COMPARISON OF PRESEASON AND POSTSEASON MEASURES FROM IMPACT AND GRADED SYMPTOM CHECKLIST ON DIVISION I FOOTBALL PLAYERS

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CHAPTER I

INTRODUCTION

Problem Statement

The topic of concussions is a growing concern in athletics today. Athletes are at a greater risk in suffering a concussion if they are involved in contact sports, such as football, wrestling, and hockey. Football has gone a long way from the leather helmets, but that has not stopped the number and severity of concussions from occurring. According to Maroon et al., in 2000 there were an estimated 40,000 to 50,000 concussions per high school football season and while still a high number, this is significantly lower than the 1983 measurement of 200,000 concussions.[1] Football players can experience a variety of magnitudes when colliding with another player[2-4] with the frequency varying by position.[4] Due to the number of hits a player can experience in a season[2-4], and sub concussive blows,[5] one questions if those particular athletes who participates throughout an entire season, from fall camp until the last game of the season, have any significant effects on their currently tested mental function via ImPACT and Graded Symptom Checklist scores?

Hypothesis

Currently, Miller et al. is the only study that investigated ImPACT scores before and after one football season. [5] One blemish of this study is that it was performed on Division III football players. The current study is designed to look at Division I football players and their compared pre-season and post-season measures from ImPACT and Graded Symptom Checklist. Based on

previous studies and knowledge, it is hypothesized that there will not be a significant difference in pre and post-season ImPACT measures however, there will be a significant difference on the players Graded Symptom Checklist scores from pre and post-season.

Definition of Terms

There are terms that need to be clarified to the reader and participants regarding certain words and/or phrases that pertain to this particular study. The main area of clarification is regarding the inclusion and exclusion criteria of the subjects. The first inclusion criterion is, "subjects must be a starter or second string for the Oklahoma State University football team." This was determined by the amount of activity the player was involved in games. Starters and the second string subjects in this study were considered to be the athletes that are listed as the starters and second string on the pre-season depth chart. The reason these individuals were selected is that it will be necessary to exclude players who never play a down in a game. It was hypothesized that these individuals did not receive the same amount of activity or hits as an individual who started and participated in games and practices.

The second inclusionary criterion was that, "the athletes must pass their pre-participation examination (PPE)." The PPE is an examination of the athlete, done by the team physician, to make sure that the athlete is healthy enough to participate in activity.[6] When an athlete passed their PPE then they are medically capable of full participation.[6]

The final term defined is a concussion. A concussion is a mild traumatic brain injury (MTBI), but the term has been defined by many different sources. The definition utilized in this study is by Wojtys et al. who stated that a concussion is, "any alteration in cerebral function caused by a direct or indirect force transmitted to the head resulting in one or more acute symptoms."[7] This topic will be further explored in Chapter II.

Assumptions

Assumptions were made in order to proceed with the current study. The first assumption is the student athletes filled out the Graded Symptom Checklist (GSC) honestly. The student athletes were educated on the importance of the study and filling out the checklist honestly. Lack of compliance on this could have greatly affected the results of this particular study.

The second assumption is the student athletes were honest in reporting if they felt they might have suffered a concussion. It has been documented in previous literature that student athletes may not report concussions to the athletic trainer or physician, [8,9] which will be discussed more in chapter II. This lack of reporting can make athletes more prone to a more serious injury. [8] Again, participants were educated so that they were more likely to report symptoms as to not cause further injury in addition to influencing the results of this study.

Limitations

Limitations existed within the current study. One limitation is the occurrence of a concussion. Due to the nature of football and the hitting, the frequency by which athletes suffered a concussion was not within the control of the author. Injuries and the influence on playing time is another example of a limitation due to the nature of the sport. The determination of starters and second string players came from the pre-season depth chart with the amount of playing time that the starter or second string experienced based solely on the coaches decision. The final limitation is the honesty by which the student athletes will complete the GSC. As previously stated, it is essential for the student athletes to be honest with their symptoms but the author recognizes that it is a subjective measure.

Delimitations

The first delimitation is that the student athletes were a starter or second string for the Oklahoma State University football team as determined by the spring 2011 depth chart. This delimitation will allow us to solely focus on athletes who experienced hits during practices and games. The second delimitation is that the student athletes passed their pre-participation examination (PPE) in order to participate in the study. The PPE is a regular examination done by the team physician to confirm that the athlete was healthy enough to participate in activity (football). Another delimitation of the study was that if the student athlete suffered a concussion then they were excluded from the study. This is so that the typical changes associated with a concussion would not affect the results of the study. The last delimitation for this study is if a student athlete sustained an injury within the study and it limited participation in a game, they were eliminated from the study, because those who miss a game means they are not being hit or tackling like a participating subject would be experiencing.

CHAPTER II

REVIEW OF LITERATURE

Concussions are mild traumatic brain injuries (MTBI) that are a serious concern to the medical field in today's sports. When looking at concussions one must understand the basic concepts and grasp a full comprehension of the injury. This literature review will examine the anatomy of the brain, what concussions are and the symptoms an individual could experience, how certain hits and positions are effected to concussions, preventative methods, when athletes do not report concussions, the proper management of treating concussions, and the function and accuracy of the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) and Graded Symptom Checklist (GSC).

Anatomy of the brain

The human brain is an extraordinary and complex organ. Specific function is determined by the location of tissue within the six divisions. The brain consists of six major divisions: the cerebrum, diencephalon, mesencephalon, pons, cerebellum, and the medulla oblongata.[10] All areas function as one for proper functioning. Each division will now be discussed.

The cerebrum, also known as the telencephalon, is the largest portion of the brain.[10] It contains two cerebral hemispheres, separated by the longitudinal fissure.[10] The main functions of the cerebrum are processing conscious thought, logical functions, storage of memory, and

intentional and unintentional regulation of skeletal muscle contractions.[10] Additionally, the cerebrum can be broken into different segments, also known as lobes. The human brain consists of four lobes; frontal, temporal, parietal, and occipital, with each having separate functions.[10]

The frontal lobe is located in the anterior portion of the brain. The major function of this lobe is conscious control of skeletal muscle.[10] The temporal lobe can be located along the anterior-lateral sides of the brain where awareness of hearing and smell are also found.[10] The parietal lobe region, which is located posterior of the frontal lobe, perception of touch, pressure, pain, temperature, and taste can be found. Finally, the occipital lobe is located posterior of the parietal lobe and is in charge of visual stimuli.[10] The second division of the brain is the diencephalon. It is attached to the cerebrum and contains three sections: the epithalamus, thalamus, and hypothalamus.[10] The epithalamus contains the pineal gland, which produces hormones.[10] The thalamus is where sensory information is relayed and processed and the hypothalamus is where your emotions, autonomic functions, and hormone production occurs.[10] The mesencephalon, also known as the midbrain, is considered a portion of the brain stem.[10] The mesencephalon's main function is to process visual and auditory data and maintenance of awareness.[10] Also included in the brain stem is the pons which is involved with both somatic and instinctive motor control.[10] The final portion of the brain stem is the medulla oblongata which assist with the regulation of autonomic function.[10]

The last division of the brain is the cerebellum. It is connected to the brain stem via the pons. The cerebellum functions as the coordinating complex somatic motor patterns.[10] Damage to the cerebellum may cause issues with balancing, posture, and motor learning.[10]

Due to the importance and fragility of the brain is must be protected by several different layers. These layers protect the human brain with the pia mater being the innermost layer, subarachnoid space with cerebrospinal fluid, arachnoid, dura mater, skull, and then the scalp

being the outer layer.[10] These layers are vital in protecting the brain from injury, such as a concussion, the function of each layer will now be discussed.

The pia mater is the innermost protective layer of the brain and is rich in blood supply.[10] This meninge provides reinforcement for the blood vessels and supplies the brain for the essential needs of nutrients.[10] The second layer, known as the subarachnoid space, is full of collagen and elastic fibers.[10] The subarachnoid space also contains cerebrospinal fluid (CSF).[10] This CSF provides for extra cushioning of the brain.[10] The next layer is the arachnoid; this is a smooth protective layer.[10] Then you have the dura mater as the next protective layer for the brain. This layer is important in keeping the CSF inside, carrying blood form the brain to the heart, and providing extra stabilization for the brain.[10] The strongest layer that covers your brain is your skull. This layer is made up of eight bones (cranium): frontal, temporal, parietal, occipital, sphenoid, and ethmoids.[10] Lastly, you have the scalp as your outermost layer of the human brain. Most of the scalp is visible to the human eye. The scalp consists of skin, connective tissue, and muscles.[10]

By looking at the anatomy of the brain, it is well protected and plays a vital role in daily activities for the human being. Participation in athletic activities may put the brain at risk for damage. That is why it is important that the athletic trainer understands the anatomy of the brain in order to know what regions of the brain may be injured. A common brain injury in sports is a concussion. Concussions are a serious condition and one that must not be overlooked by the athlete or the medical personnel. An in-depth discussion of concussions will now occur.

Concussions

As previously mentioned, a concussion is considered to be a mild traumatic brain injury (MTBI). This injury can occur throughout the entire lifespan, however the highest rate of MTBI can be found to be around the ages of 15 to 24 years old.[11] Concussions can occur due to a wide

variety of causes from a car wreck to a hit on the football field. Concussions have been defined by various authors and studies, but the Wojtys et al. definition of a concussion was selected for this study. [7] The definition states that a concussion is, "any alteration in cerebral function caused by a direct or indirect force transmitted to the head resulting in one or more acute symptoms."[7] Additionally, Wojtys et al. explains the acute symptoms that are seen with concussions, which will be explained shortly.[7] Concussions are graded on a scale,[12-14] Cantu states there are three grades of concussions, Table 1.[14]

Table 1. [14] Cantu Concussion Grading Scale

Grade	Definition	Posttraumatic Amnesia
1	Mild, no loss of consciousness	<30 min
2	Moderate, loss of consciousness <5 min	>30 min
3	Severe, loss of consciousness >5 min	>24 h

A grade 1 concussion is seen as a mild concussion and no loss of consciousness while a grade 2 concussion is considered to be moderate with less than five minutes loss of consciousness (LOC).[14] Lastly, a grade 3 level is determined to be severe with a LOC of over five minutes.[14] It is essential to note that the definition of concussions and grading concussions are not universally accepted,[1,12-14] Cantu's grading system was used based on his expertise in the field and knowledge of the subject. [14] In addition to the loss of consciousness (LOC), symptoms associated with concussions are a key component for diagnosis and return to play decisions.

Concussion symptoms

When an individual sustains a concussion symptoms may vary from type of symptoms to the intensity of symptoms. This is why researchers have recommended the use of baseline measurements for each concussive symptom which may include the following: dizziness, headache, confusion, memory impairment, attention deficit, LOC, personality changes, language deficits, sensitivity to light, sensitivity to noise, balance problems, tinnitus, nausea, vomiting,

blurred vision, drowsiness, sleeping more than usual, sleeping less than usual, glossy eyes, easily distracted, feeling in a fog, feeling slowed down, fatigue, irritable, and nervousness.[1,3,5,7,8,13,15-26] Studies have demonstrated that a headache is the most common symptom after sustaining a concussion.[21,24] It is important for the athletic trainer to be aware of these symptoms and to monitor their athletes if they suspect a concussion.

Mechanism of Injury

When looking at the mechanism of injury (MOI) for a concussion it can occur in multiple ways, such as from repeated hits and direction of impact or head rotation.[2-4] It is also known that the three stresses to injuring the brain are compressive, tensile, and shearing forces.[13] Some studies have even examined how the magnitudes of impact (*g*'s) to the head could possibly be another consideration on how concussions occur.[2,3,7] Guskiewicz et al. found that concussions occurred from various magnitudes of *g*-forces and that the symptoms relating to those *g*-forces are independent to the magnitude and location.[3]

Hits based on position

In the game of football, positions vary with each having a different rate of hard and frequent hits. With the basic knowledge on the game of football, the frequency and location on head impacts that a player experiences was examined.[4] Through practices and games, an athlete can accumulate over 1,000 head impacts in one season.[4] Crisco et al. found that the rate of injury varied between practices and games, with head impacts occurring 3 times more in a game compared to a practice.[4] This could be caused by the different level of effort or magnitude of impacts between practices and games.[4]

Few studies have investigated if an athlete is more prone or likely to receive head impacts compared to a different position. The uniqueness of the Crisco et al. study is position was investigated to identify the varying number of hits to the head.[4] The study found that the

offensive and defensive line positions experience the most of head impacts, followed by the linebacker's position.[4] Lastly, the positions to receive the fewest amounts of head impacts during the season were the quarterbacks and wide receivers.[4] This study demonstrates that impacts vary by position and that it is essential to remember that all it takes is one hard hit to the head to put an athlete in a concussion state.[2,3]

Preventative Methods

All athletes understand that participation in sports carries an inherent risk of injury. In the game of football, injuries vary but may include concussions. As injuries are an area of concern, professionals, researchers, medical personnel, and equipment managers are constantly investigating methods to better protect their athletes from sustaining all injuries, but especially concussions.

McIntosh and McCroy have researched methods of injury prevention, including the environment.[27,28] They found increased rates of concussions in Australian rules football players that play on harder surfaces.[27,28] This may be due to softer surfaces causing slower game time speeds from the athletes, thus resulting in slower collision speeds.[27,28] Additional studies suggest that artificial surfaces (Astroturf) in American football stadiums may make athletes more prone to a head injury as opposed to grass fields and artificial surfaces such as "field turf."[27,29] This must be taken into consideration when schools or professional organizations are installing playing fields and are considering the well-being of the athletes.

Another area of investigation to reduce head injuries is the skill level of an athlete.[27] Skill level has not been looked at specifically, but it is thought to be a possible preventative measure from suffering such an injury. McIntosh and McCroy state that correct skill instruction, such as tackling and ball awareness in football, may reduce the possibility of sustaining a concussions as opposed to an untrained individual.[27] The skills and technique of an athlete are not only

important to how successful the individual is, it also plays a role in affecting the individuals likelihood from suffering a concussion, compared to an individual who does not attain the same skills or proper techniques.

Prevention from the medical perspective begins with the pre-participation exam (PPE). PPE's are performed on all athletes, from the high school level to the professional level to make sure the individual is healthy enough to participate in activities. Studies have demonstrated that most schools do not screen for anatomical abnormalities or hereditary indicators of the head and neck.[27] This type of screening may allow for the medical personnel to reduce the risks of participating in physical activities. By incorporating these screenings in PPE's, athletes who suffer from cervical stenosis may be identified and possibly prevented from participating to reduce the risk of becoming paralyzed due to a hit from their sport.[27]

One of the most common preventative methods that people look at when discussing head injuries in American football is the helmet. The helmet has been found to be an effective piece of equipment in preventing serious head injuries, such a skull fracture.[27] Helmet manufacturers are constantly investigating ways to improve its ability to prevent concussions. Collins et al. found that these improvements in technology with helmets provides better protection to athletes as compared to older helmets.[30]

Lack of Reporting

When athletes participate in a sport they are playing to win a game, match, or event, however injuries may prevent them from continuing to participate. In certain situations though, there are times when this mental drive to win a game may overcome an athlete's pain threshold. This may cause athletes to not report injuries. Concussions are one of the most common injuries athletes tend to not report for proper treatment. This is dangerous as they are an injury that a player should never play through and when one does suffer a concussion they might take the risk

on still playing to try to help their team win the game. This is where second impact syndrome (SIS) can occur by an athlete returning to play to soon, which may lead to death or severe disability.

ESPN performed a survey to look at players, coaches, parents, and athletic trainers on their thoughts over concussions.[9] One question in particular demonstrated the hesitation to report concussive symptoms. The question asked, "Your team is in the state title game, and your star gets a concussion. Would you rather lose the game as he sits out, or win it because he chose to play with it?"[9] The results showed that more than 50% of the athletes would play concussed versus sitting out.[9] This implies that players are willing to put their lives in jeopardy to win a game. This is where athletic trainers need to educate athletes that they should report all concussive symptoms to the medical personnel. Many times it is evident that a player has suffered a concussion or some type or neuropsychological injury, such as when they lose consciousness.

McCrea et al. investigated unreported concussions in high school football players.[8] Subjects were asked, if they suffered a concussion during the current football season.[8] This was followed-up with a question asking if they reported their concussion.[8] The results found the following reasons as to why they didn't report their concussion(s): "didn't think it was serious enough, didn't know it was a concussion, didn't want to be pulled out of the game or practice, didn't want to let down teammates, or other reason."[8] The study concluded that less than half of those who suffered a concussion reported it and the most common or frequent reason as to why they didn't was because they "did not think it was serious enough."[8] Athletic trainers should constantly be aware of their athletes and making sure that the athlete understands what a concussion is. Proper education on reporting symptoms will allow medical personnel to treat them and manage the injury.

Treatment

Sports medicine teams should have a protocol to follow when an athlete sustains a concussion and to determine return to play. The National Athletic Trainers Association (NATA) released a position statement on the proper management of a sport-related concussion.[13] This statement should be utilized as a guideline for athletic trainers and other medical professionals to follow and assist in treating and managing a concussion from before the injury occurs to when the athlete has fully recovered from the injury. The NATA recommends that the first step is to establish a baseline test on all participants of the sport.[13] Recommended testing tools include the Standardized Assessment of Concussion (SAC), Balance Error Scoring System (BESS), symptom checklist, and neuropsychological testing battery (i.e. ImPACT).[13] The baseline will give the sports medicine team something to go back on and compare it to if an athlete sustains a concussion.

Once an athlete sustains a concussion the guidelines for the proper management of the concussion should be followed. It is recommended that the sports medicine team first identify the athlete's symptoms.[13] Documentation should include all of the information regarding the injury (mechanism of injury, symptoms, etc…).[13] It is then suggested that the medical team monitor vital signs every five minutes until symptoms improve.[13] The NATA recommends baseline measurements be retaken.[13] Once the athlete becomes asymptomatic and passes all testing it is then appropriate to perform some type of exercise that increases cardiovascular function but at the same time does not involve contact that could place the athlete at risk for a concussion.[13] It should be noted that cognitive functions have found to sometimes return back to normal before the concussion symptoms do,[20] so it is important to make sure that the athlete is asymptomatic and has passed all necessary testing before performing an exercise test. Once an athlete passes the exercise-induced test and has no symptoms from the workout then a physician may release the player for return to activity.[13]

Other treatment suggestions have included making sure someone who is responsible be with the athlete when he or she is at home and is still experiencing symptoms from the concussion.[13] Guskiewicz et al. suggest is that the athlete only to take acetaminophen or another medication prescribed by the physician.[13] The athlete should rest and avoid drugs, alcohol, driving, video games, and watching television.[13] Lastly, a well-balanced diet is recommended as well and to be sure that the athlete is being awakened at night if loss of consciousness (LOC) was experienced.[13]

ImPACT

A common test that athletic trainers use to assist in measuring an athlete's cognitive functioning is a neuropsychological test battery, known as the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT). ImPACT consists of demographic data, neuropsychological tests, and a Post-Concussion symptom scale.[31] This particular study utilized the ImPACT system to examine the actual neuropsychological tests and its corresponding measurements.

ImPACT consist of six modules, with the first portion consisting of word memory.[26,31] This section of the test looks at attention process and verbal identification memory.[26] The patient is presented with 12 target and non-target words and then the patient is asked if a certain word was previously displayed.[26] Throughout the entire test, the patient will be asked to recall the target words after the completion of all other modules.[26]

The second module of the ImPACT test is design memory. This section of the test determines visual recognition memory.[26] Just like the word memory, this test contains 12 target and non-target designs.[26] The test taker is asked to recall certain designs that were displayed by clicking either "yes" or "no."[26] The third module is known as the X's and O's. This segment of the test examines visual working memory and processing speed. [26] The test is presented with a

distracter test, which consist of the subject left-clicking when a blue square is presented or right-clicking when a red circle is shown. [26] After this distracter test has been completed then they will have a random order of X's and O's shown with three of the X's or O's being yellow. [26] Then a distracter task re-appears, once this task is completed they are then asked to click on X's or O's that were yellow. [26] Module four, known as the symbol matching, measures visual processing speed, memory, and learning. [26] The subject is presented with nine common symbols with numbers (1-9) under the symbols and a symbol is shown under the table of the nine numbers and symbols with the subject is to click on the matching number as fast as they can. [26] There are 27 trials of this task and then the symbols will disappear and the subject will have to perform the same task but without the original nine symbols showing. [26] Color match is module five of the ImPACT and this module looks at impulse control. [26] This module will have three colors shown on a screen (blue, green, and red), one at a time, and it is the task for the subject to click as fast as possible only when the word and color of ink match each other. [26] The sixth module is the last segment of the neuropsychological test and is known as three letters. This task examines working memory and visual-motor response speed. [26] The subject first practices with a distracter test, then 25 numbered squares appear on a 5x5 table. [26] The subject is to start on "25" and then click backwards to "1" as fast as possible. [26] After this task is done three consonant letters will appear on the screen, the subject is then brought back to the number grid and once completed the subject is to recall the three letters that appeared previously. [26]

Lastly, the experimenter or test giver for the ImPACT is able to know when the athlete or patient is not giving all of their effort by looking at the reaction time composite scores. [26] ImPACT states that if the test taker scores in the .80 to 1.5 second range on the *Reaction Time Composite*, below 70% correct on *Verbal Memory Composite*, or below a 60% correct on the *Visual Memory Composite* are considered to be giving a poor effort. ImPACT also states that if the athlete scores greater than a 20 on the *Impulse Control Composite*, it is determined to be an

invalid test. [26] ImPACT has determined that if postconcussion scores are significantly different by using the reliable change index (RCI), which looks at normative data in the post-concussion scale, the patient is still experiencing post-concussive symptoms. This data can be found on their website.[26] It is essential for the ImPACT to have ways to determine bad scores so that the sports medicine staff can have correct test scores to refer back on if one of their athletes does suffer a concussion. ImPACT is a very detailed and easy to understand battery test and can be a great tool for assisting the sports medicine team in the management of concussions if used properly.

Graded Symptom Checklist

Another commonly used instrument to assist an athletic trainer in determining if an athlete's symptoms have return to pre-injury status is the use of a Likert-scale based questionnaire known as the Graded Symptom Checklist (GSC).[13,17-20] There are many different types of GSC, so it is essential to utilize a valid and reliable measure. The GSC is a list of common symptoms associated with concussions found in literature with each symptom having a seven point number scale (0 to 6), with zero (0) meaning never and six (6) meaning always, corresponding with it.[17,20] The GSC that will be used for this study is one that the Certified Athletic Trainers (ATC) currently utilize at Oklahoma State University for student-athletes for baseline and post-concussion testing. This GSC is an 18-item modified version from the 16 and 21-item list that has been proven valid from previous studies[17,18,31] and through personal experience has shown to be effective in assisting with the management of concussions. The list of symptoms being used for this study are the following: headache, nausea, vomiting, balance problems/dizziness, fatigue, trouble falling asleep, sleeping more than usual, drowsiness, sensitivity to light, blurred vision, sadness/depressed, irritability, numbness/tingling, feeling like "in a fog," difficulty concentrating, difficulty remembering, and neck pain. The GSC form can be found in the Appendix as Figure 1. Studies have shown that the symptoms listed on the GSC are to be in relation with somatic, cognitive, and neuropsychological symptoms, which correlate to concussion symptoms.[17,18]

Instrument Validity

As with all testing instruments validity must be investigated. Studies were performed to do such research for both the ImPACT and GSC. The ImPACT was studied for not only short term but for the use of long-term validity as well.[32,33] When looking at the sensitivity and specificity, ImPACT has also proven to be a great tool in the assessment of concussions and for post-injury to baseline return to play decisions.[31] A study performed by Broglio et al. looked at the test-retest reliability of computerized programs.[33] The measurements were taken at baseline, 45 days, and then 50 days.[33] The ImPACT ranged from .39 to .61 on the intraclass correlation coefficients (ICC) from days 45 to 50, which is considered to be just above the accepted ICC level for test-retest reliability (.60).[33,34] Along with long-term testing, a study found that over a two year period that even the visual memory, processing speed, and reaction time show to be stable.[32]

When looking at the validity of the GSC, studies have demonstrated the usefulness of the tool.[13,17-19] When selecting a GSC, it is important to use GSC that have been created explicitly for the use by sports medicine clinicians.[13] Multiple studies have found symptom checklist to be a valid tool, such as the 16 and 9-item list.[17-19] It is important to note, as previously mentioned, that the GSC used for this study will be a modified version of the 16-item and 21-item GSC from earlier studies[17,31] to be 18 questions (two additional symptoms).

CHAPTER III

METHODOLOGY

Study Design

This study utilized a 2x2 factorial analysis. The first independent factor was the testing instrument (ImPACT and Graded Symptom Checklist) and the second factor the testing periods (pre-season measure and post-season measure).

Participants

This study began with 42 subjects but throughout the season 16 subjects were eliminated from the study by the criteria listed in the procedures. The post-season test consisted of 26 subjects, with three subjects further eliminated. During the post-season data collection two subjects were non-compliant and one performed an invalid test and was unable to retake the test. The study concluded with 23 subjects (9 offense and 14 defense). All of the subjects signed an informed consent document and the study was approved by the Oklahoma State University Institutional Review Board (IRB). The average age of the participants was 20.81±1.79 years. The participants of this study were pre-determined from the 2011 spring depth chart and were either classified as starters or second string for a Division I football team. All participants cleared the institution's appropriate pre-participation examination, performed by the OSU team physician in order to participate in the study; Figure 2 in the Appendix is the form for athletes that are first year players and Figure 3 (Appendix) is the PPE form for those athletes that are returning. Lastly, any subject that falls within the range for an invalid test stated by ImPACT, was retested.[26]

Instruments

The instrument used to measure the subject's symptoms was the modified 18 item-list Graded Symptom Checklist. ImPACT (ImPACT, Applications Inc, Pittsburgh, PA) version 6.0 was used to test subject's verbal and visual memory, reaction time, and visual motor speed.

Procedures

This study was approved by the Oklahoma State University IRB committee, 23 subjects came into the university's football Athletic Training room prior to the start of fall camp (contact between players), anytime from June to July. Subjects signed the informed consent and then completed the GSC and ImPACT in offices provided by the Certified Athletic Trainer (ATC). This was done so that outside noise could be minimized and the subjects could focus on completing the GSC and ImPACT. All subjects were given the same directions on how to complete the GSC and ImPACT. The GSC was instructed to the subject as the following:

> Here is a list of symptoms that have been associated with a concussion. Please fill out the form honestly and how you are feeling currently. The symptoms are on a scale from 0 to 6. Zero (0) meaning you are not experiencing the symptom at all, 1 means your experience with the symptom is very mild, and a 6 means the symptom is severe.

The ImPACT was then administered upon completion of the GSC. This test was instructed to the subjects as follows:

> Please complete this test by reading all the instructions before performing the certain task and try your hardest on every task as well.

Once baseline testing was completed, subjects continued with their daily activities and participated in practices and games. Those subjects who suffered a concussion throughout the timeframe of the study were eliminated, and subjects, who for any reason missed a game (i.e.

injury, suspension, etc...), were also eliminated from the study as well. A post-season measurement was then taken within a week after the final regular-season game. The same procedure used for the pre-season measurements were used for the post-season as well.

Statistical Analysis

Upon the completion of data collection it was entered into SPSS and ran as a dependent t-test. Paired differences were examined at a 95% confidence interval.

CHAPTER IV

FINDINGS

It is important to understand that each football team has a different approach to practices and games, so the author felt that a description of a normal week should be included. A typical week for the subjects would start with Monday as an off day for the players (no contact). Tuesdays were a full padded and contact practice, Wednesday and Thursday consisted of subjects practicing with helmets and shoulder pads with a wrap-up only style of tackling. Friday consisted of no pads and was a walk-though. Saturdays were game days and consisted of all pads and full tackling. Lastly, Sundays were a shoulder and helmet practice with light contact.

Graded Symptom Checklist

The pre-season 18-item GSC showed a mean score of 2.78±3.343 and concluded the season with a mean of 3.65±6.057 (Table 2). The paired t-value for GSC was -.583, with a p-value of .566. The GSC showed no statistical difference from pre to post season ($p<.05$).

ImPACT

The ImPACT test examined four different areas of brain functioning; verbal memory, visual memory, visual motor speed, and reaction time. Verbal memory had a mean score of 83.70±8.875 in the pre-season and a post-season of 88.26±8.12 (Table 2). The t-value for verbal memory was -2.898, with a significance of 0.008. These results showed to be statistically significant from pre to post-season ($p<.05$). Visual memory was the second component measured

and posted a pre-season mean score of 82.87±9.231 and post-season mean of 81.65±10.364. The t-value came out to 0.488, with a significance of 0.630, which shows no statistically significant difference ($p<.05$).

The third variable measured was visual motor speed, the mean score between the 23 subjects at pre-season was 40.04±5.27 and a post-season score of 39.47±5.64. The t-value was 0.745, with a significance of 0.464, with no statistical significance as well ($p<.05$). Reaction time was the final variable measured on the ImPACT test. Reaction time had a pre-season mean of 0.57±.06 and post-season mean of 0.61±.08 (Table 2). The t-value for reaction time was -3.093 and had a p-value of 0.005. This showed that the reaction time had a significant difference statistically between both measures.

Clinically, there were no significant differences for verbal memory in student athletes RCI ImPACT scores. There were significant decreases noted by the RCI for four visual memory, three visual motor speeds, and seven reaction time subjects (Table 3). However, the mean differences between pre and post-season would not have been recognized by ImPACT's RCI.

Table 2. Paired Samples Statistics

Test	N	Mean	Std. Deviation	t	p-value
Verbal Memory Pre	23	83.70	8.875		
Verbal Memory Post	23	88.26	8.120	-2.898	.008*
Visual Memory Pre	23	82.87	9.231		
Visual Memory Post	23	81.65	10.364	.488	.630
Visual Motor Speed Pre	23	40.04	5.275		
Visual Motor Speed Post	23	39.47	5.642	.745	.464
Reaction Time Pre	23	.574 s	.055		
Reaction Time Post	23	.614 s	.078	-3.093	.005*
GSC Pre	23	2.78	3.343		
GSC Post	23	3.65	6.057	-.583	.566

*Showed statistically significant differences from pre to post-season ($p<.05$).

Table 3. ImPACT RCI Significances

Test	# RCI Significances
Verbal Memory	0
Visual Memory	4
Visual Motor Speed	3
Reaction Time	7

*All significantly decreased

CHAPTER V

CONCLUSION

Summary

Two variables showed statically significant differences, verbal memory and reaction time. Verbal memory showed an increase from the pre-season to the post-season. This increase in verbal memory can be explained by a possible learning curve or the subjects going through classes during the season which may have increased the capability of the temporal lobe to process verbal memory.[10] The statistical reduction in reaction time can be explained by the sub-concussive blows to the head that the subjects receive during practices and games, which might show possible impairments to the cerebral cortex.[10]

When looking at the results it is important to look at the practicality and clinical implications they may have. First off, verbal memory is considered to be significant statistically, in the clinical setting it is not known to be a significant increase and would not be recognized by ImPACT, reliable change index (RCI) score, as significant either. Reaction time showed a statistically significant decrease from pre to post-season. This also would not be determined in the clinical setting as a significant decrease and would not be recognized by ImPACT as a significant reduction in reaction time. The rest of the variables showed no statistically significant differences from pre-season measures to post-season. This study can relate to the findings of Miller et al., with a 12-game regular season schedule in Division I football causing no clinically significant differences in symptoms, verbal and visual memory, visual motor speed, and reaction time. [5]

In this study, I was anticipating a significant increase in the athletes GSC scores from pre to post season, whereas the study showed no significant differences. I also hypothesized that there would be no significant differences in the subjects ImPACT scores, but the study showed significant differences in the subjects verbal memory and reaction time. This study can tell us that during one DI football season, players can experience a decline in reaction time and improvement in verbal memory. This can tell us that players might be suffering impairments to certain areas of the brain, such as the cerebral cortex, while at the same time improving the performance of other areas in the brain, such as the temporal lobe.[10] With that said, athletic trainers and team physicians should consider updating their athlete's baseline testing before the beginning of every season. This way it will provide the most up-to-date and accurate baseline test that the athlete could provide. This study shows that just one football season can affect an athlete's scores, so if athletes are only being tested once and don't suffer a concussion until three years down the road then the baseline that was recorded three years ago will not be the most accurate baseline that the medical professional could go off of. During that three year tenure the athlete could have improved and/or declined in certain measurements and therefore their baselines are not as accurate as they could be if they were done every year. Lastly, we can gain further knowledge from this study that one DI football season can indeed impair brain functioning to not only those who suffer concussions but those athletes who play every game in a season and are constantly delivering and receiving sub-concussive blows to the head. This is why it is important that athletic trainers and team physicians are always monitoring their athletes during practices and games and that every athlete maintains an updated baseline test.

Limitations

Limitations do exist in this study. The amount of playing time and repetitions that the players contributed were unpredictable and under the control of the coach. With this, some players were more exposed to hits as opposed to others; this restriction was reduced by only

testing first and second string players. Honesty was another limitation that existed within this study, it was important that the players were providing truthful responses in the GSC in order to obtain an accurate measurement. The honesty of the players reporting concussion like symptoms to the medical staff was another limitation. This was important because if the players suffered a concussion they were eliminated from the study. Lastly, due to the nature of the sport, injuries tend to occur and can sometimes remove and athlete from his or her sport for quite some time, with this said any athlete that missed a game due to injury were eliminated from the study as well to provide a more accurate measurement.

Future Research Recommendations

Researchers are constantly looking at ways to improve studies in order to obtain better results. Some recommendations to look into for future studies are by looking at functional MRI's (fMRI) to examine an possible impairments to the brain, examining professional athletes, and looking at athletes careers, opposed to one season. Functional MRI's would be a great tool to use in looking at possible impairments to the brain and help explain why there was a statistical difference in reaction time. The advantage at looking at professional athletes is that the National Football League contains players who are strictly playing football and not taking classes like collegiate athletes are doing. This might take away the explanation as to why the subjects for this study statistically improved on verbal memory. Also professional athletes compete at higher speeds and level of play and participate in a longer season compared to the collegiate level, so this might affect results in certain variables.

Another recommendation for future research is to examine athletes during their career. Most schools provide a baseline concussion test on the athlete's entry year and will never perform another baseline on the athlete during his or her collegiate or professional career. It would be strongly recommended that athletic trainers and team physicians perform baseline measurements

on each athlete every year in order to provide an up-to-date baseline. The reasoning behind this is that during an athlete's career they will be constantly be improving (or declining) in their memory, reaction time, and symptoms and by looking at this study their baselines even change throughout a season. So in order to provide a more accurate baseline test, medical professionals should strongly consider testing their athletes before each season. Research could prove this statement further by examining the affects a collegiate career has on an athlete's GSC and ImPACT scores, since one football season has shown statistically significant differences in reaction time and verbal memory.

In conclusion, this study showed that verbal memory statistically improved from pre to post-season, while reaction time decreased. Although these results show a statistic difference they still don't imply any significant meaning to the clinical or "real world" setting. But further research would benefit by looking at the professional football level and examining any possible changes. Concussions are a growing concern in today's sports and there has never been a more important time to examine sports and the affects it has on the human brain than now.

REFERENCES

1. Maroon JC, Lovell MR, J. N, K. P, Powell JW, Hartl R. Cerebral concussion in athletes: Evaluation and neuropsychological testing. *Neurosurgery.* 2000;47(3):659-672.

2. Duma SM, Manoogian SJ, Bussone WR, et al. Analysis of real-time head accelerations in collegiate football players. *Clin J Sport Med.* 2005;15(1):3-8.

3. Guskiewicz KM, Mihalik JP, Shankar V, et al. Measurement of head impacts in collegiate football players: relationship between head impact biomechanics and acute clinical outcome after concussion. *Neurosurgery.* 2007;61(6):1244-1253.

4. Crisco JJ, Fiore R, Beckwith JG, et al. Frequency and location of head impact exposures in individual collegiate football players. *J Athl Training.* 2010;45(6):549-559.

5. Miller JR, Adamson GJ, Pink MM, Sweet JC. Comparison of preseason, midseason, and postseason neurocognitive scores in uninjured collegiate football players. *Am J Sport Med.* 2007;35(8):1284-1288.

6. Goldberg B, Saraniti A, Witman P, Gavin M, Nicholas JA. Pre-participation sports assessment-an objective evaluation. *Pediatrics.* 1980;66(5):736-745.

7. Wojtys EM, Hovda D, Landry G, et al. Concussion in sports. *Am J Sport Med.* 1999;27(5):676-687.

8. McCrea M, Hammeke T, Olsen G, Leo P, Guskiewicz K. Unreported concussion in high school football players: implications for prevention. *Clin J Sport Med.* 2004;14(1).

9. Gissinger H. Concussion Confidential. *ESPN.*December 27, 2010:56-57.

10. Martini FH, Timmons MJ, Tallitsch RB. *Human Anatomy*. Fourth ed. Upper Saddle River, NJ: Prentice Hall; 2003.

11. Kelly JP. Traumatic brain injury and concussion in sports. *JAMA.* 1999;282(10):989-991.

12. Practice parameter: the management of concussion in sports (summary statement). Report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology.* 1997;48:581-585.

13. Guskiewicz KM, Bruce SL, Cantu RC, et al. National athletic trainers association position statement: management of sport-related concussion. *J Athl Training.* 2004;39(3):280-297.

14. Cantu RC. Guidelines for return to contact sports after a cerebral concussion. *Physician Sportsmed.* 1986;14:755-783.

15. Kelly JP, Rosenberg JH. Diagnosis and management of concussion in sports. *Neurology.* 1997;48:575-580.

16. Collins MW, Grindel SH, Lovell MR, et al. Relationship between concussion and neuropsychological performance in college football players. *JAMA.* 1999;282(10):964-970.

17. Piland SG, Motl RW, Guskiewicz KM, McCrea M, Ferrara MS. Structural validity of a self-report concussion-related symptom scale. *Med Sci Sport Exer.* 2006:27-32.

18. Piland SG, Motl RW, Ferrara MS, Peterson CL. Evidence for the factorial and construct validity of a self-report concussion symptoms scale. *J Athl Training.* 2003;38(2):104-112.

19. Macciocchi SN, Barth JT, Littlefield L, Cantu RC. Multiple concussions and neuropsychological functioning in collegiate football players. *J Athl Training.* 2001;36(3):303-306.

20. McCrea M, Guskiewicz KM, Marshall SW, et al. Acute effects and recovery time following concussion in collegiate football players: The NCAA concussion study. *JAMA.* 2003;290(19):2556-2563.

21. E.M. W. Banging Heads. *Sports Health.* 2010;2(6):450-451.

22. Guskiewicz KM, Weaver NL, Padua DA, Garrett J, W.E. Epidemiology of concussion in collegiate and high school football players. *Am J Sport Med.* 2000;28(5):643-650.

23. Guskiewicz KM, McCrea M, Marshall SW, et al. Cumulative effects associated with recurrent concussion in collegiate football players: the NCAA concussion study. *JAMA.* 2003;290(19):2549-2555.

24. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock RD. Concussions among United States high school and collegiate athletes. *J Athl Training.* 2007;42(4):495-503.

25. Lovell MR, Collins MW, Iverson GL, Johnston KM, Bradley JP. Grade 1 or "ding" concussions in high school athletes. *Am J Sport Med.* 2004;32(1):47-54.

26. Lovell MR. ImPACT 2007 (6.0) Clinical Interpretation Manual. 2007; http://impacttest.com/assets/pdf/2005ClinicalInterpretationManual.pdf. Accessed January 26, 2011.

27. McIntosh AS, McCrory P. Preventing head and neck injury. *Br J Sports Med.* 2005;39:314-318.

28. Norton K. SS, Lange K. Evidence for the aetiology of injuries in Australian football. *Br J Sports Med.* 2001;35(6):418-423.

29. Naunheim R. MM, Standeven J. et al. Does the use of artificial turf contribute to head injuries? *J Trauma.* 2002;53(4):691-694.

30. Collins M, Lovell MR, Iverson GL, Ide T, Maroon J. Examining concussion rates and return to play in high school football players wearing newer helmet technology: a three-year prospective cohort study. *Neurosurgery.* 2006;58(2):275-286.

31. Schatz P, Pardini JE, Lovell MR, Collins MW, Podell K. Sensitivity and specificity of the ImPACT test battery for concussion in athletes. *Arch Clin Neuropsych.* 2006;21:91-99.

32. Schatz P. Long-term test-retest reliability of baseline cognitive assessments using ImPACT. *Am J Sport Med.* 2010;38(1):47-53.

33. Broglio SP, Ferrara MS, Macciocchi SN, Baumgartner TA, Elliott R. Test-retest reliability of computerized concussion assessment programs. *J Athl Training.* 2007;42(4):509-514.

34. A. A. *Psychological Testing*. 6th ed. New York, NY: Macmillan; 1998.

APPPENDICES

Table 1. [14] Cantu Concussion Grading Scale

Grade	Definition	Posttraumatic Amnesia
1	Mild, no loss of consciousness	<30 min
2	Moderate, loss of consciousness <5 min	>30 min
3	Severe, loss of consciousness >5 min	>24 h

Table 2. Paired Samples Statistics

Test	N	Mean	Std. Deviation	t	p-value
Verbal Memory Pre	23	83.70	8.875		
Verbal Memory Post	23	88.26	8.120	-2.898	.008*
Visual Memory Pre	23	82.87	9.231		
Visual Memory Post	23	81.65	10.364	.488	.630
Visual Motor Speed Pre	23	40.04	5.2745908		
Visual Motor Speed Post	23	39.47	5.6420620	.745	.464
Reaction Time Pre	23	.574 s	.0550817		
Reaction Time Post	23	.614 s	.0775081	-3.093	.005*
GSC Pre	23	2.78	3.343		
GSC Post	23	3.65	6.057	-.583	.566

*Showed statistically significant differences from pre to post-season ($p<.05$)

Table 3. ImPACT RCI Significances

Test	# RCI Significances
Verbal Memory	0
Visual Memory	4
Visual Motor Speed	3
Reaction Time	7

*All significantly decreased

Figure 1. **Concussion Symptom Scale Checklist**

Name:_____ Sport:_____ Date:_____

Circle one: Baseline Test or Post-Concussion Test: D_____

Symptoms	None	Mild		Moderate		Severe	
1. Headache	0	1	2	3	4	5	6
2. Nausea	0	1	2	3	4	5	6
3. Vomiting	0	1	2	3	4	5	6
4. Balance Problems/Dizziness	0	1	2	3	4	5	6
5. Fatigue	0	1	2	3	4	5	6
6. Trouble Sleeping	0	1	2	3	4	5	6
7. Sleeping More Than Usual	0	1	2	3	4	5	6
8. Drowsiness	0	1	2	3	4	5	6
9. Sensitivity To Light	0	1	2	3	4	5	6
10. Blurred Vision	0	1	2	3	4	5	6
11. Sensitivity To Noise	0	1	2	3	4	5	6
12. Sadness/Depressed	0	1	2	3	4	5	6
13. Irritability	0	1	2	3	4	5	6
14. Numbness/Tingling	0	1	2	3	4	5	6
15. Feeling Like “In A Fog”	0	1	2	3	4	5	6
16. Difficulty Concentrating	0	1	2	3	4	5	6
17. Difficulty Remembering	0	1	2	3	4	5	6
18. Neck Pain	0	1	2	3	4	5	6

Column Total Score	0	

Overall Total Score	

Figure 2. **Oklahoma State University**

PREPARTICIPATION PHYSICAL EXAM

Athletic Scholarship: Yes or No DATE OF EXAM: _____

Name _____ Date of Birth _____ Sport _____

Height _____ Weight _____ Body fat (optional) _____ % Pulse _____ BP _____ / _____ (_____ / ____ / ___)

Initial BP

Last Tetanus: _____ Booster Y/N **Lab: CBC____ CMP____ Sickle Cell Screen _____**
Ferritin ____ **Other _____**

Vision: R 20 / ____ L 20 / ____ Corrected: Y N Pupils: Equal _____ Unequal _____

Medical	Normal	Abnormal Findings
Appearance		
Eyes/Ears/Nose/Throat		
Lymph Nodes		
Heart		
Pulses		
Lungs		
Abdomen		
Genitalia (male only)		
Skin		

Musculoskeletal		
Neck		
Back		
Shoulder / Arm		
Elbow / Forearm		
Wrist / Hand		
Hip / Thigh		
Knee		
Leg / Ankle		
Foot		

Current Medications: _____ Allergies: _____

CLEARANCE ( ) Cleared ( ) Cleared after completing evaluation / rehabilitation for:

_____

( ) Not cleared for: _____ Reason:_____

Recommendations:

_____

Name & Title of Examiner:_____ Date _____

Signature of Examiner _____

OSU Athletic Sports Medicine / 170 Athletics Center ~ 405-744-5430

Stillwater, OK 74078

Figure 3.

OSU Sports Medicine

Interim Physical

Name: _____ CWID: _____

Sport: _____ Height: _____ Weight: _____

Blood Pressure: _____ Pulse: _____ Allergies: _____

Corrected:

Vision: R: _____ L: _____ Yes No Meds:_____

Last tetanus: _____ LMP (if applicable): _____

Describe all illnesses and/or injuries since your last physical:

_____

_____

Pass: _____ Initials: _____

Fail: _____ Initials: _____

Restrictions:

_____

_____

_____

Name of Physician: _____Date: _____

Physicians signature: _____ Date: _____

OSU Sports Medicine/Athletic Training

170 Athletics Center ~Stillwater, OK 74078

405-744-5430

Oklahoma State University Institutional Review Board

Date:	Wednesday, June 01, 2011
IRB Application No	ED11117
Proposal Title:	Comparison of Preseason and Postseason Measures from ImPACT and Graded Symptom Checklist on Division I Football Players
Reviewed and Processed as:	Expedited

Status Recommended by Reviewer(s): Approved **Protocol Expires: 5/31/2012**

Principal Investigator(s):

Dustin Melvin
4701 N. Washington #104
Stillwater, OK 74075

Steven Edwards
325U Willard
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,

Shelia H. Kennison

Shelia Kennison, Chair
Institutional Review Board

VITA

Dustin K Melvin

Candidate for the Degree of

Master of Science

Thesis: COMPARISON OF PRESEASON AND POSTSEASON MEASURES FROM IMPACT AND GRADED SYMPTOM CHECKLIST ON DIVISION I FOOTBALL PLAYERS

Major Field: Bachelor of Science

Biographical:

Education: Purdue University, 2006-2010

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Name: Dustin K Melvin Date of Degree: May, 2012

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: COMPARISON OF PRESEASON AND POSTSEASON MEASURES FROM IMPACT AND GRADED SYMPTOM CHECKLIST ON DIVISION I FOOTBALL PLAYERS

Pages in Study: 34 Candidate for the Degree of Master of Science

Major Field: Applied Exercise Science

Scope and Method of Study:

This study examines the possible effects of sub-concussive hits that players receive throughout the season. The study consisted of 23 subjects (9 offense and 14 defense) and was approved by the university IRB. All subjects signed an informed consent and participated in every game throughout the season. Subjects came in for pre-season testing, before fall camp started, on GSC and ImPACT. Subjects then came in for post-season testing within a week after the last regular season game.

Findings and Conclusions:

Statistically significant differences in verbal memory and reaction time were observed. Verbal memory increased and reaction time decreased over one season of DI football. All other variables had no significant differences from pre to post-season. Although verbal and reaction time showed statistical differences they are not significant in the clinical setting. The RCI on ImPACT would not recognize the variation between pre and post test as significant. These results can prove that baseline testing should be done before each season on athletes in order to obtain the most up-to-date and accurate baseline measurement. Athletic trainers and team physicians should always be monitoring their athletes during practices and games for concussion like symptoms to protect the athlete from further harm. Future research recommends looking at pre and post scores over an athlete's career and examining any possible differences. Researchers could also examine NFL players and look for any differences in pre to post season measures due to the higher speeds of play and longer regular season schedules compared to college.

ADVISER'S APPROVAL: Dr. Steve Edwards