side is also recommended because this facilitates the opening of the airway while sleeping (NHLBI, 2008a). One is to avoid sleeping on his or her back because this position may contribute to airway blockage (NHLBI, 2008a).

Sleep Apnea in Athletics

While it is evident that sleep apnea can lead to serious health consequences, it is important to realize that these symptoms may be present in collegiate football athletes. Collegiate football players may present with classic predisposing factors for sleep apnea including high body weight, high body mass index, and a large neck circumference. Little research has investigated the incidence of sleep apnea in athletic populations despite the numerous predisposing conditions for sleep apnea.

In current literature searches, no current or previous studies have investigated the incidence of sleep apnea in collegiate football athletes. One study conducted by George, Kab, Kab, Villa, and Levy (2003) has investigated a link between sleep apnea and professional football players. The population in this study was found to be sleepier than expected with an increased prevalence of sleep disordered breathing (George, et al., 2003). When compared to previous studies regarding prevalence of sleep apnea in the general population, the athletic population in this study had a 14% prevalence estimate for sleep apnea in the entire studied population, with a 34% prevalence estimate for sleep apnea in the special high risk athletes (George, et al., 2003). These rates were five times greater and eleven times greater respectively when compared to prevalence rates in the general population (Bixler, Vgontzas, Have, Tyson, & Kales, 1998). These findings are quite astonishing and could mean that sleep apnea may affect dozens of individuals on one specific sports team.

Some research has investigated the association between physical activity and sleep apnea. This research was not necessarily performed on conditioned athletes; however physical activity was used as more of a conditioning and treatment for sleep apnea. Research by Vanuxem, et al. (1997) found that individuals with sleep apnea who exercised had lower maximum load and lower peak oxygen uptake. Results of this study also discovered that individuals with sleep apnea had lower lactate concentration with minimized lactate removal (Vanuxem, et al., 1997). Lactate concentration and poor lactate removal in the blood stream is associated with muscular fatigue (Wilmore & Costill, 2004). The authors inferred that this could result in impaired glycolytic metabolism and oxidative metabolism (Vanuxem, et al., 1997). Glycolytic metabolism is responsible for providing energy during quick, fast movements and oxidative metabolism is responsible for providing energy during prolonged bouts of physical activity.

These medical conditions could be translated to the athletic field in athletic individuals with undiagnosed sleep apnea. If the above findings were true, then athletes with sleep apnea would not be able to perform athletic activity at maximal effort. Because oxidative metabolism delivers oxygen to the muscles during exercise (Wilmore & Costill, 2004) and oxidative metabolism may be impeded in individuals who suffer from sleep apnea (Vanuxem, et al., 1997), the pulmonary system may have difficulty adapting to athletic activity. This could prevent adequate oxygen and blood from reaching the muscles resulting in premature muscular fatigue during athletic activity.

Glycolytic metabolism is associated with the lactic acid system; as the glycolytic system begins to slow down during sprinting activities, lactic acid accumulates in the muscles (Wilmore & Costill, 2004). This increased acidity in the muscles inhibits further glycogen breakdown and may impede muscle contraction (Wilmore & Costill, 2004). As Vanuxem, et al. (1997) indicated, individuals with sleep apnea had minimized lactate removal. If this is true, then the lactic acid in the muscles may accumulate sooner without lactate removal, resulting in decreased muscle function.

In individuals with sleep apnea who may have diminished efficiency of glycolytic and oxidative metabolism, the may not be able to perform quick bursts of energy or prolonged bouts of athletic activity as well as individuals without sleep apnea. This has major athletic implications for athletes. The nature of the role of football linemen is to perform short, quick movements repeatedly over time. A football lineman who suffers from sleep apnea may not be able to be as quick performing specific drills or specific team plays.

Athletes who currently participate with undiagnosed sleep apnea may be participating below their potential. Not only would athletes with sleep apnea suffer on the athletic field, but they would also be at risk for the numerous health risks mentioned previously. Sleep apnea is associated with multiple health risks and a poor quality of life. It is important to screen for individuals who could be at high risk for developing sleep apnea because individuals who have sleep apnea typically do not know that they have the disorder. This research is needed to investigate the possibility of sleep apnea in an athletic population. As mentioned, football linemen seem to present with high risk factors for sleep apnea. This research would investigate whether there is a link to sleep apnea in football linemen. Correcting sleep apnea may result in improved athletic performance on the athletic field, a decrease in the risk for future health problems, and an increase in quality of life for these individuals.

CHAPTER III

METHODS

Sleep apnea is highly under diagnosed in the general population and affects sedentary males with high body weight and body mass index. Undiagnosed sleep apnea may result in a decreased quality of life including daytime sleepiness. Little research and literature pertains to sleep apnea in an athletic population. Due to the larger size and stature of football linemen, it would seem that they would be at risk for sleep apnea. Undiagnosed sleep apnea in an athletic population could possibly result in decreased athletic effort on the football field, an increased risk for health problems, and a decreased quality of life.

The purpose of this research was to determine if offensive and defensive linemen presented with increased risk factors for sleep apnea, including height, weight, body mass index, neck circumference, and Modified Berlin Questionnaire scores when compared to all other football positions (quarterbacks, wide receivers, running backs, tight ends, defensive backs, linebackers, kickers, punters, place holders, and snappers). In addition, this research study was also used to determine whether there was a positive correlation between weight (kg) and neck circumference (cm); body mass index (kg/m^2) and neck circumference (cm); neck circumference (cm) and Berlin score; and weight (kg) and Berlin score.

Perceived incidence of sleep apnea was determined by having each subject complete a Modified Berlin Questionnaire and obtaining anthropometric measurements. The Berlin Questionnaire is a survey that addresses questions pertaining to snoring habits, daytime sleepiness, history of high blood pressure, and body mass index. A disqualifying question was added to the questionnaire ascertain whether any subject had previously undergone any surgery to correct sleep apnea. An answer of 'yes' to this question disqualified the subject. Anthropometric measurements including height (in inches, then converted to meters), weight (in pounds, then converted to kilograms), and neck circumference (in centimeters) were obtained by the researcher. From this information, body mass index was calculated for each subject. Age and football position was also obtained from each subject.

Subjects

The sample population was Division I male collegiate football players from the Oklahoma State University football team, participating during the 2007-2008 academic year. These subjects were chosen due to convenience and accessibility to the researcher. There were 80 male subjects between the ages of 17-24 years (mean: 20.14; sd ± 1.524) old who participated in the study. All subjects volunteered for the study and were not reimbursed in any way. Each subject read and signed an informed consent document in accordance with the Institutional Review Board at Oklahoma State University that was explained to each individual subject by the principle investigator (see Appendix C). A disqualifying question was added to the Berlin Questionnaire which asked about previous surgical procedures to correct sleep apnea. If this question was answered 'yes', then the subject was to be disqualified. However, no subjects answered in accordance to this question, so no subjects were disqualified from the study.

Selection of Instruments

Berlin Questionnaire

The instruments used in this study included a modified Berlin Questionnaire and anthropometric measurements including height, weight, neck circumference, and body mass index. The Berlin Questionnaire is a survey that was developed from information gathered by pulmonary specialists and primary care physicians from the United States and Germany (see Appendix A). These individuals gathered for the Conference on Sleep in Primary Care in Berlin, Germany in April 1996 and developed the Berlin Questionnaire (Netzer, et al., 1999). These professionals determined questions to elicit factors or behaviors that consistently predict the presence of sleep-disordered breathing (Netzer, et al., 1999). Questions in this survey are organized into subjects of daytime sleepiness, sleepiness and driving, snoring behaviors, history of high blood pressure, and body mass index. The subjects are further broken down into three categories: snoring behavior, daytime sleepiness, and history of high blood pressure and body mass index.

The Berlin Questionnaire has been used and validated by the original panel and developers of the Berlin Questionnaire (Netzer, et al., 1999) and a poll conducted by the National Sleep Foundation (Hiestand, Britz, Goldman, & Phillips, 2006). Both studies found that the Berlin Questionnaire was valid and reliable in identifying individuals who are at risk for sleep apnea. In the study conducted by Netzer, et al. (1999), the internal validity was 0.92 for the Cronbach α value for questions within category 1 and 0.63 for cagetory 2. When the question about sleepiness behind the wheel was excluded, the Cronbach α value increased to 0.86 (Netzer, et al., 1999).

Anthropometric Measurements

Neck Circumference

According to current research, the specific anthropometric measurements being investigated in this research study are linked with incidence of sleep apnea. Current research has found that most individuals affected by sleep apnea have a large neck circumference greater than 44 centimeters (Caples, et al., 2005). Neck measurements found in this research study were compared to this standard, so a large neck circumference was any measurement greater than or equal to 44 centimeters and a normal/small neck circumference was any measurement under 44 centimeters. The researcher measured each subject's neck circumference with a cloth, non-elastic tape measure. The tape measure was placed over the thickest portion of the thyroid cartilage and the tape measure was circumscribed around the neck, just parallel to this point. There was just enough tension that the tape measure adhered around the neck but was not puckering the skin. The measurement was recorded to the nearest quarter of a centimeter. One measurement was taken for each subject. Neck circumference protocol as an indication for sleep apnea has not been previously stated in research, so this protocol was developed by the principle investigator.

Body Mass Index

Research has also indicated a standard for body mass index in individuals with sleep apnea. A body mass index greater than 30 has been associated with a high risk of sleep apnea (Netzer, et al., 1999). Individuals with a body mass index greater than or equal to 30 were considered to be at risk for sleep apnea, and those with a body mass index less than 30 were considered to be at lesser of a risk. In order to obtain body mass index in this study, current height and weight were measured by the researcher. Height was measured in inches using a height chart that was pre-measured. This pre-measured height chart was a piece of athletic tape that was measured against a ruler and tick marks were placed at each quarter inch. The tape was then placed up on the wall in accordance to the pre-measured numbers. Once height was recorded in inches, the principle investigator converted the inches to meters by multiplying inches by 0.0254. Weight in pounds was measured using an electric scale (Tanita, Tanita Corporation of America, Arlington Heights, Illinois). However, the electric scale was not calibrated for each subject. Body weight was then converted to kilograms later by the principle investigator by dividing the weight in pounds by 2.2. Body mass index was then calculated by the principles investigator using the following formula: weight (kg)/height (m)^2.

Procedures

The data for this research study was collected from each subject utilizing the results of the modified Berlin Questionnaire and the anthropometric measurements obtained by the researcher. Each subject was recruited from the Oklahoma State

University football team by the researcher at a team activity. Before the team activity began, the researcher explained the research study to the entire team and asked for voluntary involvement by members of the football team. The subjects were asked to volunteer to participate in the research study and to report to the athletic training room for participation. The data collection took place from January 22, 2008 – February 11, 2008.

Each subject reported to the athletic training room at his convenience to complete the study. First, the informed consent document was read and explained to each subject. The subject was given an opportunity to ask any questions and then signed the informed consent document (see Appendix C). The subject then completed the modified Berlin Questionnaire (see Appendix A), and then the researcher measured height, weight, and neck circumference as described previously.

After all data was gathered, the researcher scored the modified Berlin Questionnaire of each subject (see Appendix B). Scoring the Berlin Questionnaire involves breaking down the questions into three categories: category one (snoring behavior), category two (daytime sleepiness), and category three (history of high blood pressure or high body mass index). Category one involves questions one through five. One point is assigned to question one if the answer is yes. One point is assigned to question two if the response is 'c' or 'd'. One point is assigned to question three if 'a' or 'b' is the response. One point is assigned to question four if 'a' is the response. In question number five, if the response is 'a' or 'b', then two points is assigned. Category one is awarded one point if the total score of the category is two or more points (Netzer, et al., 1999). Category two involves questions six through eight. One point is assigned to question six if the answer is 'a' or 'b'. The same is true for question seven. Question eight is assigned one point if the response is 'a'. Category two is awarded one point if the total score of the category is two or more points (Netzer, et al., 1999). Category three is positive if the subject answers 'yes' to the question regarding a history of high blood pressure or if the body mass index of the subject is greater than 30 kg/m^2 (Netzer, et al., 1999). The history of high blood pressure is a self-reported question and no guidelines for high blood pressure were specified. The body mass index used in the survey was the value calculated from current height and weight measurements gathered by the principle investigator. High risk for sleep apnea is determined if the subject has a positive score in two or more categories; i.e. a total score of 2 on the questionnaire (Netzer, et al., 1999). Low risk for sleep apnea is determined if there is only one or no categories where the score is positive (Netzer, et al., 1999). All Modified Berlin Questionnaires were scored by the principle investigator.

The final question in the modified Berlin Questionnaire used in this study asked whether the subject had ever undergone surgery to correct sleep apnea. This question was used to exclude certain subjects if they had undergone a surgical procedure to correct sleep apnea. If an individual had undergone this type of surgical procedure, he would typically not present with symptoms of sleep apnea, thus disqualifying him from the study. However, none of the subjects from this study answered positively to this question.

Data Treatment and Analysis

An independent t-test was used to compare variables (age, height, weight, body mass index, neck circumference, and modified Berlin Questionnaire scores) of offensive and defensive linemen to variables of athletes of other football positions. A Pearson Correlation was also calculated to determine the possibility of a positive correlation between weight (kg) and neck circumference (cm); body mass index (kg/m^2) and neck circumference (cm); neck circumference (cm) and Berlin score; and weight (kg) and Berlin score. All hypotheses were tested at the probability of $p<0.01$. The statistics were conducted by using the Statistical Package for the Social Sciences (SPSS) version 14.0 for Windows.

CHAPTER IV

RESULTS

This research study investigated whether offensive and defensive linemen presented with greater risk factors for sleep apnea than remaining football positions on a Division I collegiate football team. Current research pertains to prevalence of sleep apnea in the general population, but does not address athletic populations specifically. The goal of this research study was to investigate whether larger football athletes, specifically offensive and defensive linemen, had a statistically significant difference in risk factors associated with sleep apnea as compared to smaller athletes of other positions. Previous research has also not indicated whether correlations exist between anthropometric measurements and Berlin scores. This research also investigated the possibility of a positive correlation between weight (kg) and neck circumference (cm), body mass index (kg/m^2) and neck circumference (cm), neck circumference (cm) and Berlin score, and weight (kg) and Berlin score.

Description of Population

The subjects who participated in this research study were members of the Oklahoma State University football team ranging in age from 17-24 years of age (mean 20.14 ± 1.524). There were 80 participants who volunteered for the research study, and they were not reimbursed in any way. This number differed from the total roster as some did not wish to participate in the study. No subjects were disqualified in this study. All subjects signed an informed consent document in accordance with the Institutional Review Board at Oklahoma State University (see Appendix C) prior to completing the Modified Berlin Questionnaire and prior to allowing the researcher to record anthropometric measurements.

The information found in Table 1 lists the means and standard deviations of each of the variables for the subjects investigated in this research study. This study investigated anthropometric variables including age (years), height (m), weight (kg), and body mass index (kg/m^2) in addition to the scores of a Modified Berlin Questionnaire. The Modified Berlin Questionnaire is scored out of a possible score of zero, one, or two. A score of zero or one indicates a low-risk of suffering from sleep apnea, and a score of two indicates a high-risk of suffering from sleep apnea. See Table 1 for all subjects' descriptive statistics.

Table 1

DESCRIPTIVE STATISTICS FOR SUBJECTS		
N = 80		
Variable	**Mean**	**Standard Deviation**
Age (yrs)	20.14	±1.524
Height (m)	1.869	±0.067
Weight (kg)	108.057	±20.636
BMI (kg/m^2)	30.762	±4.556
Neck (cm)	43.175	±2.923
Berlin Score	1.08	±0.792

Data Results

The SPSS version 14.0 for Windows was used to conduct the statistical analysis for the data of this research study. Independent samples t-tests were used to compare the variables (age, height, weight, body mass index, neck circumference, and Modified Berlin score) of offensive and defensive linemen to the remaining positions (kickers, punters, snappers, holders, quarterbacks, running backs, defensive backs, tight ends, and linebackers). These independent samples t-tests were used to investigate whether offensive and defensive linemen as a group presented with statistically significantly different values for the variables of height (m), weight (kg), body mass index (kg/m^2), and Modified Berlin score. One group included offensive and defensive linemen, and the second group included all remaining positions. The probability level of $p<0.01$ was used for the analysis of each variable for the two groups. See Table 2 for the results of independent samples t-test for the subjects used in this study.

A Pearson Correlation statistical analysis was used to determine if there was a positive correlation between weight (kg) and neck circumference (cm); body mass index (kg/m^2) and neck circumference (cm); neck circumference (cm) and Berlin score; and weight (kg) and Berlin score. The probability level of $p<0.01$ was used for each of the correlation analyses.

Table 2

COMPARISON OF VARIABLES BETWEEN LINEMEN AND OTHER POSITIONS					
Variable	**Group**	**N**	**Mean**	**Standard Deviation**	**Sig. (2-tailed)**
Age	Linemen	31	20.03	±1.378	.626
	Others	48	20.20	±1.620	.614
Height (m)	Linemen	31	1.920	±0.039	.000
	Others	48	1.836	±0.061	.000
Weight (kg)	Linemen	31	130.543	±9.259	.000
	Others	48	93.831	±10.684	.000
BMI (kg/m^2)	Linemen	31	35.415	±2.549	.000
	Others	48	27.818	±2.697	.000
Neck (cm)	Linemen	31	45.637	±2.330	.000
	Others	48	41.617	±2.068	.000
Berlin Score	Linemen	31	1.61	±.558	.000
	Others	48	.73	±.730	.000

There was a total of 31 offensive and defensive linemen analyzed compared to 48 participants of the remaining other positions (kickers, punters, snappers, holders, quarterbacks, running backs, defensive backs, tight ends, and linebackers). According to the independent samples t-test, age was the only variable for which there was not a statistically significant difference from linemen to the other remaining players with a significance level of $p<0.63$. The mean age was nearly identical between the two groups, 20.03 years ±1.378 for the linemen and 20.20 years ±1.620.

For the remaining variables (height, weight, body mass index, neck circumference, and Modified Berlin score), there was a statistically significant difference between the values for linemen compared to values of the remaining other players ($p = 0.00$ for each). The mean height for linemen was 1.920 meters ± .039 ($p = 0.00$)

when compared to the mean height for the remaining other players at 1.836 meters ± .061 (p = 0.00). While the difference between the two average heights seems small (.084 meters difference), linemen appear to be statistically taller than the remaining players (p = 0.00).

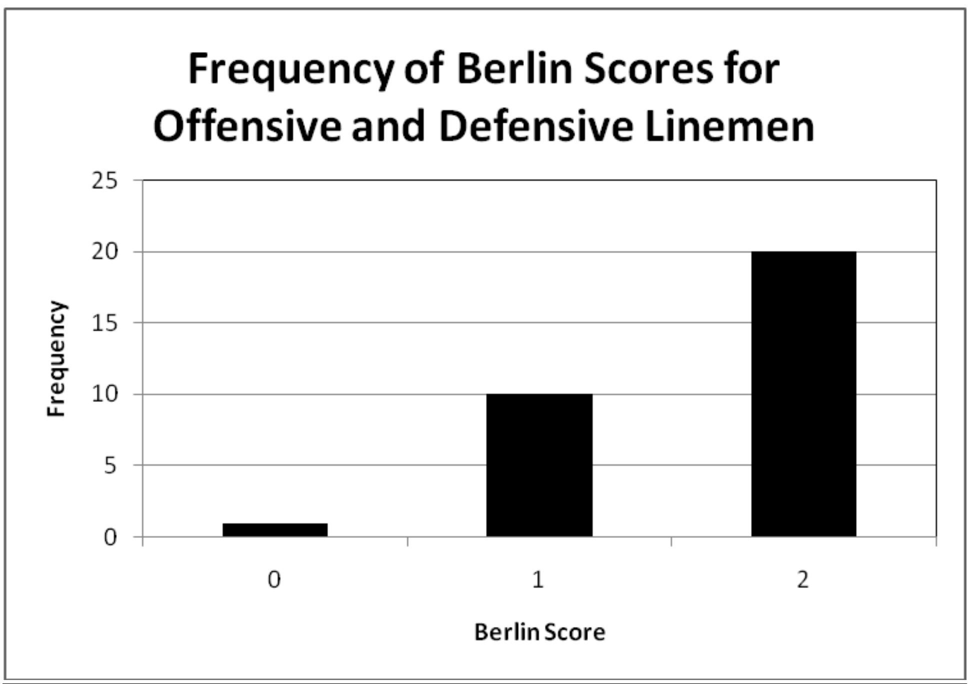
Offensive and defensive linemen were significantly heavier at an average of 130.542 kilograms ± 9.260 (p = 0.00) as compared to other players who weighed an average of 93.831 kilograms ± 10.684 (p = 0.00). This means that linemen were on average, 36.712 kilograms heavier than the remaining other players.

Body mass index calculations for linemen were considerably higher than the remaining other players. Linemen on average had a body mass index of 35.415 kg/m^2 ± 2.549 (p = 0.00) compared to an average body mass index of 27.818 kg/m^2 ± 2.697 (p = 0.00) for other players. This average for linemen is significantly higher than the 30 kg/m^2 that is considered to be an at-risk for sleep apnea through research (Netzer, et al., 1999).

Linemen also presented with statistically larger neck circumference measurements as compared to the remaining subjects. The average neck circumference for linemen was 45.637 centimeters ± 2.330 (p = 0.00) as compared to the average of 41.617centimeters ± 2.068 (p = 0.00) found in the remaining subjects. The high-risk measurement for neck circumference to predict sleep apnea is 44 centimeters (Netzer, et al., 1999), and this average value is greater than 44 centimeters.

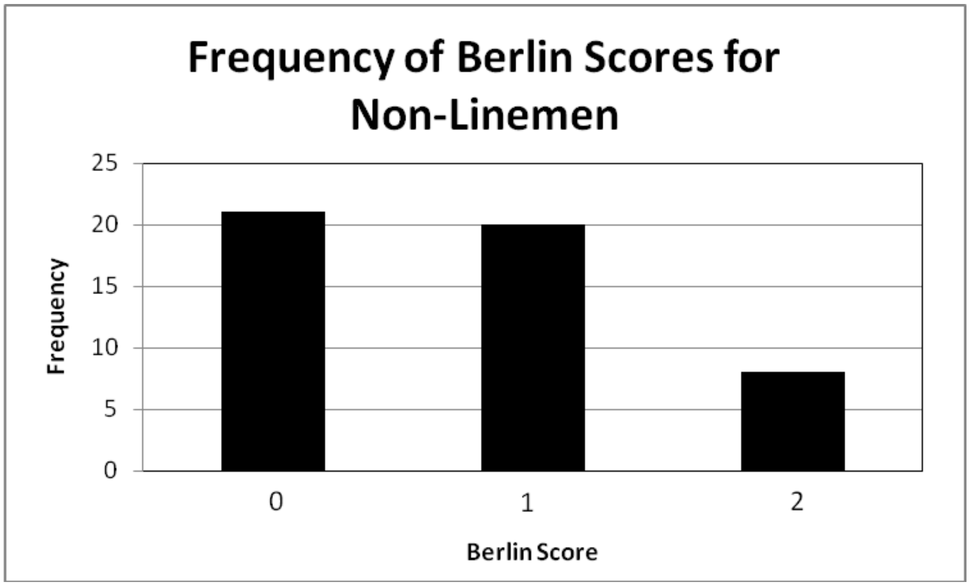
The final variable that was analyzed was the scores from the Modified Berlin Questionnaire. The Modified Berlin Questionnaire is scored on a scale from zero to two. A score of zero or one indicates no risk or low-risk of sleep apnea and a score of two indicates a high-risk for sleep apnea (Netzer, et al., 1999). Linemen presented with an average score of 1.61 ± .558 ($p = 0.00$) for the Modified Berlin Questionnaire. The other subjects presented with an average score of .73 ± .730 ($p = 0.00$). While the difference between the two average scores was relatively small (.88), the analysis revealed that the linemen still scored statistically higher than the other subjects. In addition, out of 31 linemen, 20 subjects had a score of two on the Modified Berlin Questionnaire. That means that 65% of linemen in this research presented with a high-risk Berlin score. The frequency distribution of Berlin scores of linemen can be seen in Figure 1.

Figure 1



Inversely, football players of the remaining positions had higher frequencies of lower Berlin scores. Of the remaining players, 21 had a score of zero on the Berlin score, 20 had a score of one, and 8 had a score of 2. The frequency distribution of Berlin scores in non-linemen can be seen in Figure 2.

Figure 2



A Pearson Correlation test was also used to see whether or not there was a correlation between any of the variables of height (m), weight (kg), body mass index (kg/m^2), neck circumference (cm), or Berlin score for the entire research population. A probability value of $p<0.01$ was used for the analysis. See Table 3 for the results of the Pearson Correlation analysis.

Table 3

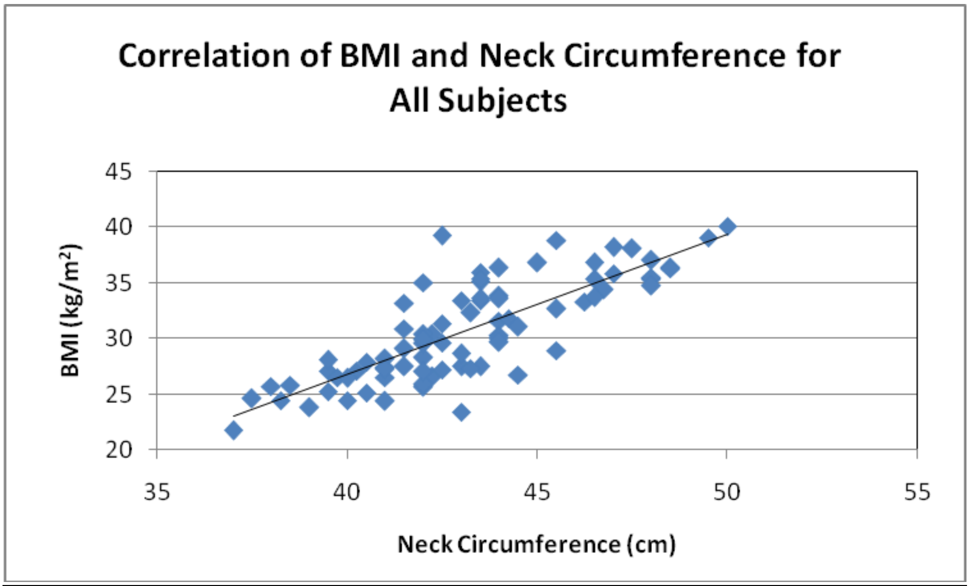
CORRELATION OF VARIABLES IN THE POPULATION						
N = 80						
		Height (m)	Weight (kg)	BMI (kg/m^2)	Neck (cm)	Berlin Score
Height (m)	Pearson Correlation Sig. (2-tailed)	1	.698* .000	.430* .000	.418* .000	.483* .000
Weight (kg)	Pearson Correlation Sig. (2-tailed)	.698* .000	1	.945* .000	.790* .000	.675* .000
BMI (kg/m^2)	Pearson Correlation Sig. (2-tailed)	.430* .000	.945* .000	1	.806* .000	.634* .000
Neck (cm)	Pearson Correlation Sig. (2-tailed)	.418* .000	.790* .000	.806* .000	1	.454* .000
Berlin Score	Pearson Correlation Sig. (2-tailed)	.483* .000	.675* .000	.634* .000	.454* .000	1

*Correlation is significant at the 0.01 level (2-tailed)

While there were not many strong correlations from the analysis, there are a few correlations of interest. The strongest correlation was that of the correlation between weight and body mass index, with an r value of .945 ($p<0.01$). This is due to the fact that weight is a component of body mass index, so as weight increases, so does body mass index.

The next strongest correlation was the correlation between neck circumference and body mass index. This correlation yielded an r value of .806 ($p<0.01$). As neck circumference increased, so did body mass index. From this analysis, it indicated a positive relationship between body mass index and neck circumference. See Figure 2 for a graphical representation of this correlation.

Figure 3



The correlation between body mass index and neck circumference was similar to the correlation between neck circumference and weight. The correlation coefficient for this relationship was .790 ($p<0.01$). This positive relationship indicated that as neck circumference increased, so did weight. The similarity between this correlation and the previous correlation is the connection between neck circumference and weight.

The highest point of interest was whether the Berlin scores could be correlated with any of the anthropometric measurements. Current research has not indicated any type of correlation between Berlin scores and anthropometric measurements. This research study did not have any exceptionally strong correlations between Berlin scores and anthropometric measurements. The strongest correlation was the relationship between Berlin score and weight with a correlation coefficient of .675 ($p<0.01$). Again, there appears to be a strong correlation between weight and the other remaining variables used to target individuals at-risk for sleep apnea.

Hypothesis One

It was hypothesized that the offensive and defensive linemen would have statistically significantly different values for variables of height, weight, body mass index, neck circumference, and Berlin scores when compared to the remaining football positions (quarterbacks, wide receivers, running backs, tight ends, defensive backs, linebackers, kickers, punters, place holders, and snappers); placing the linemen at increased risk for sleep apnea. From the results of an independent samples t-test, it revealed that there was in fact a statistically significant difference between linemen and the remaining football positions for variables of height, weight, body mass index, neck circumference, and Berlin scores. This analysis may indicate an increased risk for sleep apnea in this group of individuals.

Hypothesis Two

It was hypothesized that there would be a positive correlation between subject weight (kg) and subject neck circumference (cm). The results of a Pearson Correlation revealed that there was a positive correlation between these two variables. A correlation coefficient of .790 ($p<0.01$) was found in the correlation between body weight and neck circumference.

Hypothesis Three

It was hypothesized that there would be a positive correlation between subject body mass index (kg/m^2) and neck circumference (cm). There was in fact a positive correlation between these two variables yielding a correlation coefficient of .806 ($p<0.01$). As body mass index increased in the research subjects, so did neck circumference (See Figure 2).

Hypothesis Four

It was hypothesized that there would be a positive correlation between subject neck circumference (cm) and Berlin score (a score from 0-2, with score of zero or one being no risk to low-risk and a score of two being high risk for sleep apnea). The Pearson Correlation analysis did reveal a positive relationship between these two variables with a correlation coefficient of .454 ($p<0.01$). However, this correlation was not an overly strong correlation.

Hypothesis Five

It was hypothesized that there would be a positive correlation between subject weight (kg) and Berlin score (a score from 0-2, with score of zero or one being no risk to low-risk and a score of two being high risk for sleep apnea). The Pearson Correlation analysis did reveal a positive relationship between these two variables with a correlation coefficient of .675 ($p<0.01$).

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Discussion

Due to the increasing size of football linemen over the past several decades, there is a possibility for increased health risks associated with high body weight. One of these health risks is sleep apnea. Sleep apnea is found in individuals with high body mass index and high body weight (Caples, et al., 2005; Netzer et al., 1999). It is common for football linemen to present with both a high body mass index and high body weight. Previous research has not investigated the prevalence of sleep apnea in an athletic population. The purpose of this study was to investigate the perceived incidence of sleep apnea in an athletic population, specifically Division I collegiate offensive and defensive linemen. This study was also used to investigate whether there was a correlation between anthropometric measurements of weight and body mass index to high risk factors for sleep apnea such as neck circumference and Berlin scores.

This study utilized a Modified Berlin Questionnaire which is a sleep questionnaire that evaluates snoring behavior, daytime sleepiness, history of high blood pressure, and previous history of a surgical procedure to correct sleep apnea. The scores from this questionnaire were used in conjunction with anthropometric measurements including current height (m), weight (kg), neck circumference (cm), and body mass index (kg/m^2).

Previous research has indicated that a neck circumference greater than 44 centimeters (Caples, et al., 2005) and a body mass index greater than 30 kg/m^2 (Netzer, et al., 1999) are linked to individuals with sleep apnea. The scores from the Modified Berlin Questionnaire, height, weight, neck circumference, and body mass index were used to determine if there was a statistically significant difference between the measures of offensive and defensive football linemen and the remaining football positions. In other words, this study was used to investigate whether or not offensive and defensive linemen were found to be at higher risk for sleep apnea than the other smaller remaining football positions.

The results of this research indicated that there was in fact a statistically significant difference between offensive and defensive linemen and other remaining football players (quarterbacks, wide receivers, running backs, tight ends, defensive backs, linebackers, kickers, punters, place holders, and snappers) for variables of height (m), weight (kg), body mass index (kg/m^2), neck circumference (cm), and Berlin scores. From the results of an independent samples t-test, offensive and defensive linemen were taller, heavier, had a higher body mass index, a larger neck circumference, and higher Berlin scores. Research has indicated that a body mass index greater than 30 kg/m^2 (Netzer, et al., 1999; Caples, et al., 2005) a neck circumference greater than 44 centimeters (Netzer, et al., 1999; Caples, et al., 2005), and a Berlin score of 2 place an individual at higher risk for sleep apnea (Netzer, et al., 1999).

From the results of this research, 29 out of 31 linemen had a body mass index greater than 30 kg/m^2. That means that 94% of the linemen represented in this research study had a body mass index greater than 30 kg/m^2. This compares to only 24% of subjects from the other remaining football positions that had a body mass index greater than 30 kg/m^2. Not only does this place these individuals at greater risk for sleep apnea, but this value also places these individuals at greater risk for other health issues such as hypertension, type 2 diabetes, coronary heart disease, and stroke (CDC, 2007a). In addition to high body mass index, these linemen also had large neck circumferences. Of the linemen in this research study, 22 out of 31 had a neck circumference greater than 44 centimeters, the guideline for individuals with sleep apnea. This means that approximately 71% of the linemen investigated in this research presented with a high risk neck circumference. This compares to only 8 out of 49 subjects (16%) from the other remaining football positions with a neck circumference greater than 44 centimeters. As mentioned previously, 65% of the linemen investigated in this research study had a score of 2 on the Modified Berlin Questionnaire. This compares with 16% of subjects of the remaining positions who scored a 2 on the Modified Berlin Questionnaire.

This research study was also used to investigate the possibility of correlation between weight (kg) and neck circumference (cm), body mass index (kg/m^2) and neck circumference (cm), neck circumference (cm) and Berlin score and weight (kg) and Berlin score. There was a positive correlation between each of the correlations analyzed. However, some correlations were stronger than others. The strongest correlation was the relationship between body mass index (kg/m^2) and weight (kg) with a correlation coefficient of 0.945 ($p<0.01$). The next strongest correlation was the relationship between body mass index (kg/m^2) and neck circumference (cm) with a correlation coefficient .806 ($p<0.01$). In a similar relationship, the correlation between weight (kg) and neck circumference (cm) revealed a correlation coefficient of .790 ($p<0.01$). The correlation of neck circumference (cm) and Berlin score revealed a correlation coefficient of .454 ($p<0.01$). The correlation of weight (kg) and Berlin score was a stronger correlation with a correlation coefficient of .675 ($p<0.01$).

Of these correlations, the most statistically significant was the correlation between body mass index (kg/m^2) and neck circumference (cm) and the correlation between weight (kg) and neck circumference (cm). These correlations were used to make a possible connection between weight and body mass index to neck circumference. These correlations have not been indicated in previous research and these correlations may further link risk factors for sleep apnea. Weight, body mass index, and neck circumference have been independently used as predictors for sleep apnea, but they have not previously been correlated. This could indicate that when screening individuals with sleep apnea, high weight and high body mass index should prompt a medical professional to investigate neck circumference as well. This could result in further investigation to diagnosing an individual with sleep apnea.

The other two correlations that were investigated were the correlations between neck circumference (cm) and Berlin score and the correlation between weight (kg) and Berlin score. While these two had lower correlation coefficients, .454 and .675 (both with a $p<0.01$) respectively, as compared to the previous correlations, these results still have some significance to the investigator. Neck circumference and Berlin score are two measurements that are centrally connected to sleep apnea, and have not been correlated in previous research. Due to heavy reliance on these measurements, it would seem that they would have a higher correlation to each other. However, their correlation was not as statistically significant as the other correlations in this research. There may have been a stronger correlation if more subjects had been used.

The correlation between weight and Berlin score had a somewhat higher correlation than the correlation between neck circumference and Berlin score. It was encouraging that the Berlin score was moderately correlated to one anthropometric measurement, weight. It seems that Berlin score is more correlated to weight than any other variable (height, body mass index, and neck circumference) investigated in this research.

Of the correlations with the highest correlation coefficients (weight and neck circumference; body mass index and neck circumference; and weight and Berlin score), all of them have a common thread: weight specific variables. Each correlation involves either weight or body mass index, which is a variable that is dependent on weight. It appears that as weight increases, so do other variables related to sleep apnea: neck circumference, body mass index, and Berlin scores. Weight appears to be the factor that most influences other risk factors for sleep apnea.

Conclusion

There were many significant findings from this research. Each of the variables (height, weight, neck circumference, and Berlin score) was statistically significantly different for offensive and defensive linemen as compared to remaining football positions. Since all variables were found to be statistically significant, it is apparent that further research is needed regarding sleep apnea in athletic populations. From this study, offensive and defensive linemen appear to be at a high risk for sleep apnea when utilizing scores from a Modified Berlin Questionnaire, measures of body mass index, and neck circumference. Offensive and defensive linemen were heavier, had higher body mass indexes, larger neck circumferences, and higher Berlin scores. These risk factors all contribute to the incidence of sleep apnea.

Because of these findings, research should be continued for similar athletic populations. Continued research on this topic should include follow up for subjects with high risk variables with polysomnography to properly diagnose these subjects. This would then officially confirm or deny the use of weight, body mass index, neck circumference, and Berlin scores when estimating the incidence of sleep apnea. Diagnosing high risk individuals would also determine if there is a need to screen for this condition on pre-participation physical evaluations in athletics. Screening for sleep apnea during pre-participation physical evaluations may identify individuals with sleep apnea. Properly diagnosing individuals with sleep apnea is crucial because the debilitating symptoms will not go away without some form of treatment. Athletes performing with sleep apnea could be performing below potential on the athletic field and diagnosis could allow participation without the nagging side effects.

In addition, a positive correlation was found when comparing weight (kg) and neck circumference (cm), body mass index (kg/m^2) and neck circumference (cm), neck circumference (cm) and Berlin score and weight (kg) and Berlin score. These correlations further emphasize the link between high weight and other high risk variables for sleep apnea. As weight increases, body mass index, neck circumference, and Berlin score also increase. Polysomnography for subjects in future research could also confirm or deny these correlations as well.

The body composition of athletes should also be considered for further generations of athletic participants. Is it worth having large athletes in order to get ahead in athletics when there are a multitude of health risks associated with high body weight and high body mass? More research regarding body composition in an athletic population should also be conducted to determine whether body mass index is accurate in an athletic population, especially when using this as criteria for sleep apnea. While athletes tend to have a high body mass index, is this due to large amounts of fat free mass or to large amounts of fat? Other research in this area could investigate body fat percentage in addition to body mass index and the incidence of sleep apnea. Current research has not indicated whether large amounts of body fat contribute to sleep apnea, but that high body mass index contributes to sleep apnea. Further research should evaluate the relationship between body fat percentage and sleep apnea.

Recommendations

1. It is recommended that more Division I universities with football programs be involved with research regarding sleep apnea to add to the number of subjects for research in this area.
2. It is recommended that future research involving sleep apnea in athletics investigate the actual prevalence of sleep apnea in an athletic population by confirming sleep apnea diagnosis by polysomnography.
3. It is recommended that screening techniques during pre-participation physical evaluations be developed should there be a confirmed high prevalence of sleep apnea in athletic populations.

4. It is recommended that future research should involve investigating the body fat percentage of football athletes and whether or not body fat percentage plays a role in the incidence of sleep apnea.
5. It is recommended that future research investigate the overall long-term effects of high body weight, high body mass index, and high body fat in football athletes after athletic competition has ended.

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APPENDIX A

MODIFIED BERLIN QUESTIONNAIRE

Modified Berlin Questionnaire

Name:________________ Football Position:________________ Age:_________

Height:__________ Weight:_______ Neck Circumference:______ BMI:__________

Please answer the following questions. Your name will not be associated in any way with the information collected on this questionnaire or with the research findings from this study. The researchers will use a subject number instead of your name. The researchers will not share this information about you with anyone not specified as a researcher in this study, unless you give written permission.

CATEGORY 1

1. Do you snore?
    a. Yes
    b. No
    c. I don't know

2. If you do snore, your snoring is:
    a. Slightly louder than breathing
    b. As loud as talking
    c. Louder than talking
    d. Very loud; it can be heard in surrounding rooms
    e. I don't know
    f. I don't snore

3. How often do you snore?
    a. Nearly every day
    b. 3-4 nights per week
    c. 1-2 nights per week
    d. 1-2 nights per month
    e. Never
    f. I don't know

4. Has your snoring ever bothered other people?
    a. Yes
    b. No
    c. I don't know

5. 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
    f. I don't know

CATEGORY 2

6. How often do you feel tired or fatigued after you 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
    f. I don't know

7. During your wake time, 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. 1-2times a month
    e. Never
    f. I don't know

8. Have you ever nodded off or fallen asleep while driving a vehicle?
    a. Yes
    b. No
    c. I don't know

9. If yes to question #8, how often does this 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
    f. I don't know

CATEGORY 3

10. Do you have high blood pressure?
    a. Yes
    b. No
    c. I don't know

11. Have you ever had any surgery performed to correct issues relating to sleep apnea?
    a. Yes
    b. No

12. If so, what was the surgery?

APPENDIX B

SCORING CRITERIA FOR THE MODIFIED BERLIN QUESTIONNIARE

Scoring Criteria for Modified Berlin Questionnaire

Categories and Scoring

Category 1: items 1, 2,3,4,5

Item 1: If **yes,** assign **1 point**
Item 2: If **c** or **d** is the response, assign **1 point**
Item 3: If **a** or **b** is the response, assign **1 point**
Item 4: If **a** is the response, assign **1 point**
Item 5: If **a** or **b** is the response, assign **2 points**

Add points. Category 1 is positive if the total score is 2 or more points.

Category 2: items 6,7,8 (Item 9 should be noted separately)

Item 6: If **a** or **b** is the response, assign **1 point**
Item 7: If **a** or **b** is the response, assign **1 point**
Item 8: If **a** is the response, assign **1 point**
Item 9: Should be noted separately

Add points. Category 2 is positive if the total score is 2 or more points.

Category 3:

Category 3 is positive if the answer to item 10 is yes OR if the BMI of the subject is greater than or equal to 30 kg/m^2.
(BMI must be calculated. BMI is defined as weight (kg) divided by height (m) squared, kg/m^2.)

High Risk: If there are 2 or more categories where the score is positive

Low Risk: If there is only 1 or no categories where the score is positive

Item 11: If the answer is **yes**, then the subject will be disqualified from the study.

APPENDIX C

INFORMED CONSENT

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
OKLAHOMA STATE UNIVERSITY

Project Title: Incidence of Perceived Sleep Apnea in Division I Football Athletes Using Anthropometric Measurements and a Modified Berlin Questionnaire

Investigators:
Aric J. Warren, EdD, ATC, Assistant Professor
Matthew O'Brien, PhD, ATC, Assistant Professor
Steven Edwards, PhD, Coordinator of Graduate Studies
Meghan M. Reilly, ATC, Graduate Student

Purpose: This study is being conducted through Oklahoma State University. The purpose of this study is to investigate the sleeping habits and behaviors of collegiate football athletes and if these behaviors have a connection with body size and shape. Current research on sleeping behavior is localized to the general population, and this study will look at sleeping behavior in an athletic population. In this study we will compare sleeping behavior to measurements of height, weight, neck circumference, body mass index (BMI) and body fat percentage.

Procedures: In order to conduct this study, the researchers will need to collect information about you. This information will be obtained from a sleep questionnaire, measuring your current height, weight, and neck circumference, calculating your BMI, and obtaining your body fat percentage from your pre-existing medical file. All information gathered through this study will remain completely confidential (see Confidentiality section).

Subjects will meet at a regularly scheduled athletic activity and participation will take approximately 30-45 minutes. First you will complete a modified Berlin Questionnaire which evaluates your current sleeping habits and behaviors. Once the questionnaire is completed, the investigators will measure your neck circumference using a non-elastic, fabric tape measure. Then your current height and weight will be measured.

Risks of Participation: I understand that there are no inherent risks in this study.

Benefits: Understanding sleeping habits and having the knowledge of personal height, weight, and neck circumference.

Confidentiality: The records of this study will be kept completely private. The data will be identified by a number that is not previously associated with you. These subject numbers are coded so that the primary PI can initially match information from your medical file to the research data sheet. This information will be stored in a locked file drawer in the office of the research advisor and will not be accessible to anyone other than the research advisor and the primary investigator. This data sheet linking names and subject numbers will be maintained for 6 months after the data has been collected. These results will not be given to your coaches or teammates. Any written results will discuss group findings and will not include information that will identify you personally. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

Compensation: No monetary compensation for your involvement will be provided. Study subjects will receive information regarding sleeping behaviors and habits and personal anthropometric measurements.

Contacts: I understand that I may contact the lead investigator and advisor for this study at the following address and phone number, should I desire to discuss my participation in the study and/or request information about the results of the study:

Meghan Reilly, ATC
Oklahoma State University
Athletics Center
Stillwater, OK 74078
(405) 334-3970
Meghan.reilly@okstate.edu

Aric Warren, EdD, ATC
Oklahoma State University
194 Colvin Recreation Center
Stillwater, OK 74078
(405)744-4060
Aric.warren@okstate.edu

If you have questions about the research and your rights as a research volunteer, you may contact Dr. Sue C. Jacobs, IRB Chair, 219 Cordell North, Stillwater, OK 74078, (405) 744-1676 or irb@okstate.edu

Participation Rights: I understand that my participation in this research is voluntary, and that there is no penalty for refusal to participate. I also understand that I am free to withdraw and revoke my consent and participation in this research in writing at any time, without penalty.

Signatures: I have read and fully understand the consent form. I sign it freely and voluntarily. A copy of this form has been given to me.

______________________________ ______________
Signature of Participant Date

I certify that I have personally explained this document before requesting that the participant sign it.

____________________________ ______________
Signature of Researcher Date

APPENDIX D

INSTITUTIONAL APPROVAL FORM

Oklahoma State University
Institutional Review Board

Date : Wednesday, November 28, 2007 IRB Application No ED07116

Proposal Title: Incidence of Perceived Sleep Apnea in Division I Football Athletes Using Anthropometric Measurements and a Modified Berlin Questionnaire

Principal Investigator(s) :

Meghan Reilly	Matthew O'Brien	Aric Warren
1200 N. Perkins Rd. Apt V4	195 Colvin Center	194 Colvin Center
Stillwater, OK 74075	Stillwater, OK 74078	Stillwater, OK 74078

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s) : Pending Revision

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There are revisions to your application to the IRB, which must be completed satisfactorily before your protocol will be approved. They are listed on the following page.

Please submit a revised IRB application incorporating and HIGHLIGHTING the changes listed. The revised application does not need to be signed. If any changes are requried to your consent form, you must submit a new consent form incorporating the changes.

The material containing your revisions should be returned to the IRB Office, 219 Cordell North, Stillwater, OK 74078. These revisions will be reviewed by the IRB Chair and/or the review committee of the IRB. When all outstanding issues have been addressed satisfactorily, you will receive an approval letter from the Chair of the IRB.

You may not begin this research until these revisions have been made and the IRB has granted final approval to conduct research using human subjects under this protocol. You will be allowed 60 days to respond satisfactorily to the revisions required by the IRB. After that period of time, your protocol will be CLOSED.

If you have questions or wish to discuss the reviewers' comments, please contact Beth McTernan at 405-744-5700 or via e-mail at beth.mcternan@okstate.edu.

Oklahoma State University Institutional Review Board

Date:	Tuesday, December 11, 2007
IRB Application No	ED07116
Proposal Title:	Incidence of Perceived Sleep Apnea in Division I Football Athletes Using Anthropometric Measurements and a Modified Berlin Questionnaire
Reviewed and Processed as:	Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 12/10/2008

Principal Investigator(s)

Meghan Reilly	Matthew O'Brien	Aric Warren
1200 N. Perkins Rd. Apt V4	195 Colvin Center	194 Colvin Center
Stillwater, OK 74075	Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☑ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C Jacobs

Sue C. Jacobs, Chair
Institutional Review Board

VITA

Meghan Michelle Reilly

Candidate for the Degree of

Master of Science

Thesis: PERCEIVED SLEEP APNEA IN DIVISION I FOOTBALL ATHLETES USING ANTHROPOMETRIC MEASUREMENTS AND A MODIFIED BERLIN QUESTIONNAIRE

Major Field: Health and Human Performance

Emphasis: Health Promotion

Biographical:

Personal Data: Born in Kansas City, Missouri on July 10, 1984, the daughter of John and Lynn Reilly.

Education: Graduated from Shawnee Mission South High School, Overland Park, Kansas, in May 2002. Completed Bachelor of Science degree with a major in Sports Medicine and Athletic Training at Missouri State University, Springfield, Missouri, in May 2006. Completed the requirements for the Master of Science degree with a major in Health and Human Performance and an emphasis in Health Promotion at Oklahoma State University in May 2008.

Experience: Became a Certified Athletic Trainer in June 2006. Graduate Assistant Athletic Trainer for the Oklahoma State University cheer squad, pom squad, and men’s and women’s tennis teams from August 2006-May 2007. Graduate Assistant Athletic Trainer for the Oklahoma State University football team from August 2007-present.

Professional Memberships: National Athletic Trainers’ Association, Oklahoma Athletic Trainers’ Association

Name: Meghan Reilly Date of Degree: May, 2008

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: INCIDENCE OF PERCEIVED SLEEP APNEA IN DIVISION I FOOTBALL ATHLETES USING ANTHROPOMETRIC MEASUREMENTS AND A MODIFIED BERLIN QUESTIONNAIRE

Pages in study: 64 Candidate for the Degree of Master of Science

Major Field: Health and Human Performance

Scope and Method of Study: The purpose of this study was to investigate the risk factors for sleep apnea in an athletic population. This study investigated whether football linemen had an increased incidence of perceived sleep apnea using anthropometric measurements and a Modified Berlin Questionnaire as compared to the remaining football positions. This research also investigated the possible correlations between risk factors for sleep apnea. Participants in this study were 80 football players competing on the Oklahoma State University football team during the 2007-2008 academic year. Each participant completed a Modified Berlin Questionnaire and allowed the principle investigator to obtain height (meters), weight (kilograms), neck circumference (centimeters), and body mass index (kg/m^2). Independent samples t-tests and Pearson's *r* were used to test five null hypotheses. A value of $p<0.01$ was used for each hypothesis.

Findings and Conclusions: The findings of this study revealed that the offensive and defensive linemen had statistically higher height (meters), weight (kilograms), neck circumference (centimeters), and body mass index (kg/m^2) as compared to the remaining positions when using an independent samples t-test with a probability value of $p<0.01$ for each variable. Pearson correlation tests were used to evaluate the possible correlations between high risk sleep apnea variables. The relationship between neck circumference and weight revealed a correlation coefficient of 0.790 with a significance value of $p<0.01$. The relationship between neck circumference and body mass index revealed a correlation coefficient of 0.806 with a significance value of $p<0.01$.

Advisor's Approval: Aric Warren