CONCUSSIONS: THE IMPACT OF CONTACT IN FOOTBALL AND SOCCER AND PREVENTATIVE MEASURES

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Abstract

Sport-related concussions are not limited to age, gender, or professional athletes. Medical professionals' resources are limited when it comes to diagnosing concussions, and the symptoms are not always immediate in the athlete. Both Football and Soccer athletes sustain the highest percentage of concussions, due to the level of physical contact in the sports. It is essential that these athletes, coaching staff, and parental guardianship are informed of the immediate and long-term symptoms of a concussion. This paper includes descriptions of what concussions are, how they occur, how they are diagnosed, how practitioners determine when it is safe for an athlete to return to sport, mechanisms of injury and rates of injury in both soccer and football, and interventions to reduce concussions.

The concussion protocols limit the medical professional as the athlete may or may not acknowledge the concussion symptoms they are experiencing, and the healthcare practitioner time engagement is limited. It is critical that the medical professional/athletic trainer, coaching staff, and parental guardian work together as a team to ensure the long-term health of the athlete.

Keywords: Concussion, Mechanism of Injury, Diagnostic Tools, Return to Play, Football, Soccer.

Chapter one: Introduction

Sport-related concussions have recently become the most discussed injury in all of sports. There is a new focal point on player safety in athletics. The mild Traumatic Brain Injury (TBI) or better known as a concussion has evolved into something much larger. It has become so critical that athletes, coaches, and parents are now becoming aware of the dangers associated with concussive injuries. These individuals need to know what a concussion is and how a concussion (how often a concussion occurs) can impact an individual. A concussion is one type of traumatic brain injury that occurs when the individual experiences a direct or indirect blow to the head, face, or neck area (Daneshvar, Nowinski, McKee, and Cantu, 2011). In the United States, millions of people sustain a TBI a year, but only 1.6 to 3.8 million concussions are reported and adequately treated.

Given the high possibility of an athlete being susceptible to a blow to the head during any sport at any time, awareness of the symptoms is important. Understanding the symptoms in the athlete's perspective is just as important as having the athlete report their symptoms to a healthcare practitioner. The reason for one to report a possible concussion is because young, developing athletes become susceptible to more brain damage if the concussion is improperly treated. When a TBI is misdiagnosed or improperly treated there are three potential outcomes the athlete may face: 1) second impact syndrome, 2) prolonged recovery from a sequential concussion, and 3) chronic traumatic encephalopathy or CTE (d'Hemecourt, 2011). It is important for an athlete to seek a healthcare practitioner when symptoms of a concussion first occur. Concussions are a common injury in contact sports, especially in football and also both men's and women's soccer. Both sports can involve a significant number of blows to the head throughout a single game. An athlete needs to be educated about concussions and understand the

risks of playing football or soccer. The Athlete can then determine if the health risks are worth playing the sport.

Statement of the Problem

This paper will research concussions and the research question driving the research is the amount of concussions occurring in contact sports such as football and soccer. Concussions are common injuries in all contact sports especially in football and soccer. Concussions are typically misunderstood amongst the coaches and parents. In efforts to minimize concussions everyone should be educated from the athlete to the coaches, parental guardians, school administrators, athletic directors, and teachers. Educating all on how concussions occur, what signs or symptoms to look for and how to implement safeguards when an athlete is suspected of a concussion and how to reduce the risks of concussions. An Athlete may have immediate signs of vomiting, appeared dazed or nausea and delayed symptoms of sleep disturbances, sensitivity to light, and irritability. Suspicion of a concussion during or after the game the coaches or parental unit would follow standard protocol by removing the athletic from the game or interactions and seek an appropriate health-care professional. If coaches, parental guardians, school administrators, athletic directors, and teachers become educated about concussions they will be able to help minimize the amount of concussions in football and soccer.

Significance of the Study

It is important to study this problem because concussions can occur in all sporting events, but the highest incidences come from football and soccer (Harmon et al. 2013). Sport-related concussions are not limited to age ranges, professional athletes, or gender. An athlete can sustain a concussion at any time during a sporting event (Brady and Brady, 2011). This study will benefit athletes, coaches, and parents. It will help them understand why healthcare practitioners are so cautious with concussions and the concussion procedures healthcare practitioners will put

an athlete through before an athlete is allowed participate in their sports again. Sporting events play a significant role in the lives of many people. It is important for them to understand the brain injuries that can occur from participation in these sports.

Purpose of the Study

In general, the purpose of this study is to inform athletes, coaches, and parents to understand the safeguards of a concussion. This is especially important when looking at two contact sports such as football and soccer. These two sports produce high rates of concussions and it is crucial to look at current and future preventative measures. This study will make connections with concussion education, inventions, and possible solutions in football and soccer.

Definition of Terms

Concussion (1): an induced transient disturbance of brain function that involves a complex injury process. Concussions are a mild traumatic brain injury that is on the less severe side of the brain injury spectrum (Harmon et al., 2013).

Concussion (2): a concussion refers to a sudden and transient alteration in consciousness induced by traumatic biomechanical forces transmitted directly or indirectly to the brain (Khurana & Kaye, 2011).

Concussion (3): The third definition is a complex pathophysiological process affecting the brain, induced by biomechanical forces (Miyashita, (2013).

Chronic Traumatic Encephalopathy: repeated head trauma that results in loss of intellect, memory, and balance and coordination (d'Hemecourt, 2011).

ImPACT: Immediate Post-Concussive Assessment and Cognitive Testing

SCAT: Sport Concussion Assessment Tool

Return-to-play: the process of determining when an injured athlete may safely return to practice or games.

Method of Approach

Methods of approach began with determining the topic. From deciding the topic, the paper was categorized into different sections. The literature review in Chapter 2 covers various topics related to concussions in sports. One possible solution to reduce the risk of concussion in football would be to ban all head-to-head contact, and for soccer eliminate or ban the athlete from heading the soccer ball. These suggested solutions would decrease the concussion rates. The key terms identified through research and included in the overall topic were concussions, return to play, diagnostic, football, soccer, epidemiology or cause, history, and mechanism of injury. The search engines used were Google Scholar, which was accessed through the Internet and Ebsco which was accessed through the Karrmann Library at the University of Wisconsin-Platteville. The articles were limited from the year 2010-2017. The findings were summarized and synthesized in Chapter 2 of this paper. Conclusion and recommendations were included in Chapter 3.

Chapter Two: Review of Related Literature

Introduction

Sport-related concussions have recently become the most discussed injury in all of sports. There is a new focal point on player safety in athletics. The mild Traumatic Brain Injury (TBI) or better known as a concussion has evolved into something much larger. It has become so critical that athletes, coaches, and parents are now becoming aware of the dangers associated with concussive injuries. These individuals need to know what a concussion is and how a concussion (how often a concussion occurs) can impact an individual. A concussion is one type of traumatic brain injury that occurs when the individual experiences a direct or indirect blow to the head, face, or neck area (Daneshvar, Nowinski, McKee, and Cantu, 2011). In the United States, millions of people sustain a TBI a year, but only 1.6 to 3.8 million concussions are reported and adequately treated.

Given the high possibility of an athlete being susceptible to a blow to the head during any sport at any time, awareness of the symptoms is important. Understanding the symptoms in the athlete's perspective is just as important as having the athlete report their symptoms to a healthcare practitioner. The reason for one to report a possible concussion is because young, developing athletes become susceptible to more brain damage if the concussion is improperly treated. When a TBI is misdiagnosed or improperly treated there are three potential outcomes the athlete may face: 1) second impact syndrome, 2) prolonged recovery from a sequential concussion, and 3) chronic traumatic encephalopathy or CTE (d'Hemecourt, 2011). It is important for an athlete to seek a healthcare practitioner when symptoms of a concussion first occur. Concussions are a common injury in contact sports, especially in football and also both men's and women's soccer. Both sports can involve a significant number of blows to the head

throughout a single game. An athlete needs to be educated about concussions and understand the risks of playing football or soccer. The Athlete can then determine if the health risks are worth playing the sport.

What is a concussion?

There is no universal agreement upon the definition of a concussion. This paper defines concussions in three different ways. The first definition is that a concussion is defined as a traumatically induced transient disturbance of brain function and involves a complex pathophysiological process. A concussion is a mild traumatic brain injury but is on the less severe side of the brain injury spectrum (Harmon et al., 2013). The second definition is that a concussion refers to a sudden and transient alteration in consciousness induced by traumatic biomechanical forces transmitted directly or indirectly to the brain (Khurana & Kaye, 2011). The third definition is a complex pathophysiological process affecting the brain, induced by biomechanical forces (Miyashita, 2013).

Concussions are commonly misinterpreted in media and are often downplayed as a minor injury. This has changed over the past several years. The reason this has changed is that of former and deceased NFL players who have been diagnosed with CTE. This disease is caused by the repetitive head trauma over a lifespan and can only be diagnosed after death. From the recent rise of CTE diagnoses the sport of football has implemented many new rules to protect defenseless players from taking any unnecessary blows to the head or neck area (Brady & Brady, 2011).

Headaches are one of the most commonly reported symptoms following traumatic brain injury (Dikemen et al. 2010). A headache is the most common complaint of the athlete that is suffering a concussion. Concussions are a common problem in many contact sports, but over

50% of concussions are unreported each year (Harmon et al., 2013). When a concussion is unreported, it predisposes an athlete to a more severe and life-threatening injury. Short-term effects can decrease reaction time. Long-term effects can be chronic cognitive dysfunction (Harmon et al., 2013). Therefore, it is essential that parents, coaches, and athletes are educated on concussion recognition, prevention, and management.

Mechanism of Injury for a Concussion

In 2011, there were an estimated 38 million children and adolescents who participated in organized sports in the United States (Daneshvar, Nowinski, McKee, and Cantu 2011). Additionally, 170 million adults engage in physical activities yearly. Many of these activities are associated with an increased risk of traumatic brain injury (TBI) (Daneshvar et al., 2011). Therefore, recognition of the mechanism of injury for a concussion is important to understand. According to Miyashita (2013), the means by which athletes get concussions is a direct blow to the head or to the body where a force is transmitted to the brain, referred to as the "Mechanism of Injury." A blow to the body can result in whiplash. In a whiplash injury, the athlete's head suffers a severe jerking motion which can come from head-to-head contact or body-to-body contact. The jerking motion can cause an athlete to sustain a concussion even though he/she did not receive a direct blow to the head. Athletes with a history of previous concussions are 4 to 6 times more likely to sustain an additional concussion (Miyahita, 2013).

Of all the sports played in the United States, football is associated with the greatest number of TBIs. Football players hit (two individuals running towards each other until they make contact) head-to-head in almost every play throughout an entire game. The intensity, velocity, and the angle of the impact of the athlete's body can be cause for the injury. Depending on the velocity and the angle of the impact, the athletes head can be jolted in a multitude of

ways. From repeated head trauma, football athletes are at risk of suffering a concussion. In football, there is a variety of protective equipment that is worn. The type of equipment that is used consists of a helmet, shoulder pads, thigh pads, knee pads, and a girdle. These devices were created to help protect the athlete. The purpose of a football helmet is to prevent a TBI in a football player. Even though the purpose of the helmet is to prevent a TBI, there is no helmet that can guarantee that a TBI is 100% preventable. Therefore, the mechanism of injury in football is repeated head trauma (Daneshvar, Nowinski, McKee, & Cantu (2011).

In the United States, soccer is one of the fastest growing sports. Approximately, 12.5 million men and women play competitive soccer. A TBI in soccer is likely to occur. The most typical mechanism of injury is head-to-head contact (Daneshvar, Nowinski, McKee, & Cantu, (2011). Head-to-head contact is when a soccer player uses his or her head to make contact with the ball, but instead makes contact with an opponent's head. When two athletes collided head-to-head with each other, both athletes would be suspects of a concussion. The contact from the heads hitting each other can occur at different velocities and angles which affects the player's head and neck. The second mechanism of injury is heading the ball (Daneshvar, Nowinski, McKee, & Cantu (2011). When a soccer ball is in flight and a player uses his or her head to control the direction of the ball. The ball is kicked at different velocities which can jolt the head or neck. Therefore, these are the two mechanisms of injuries for soccer.

Clinical Diagnostic Tools

Concussion diagnostic tools were developed to help healthcare practitioners diagnose concussions. These tools allow the healthcare practitioners to determine when the athlete may return to play. The diagnostic tools that a healthcare practitioner can use for a sport-related concussion are the Sport Concussion Assessment Tool (SCAT) and Immediate Post-Concussive

Assessment and Cognitive Testing (ImPACT). To be able to determine if an athlete has sustained a concussion, the athlete is required to complete a baseline concussion test in either a SCAT, an ImPACT or both. The baseline concussion test examines and documents an athlete's normal cognitive function. The concussion baseline allows a healthcare practitioner to examine an athletes' normal cognitive function compared to examining an athlete's impaired cognitive function when suspected of a concussion.

The Third International Conference on Concussion developed the SCAT (Jinguji et al., 2012). The purpose of this concussion diagnostic tool is to guide healthcare practitioners to make appropriate return-to-play decisions for athletes suspected of suffering a concussion. The SCAT consists of a subjective and an objective portion and is scored up to 100 possible points. The subjective portion has a concussion symptom score index which is graded on a 0-6 scale on severity. The objective portion contains physical signs, Glasgow Coma Scale (level of consciousness), balance testing, coordination testing, and a cognitive assessment. The cognitive assessment includes orientation, immediate memory, concentration, and delayed recall (Jinguji et al., 2012).

Jiguuji et al. (2012), looked at the Sport Concussion Assessment Tool and baseline values for high school athletes. The purpose of the study was to determine SCAT baseline scores among high school athletes without a history of concussions. The SCAT was administered to 214 athletes in football, women's soccer, men's basketball, gymnastics, baseball, softball, and track. From administering the SCAT on healthy individuals, they found that the average SCAT score was 89 out of a possible 100. They also found that females scored significantly higher on balance, immediate memory, and concentration scores. Overall, concentration scores were low. Only 67% of athletes could recite the months in reverse, and 41% could correctly sequence five

digits backward when healthy. The study recommended that return-to-play decisions should rely on the overall baseline test rather than just the concentration section when determining the return-to-play status (Jiguuji et al., 2012).

Snyder and Bauer (2014), looked at the Sport Concussion Assessment Tool in children and adolescents. The purpose of this study was to develop child and adolescent baseline norms for the SCAT to provide reference values for different age and gender groups. The study consisted of 761 participants of boys and girls with an age range of 9 years of age to 18 years of age. The older adolescents and teenagers produced higher scores than the younger children. The younger children were between the ages of 9 and 11. The age differences were noted on individual component measuring cognition, stability tests (BESS Tests), and on the symptom report. It was also pointed out that females had higher numbers of symptoms than males. This study produced the standard data tables for gender and age to use as a comparison measure. From the normative data tables, the SCAT was effective in assessing baseline functioning in teenagers.

The ImPACT diagnostic tool is computerized and is the most commonly used neurocognitive test for concussion management (Elbin, Schatz, & Covassin, 2011). This tool evaluates multiple aspects of neurocognitive function including memory, attention, brain processing speed, reaction time, and post-concussive symptoms. This tool is only effective when athletes have completed an ImPACT baseline concussion test. The ImPACT baseline composite scores are put into subcategories. The categories are memory composite (verbal) which tests verbal memory, memory composite (visual) which tests visual memory, visual motor speed composite which tests speed of recall, reaction time, impulse control composite, and total symptom score (Elbin et al., 2011).

Mayers and Redick (2012), examined the clinical utility of ImPACT assessment for post-concussion return-to play-counseling. The purpose of this study was to determine if ImPACT testing could pinpoint the time of post-concussion ability to return to full participation in the sport. The study looked at the ImPACT's baseline test and post-concussion test reliability and validity. They found that there was a lack of reliability in the baseline test and the post-concussion test. The researchers recommend that high school athletes should be tested based on the standard levels every two years in their four-year athletic career. As for collegiate athletes, they should be examined every year in their four-year athletic career. This difference in how often athletes should be tested is due to the finding that the cognitive function of young high school students doesn't change as rapidly as young adults. Furthermore, there could be months to years between baseline testing and post-concussion testing. The ImPACT testing did, however, have high validity. The high validity was because the test consisted of the same format and scores in the same categories. The article found that further examination of the diagnostic tool to support ImPACT testing for pinpointing the time of post-concussion return to full the participation of the sport (Mayers & Redick, 2012).

Elbin, Schatz, and Covassin (2011) looked at the reliability of ImPACT testing in high school athletes. The purpose of the study was to look at high school athlete's first baseline test compared to their second baseline test after one year of ImPACT testing. This study included 369 high school athletes who were administered baseline tests exactly one year apart from each other. From the six composite scores, the most stable composite scores were reaction time, visual memory, and verbal memory. They found that ImPACT baseline is a stable measurement for neurocognitive performance across a one-year baseline-testing period for collegiate athletes and a two-year baseline-testing period for high school athletes (Elbin et al., 2011).

Concussion Return-to-Play

Determining return-to-play guidelines for athletes who have been diagnosed with a concussion is a critical factor. Return-to-play is the process of determining when an injured athlete can safely return to practice or a game. The reason it is a critical factor is that athletes are predisposed to more brain damage which can result in second impact syndrome, prolonged recovery from sequential concussions, and CTE. Second impact syndrome occurs when an athlete who is still symptomatic sustains another concussion which could prove to be fatal. Prolonged recovery from sequential concussions is when one suffers from more than one concussion which results in a longer recovery period (d'Hemecourt, 2011). CTE is similar to the Alzheimer's Disease and Parkinson Disease, but the main difference is that CTE cannot be diagnosed until the patient is dead and when the autopsy is complete.

When determining return-to-play for an athlete, the priority is assessing the athlete's symptoms that are related to concussion-type symptoms. The symptoms are broken up into three categories. The three categories are somatic, emotional, and cognitive. Somatic symptoms include headaches, balance issues, and sleeping problems. Emotional symptoms include depression and anxiety. Cognitive symptoms include concentration and memory problems (d'Hemecourt, 2011). Athletes should fill out a symptoms checklist daily when they are in a concussion protocol. A concussion protocol is a protocol that contains steps for a healthcare practitioner to follow that ease an athlete back to full sports participation. Depending on the protocol, athletes will have to have three to five days of symptom-free days before they can advance to the next stage of the protocol. The athlete is kept at a cognitive and physical rest in efforts to manage the concussion-type symptoms. Cognitive rest refers to limiting the athlete's activities, such as video games and texting. Symptoms typically last up to seven to ten days.

Physical rest refers to limiting any strenuous physical activity. Symptoms can typically last up to 7 to 10 days (d'Hemecourt, 2011).

Before returning to play, an athlete must prove to be symptom-free during rest and physical exertion. In general, a return-to-play protocol follows general guidelines. The general protocol guidelines include the following steps:

1. A symptom-free: no headaches, no body fatigue or poor balance, mental confusion, sleepiness, irritability, no mild depression or ringing in the ears
.
2. Light aerobic exercise: walking, swimming, or cycling
3. Sport-specific activities: Football and Soccer intensity on short and long runs, kicking and jumping
4. Noncontact drills: Athlete participates in daily practice drills with no contact
5. Medical clearance by a medical doctor: A medical release is required for athlete to return to the team which allows the athlete to participate fully in practice.
6. Full contact practice: Coaching staff utilizes athlete to their full potential
7. Gameplay: Athlete is on the active roster to play with no limitations

(May, Marshall, Burns, Popoli, & Polikandriotis, 2014).

Carson et al. (2014) looked at premature return-to-play and return-to-learn after a sport-related concussion. Return-to-learn is when an athlete can fully participate in class without restriction due to impaired brain function. The purpose of the study was to determine which percentage of athletes experienced worsening symptoms as a result of premature return-to-play. The study looked at a total of 170 concussions of athletes in middle school, high school, and college. It was found that 43.5% of the 170 athletes diagnosed with a concussion returned to the game play too soon. The athletes that sustained previous concussions, will require additional days of rest before beginning physical activity, and the athletes that did not have a previous concussion, would require fewer days of rest. In the protocol that was used, they recommended

restrictions on cognitive and physical activity, but the documentation did not define clearly what cognitive rest included. Clear and concise guidelines would need to be created for athletes who have sustained a concussion (Carson et al. 2014).

May et al., (2014) looked at sports specific return-to-play guidelines following a concussion. The purpose of the study was to implement a six-step process that provided structure to guide an athlete in the process of recovering from a concussion. The six-step process included the following:

1. No physical or cognitive activity. The main objective is recovery.
2. Light aerobic exercise and the objective is to increase heart rate.
3. Sport-specific exercises and the objective is added movement.
4. Non-contact practice and the objective is exercise, coordination, and cognitive loading.
5. Full-contact practice and the objective is restoring athlete's confidence and assessing functional skills.
6. Return-to-play without any restriction.

With the ongoing confusion among athletes and coaches, this study states that the same six-step program should be implemented for every sport. This would create more of an understanding for athletes and coaches when going through a concussion protocol (May et al., 2014).

Even when a return-to-play protocol is implemented into a sports program, the healthcare practitioner might be pressured by the coaching staff to prematurely return an athlete to full participation after suffering a diagnosed concussion. Kroshus et al. (2015) looked at pressure on sports medicine clinicians to prematurely return collegiate athletes to play after a concussion. This study found that players, coaches, and other athletic staff personnel put pressure on sports medicine clinicians to return athletes early from a concussion. Coaches were rated as the highest

person pressuring the Sports Medicine Clinician. Furthermore, female clinicians felt more pressure for premature return than male clinicians. Even though clinicians were pressured, they still need to use the protocol that is put in place. Therefore, clinicians should have a meeting with both the athletes and the coaching staff before the season and explain the concussion protocol (Kroshus et al., 2015).

Contact Sports Involving Head Trauma

Football

In all sports there is a possibility that an athlete could sustain a blow to the head or neck area at any time. The trauma can be due to the type of sport it is, or it could be from accidental contact to the head area. The two games in which contact to the head is imminent is in football and soccer. These two sports are most likely to have athletes suffer a concussion due to direct contact with the head more frequently than other sports (Brady & Brady, 2011).

Football is one of the most popular sports in the United States with approximately 3 million youth athletes, 1.1 million high school athletes, and 100,000 college athletes participating in football annually (Dompier et al., 2015). Despite the benefits of the sport, there is increasing attention on the safety of the participants.

Dompier et al., (2015) looked at the incidence of concussion during practice and games of grade school, high school, and college. The purpose of the study was to describe the epidemiology of concussions in football players aged from 5 to 23 years of age. They found that game concussion percentage rates were higher than practices, in all three age groups. The college athlete concussion percentage rate during game participation was overall higher than that of the high school or the youth athletes. However, when evaluating the athlete percentage rate during practice, the High School Athlete concussion rate is higher than the College athlete is. The

lowest concussion rate was identified in the grade school athlete in a practice environment. The highest concussions were identified among the high school football players in a game environment. From this study, it was noted that concussions in games were higher than concussion in practice. These results may be a little unrealistic as contact or impact during practice is often limited, to ensure that players are not hurt during practice. Many strategies were also used to limit head contact in practices (Dompier et al., 2015).

Daniel, Rowson, and Duma (2012) looked at head impact exposure in youth football. The purpose of this study was to investigate the head impact exposure using a head acceleration measurement device, the head impact telemetry (HIT). The HIT device consists of a series of accelerometers that fit inside a player's football helmet and the device recorded a player's biomechanical head response to every contact to the player's head. There were seven youth football participants who wore the device throughout the season. There was a total of 748 impacts to the head or roughly 107 impacts per player. This study reported that the majority of head impacts occurred during practice, instead of during the game. The researchers recommended that the football coaches needed to limit or modify practice drills to eliminate the risky elements of game situations (less frequent collisions, less high intensity impacts, etc.) to decrease the impact to the players' head (Daniel et al., 2012).

Broglio et al. (2010) looked at the biomechanical properties of concussions in high school football. It's important to understand the biomechanical properties of a concussion because it helps develop better diagnostic and preventative techniques. The purpose of this study was to explain the biomechanical threshold or impact for concussive injuries. The study used a device called the head impact telemetry (HIT) to measure impacts to an individual's head. A total of 78 athletes participated and a total of 54,247 impacts were recorded with a total of 13 concussions

being diagnosed during the study. The impacts were recorded by either rotational acceleration, linear acceleration, or impact location. The researchers found that HIT devices should be implemented for medical use on the sideline. From the degree of a head impact, a medical doctor or an athletic trainer will be able to diagnose 1 out of every 5 athletes with a concussion when an impact to the head exceeds the threshold when wearing the device.

Beckwith et al. (2013) looked at head impact exposure sustained by football players on days of diagnosed concussion. The purpose of this study was to compare the frequency and severity of head impacts sustained by football players on days with and without diagnosed concussion. There were 1,208 participants in which 95 of them were diagnosed with concussions. They measured head motion which included peak linear and rotational acceleration, GADD severity index (severity of head impact), head injury criteria, change of velocity, and number of head impacts. The HIT device did this. They found that players sustained more head impacts and higher severity impacts on days of diagnosed concussion than of days without diagnosed concussion (Beckwith et al., 2013). From this they found that higher severity impacts occurred during games than head impacts that occurred during practices.

Talavage et al. (2014) looked at functionally-detected cognitive impairment in high school football players without a clinically diagnosed concussion. The purpose of this study was to examine the neurological performance and health in the presence of head collisions in high school football players using measures of the HIT device, ImPACT testing, and functional magnetic resonance imaging. The study aimed to look at two categories, which were:

- clinically diagnosed concussion with no changes to neurological behavior, and
- clinically diagnosed concussion with changes in neurological behavior.

There was an unexpected third category created:

- clinically-observed concussion symptoms without a clinical diagnosis of concussion.

From the findings, researchers stated that traditional concussion assessment tools were not totally reliable such as in the cases in this third, unexpected category. This means that individuals participating in football activities might have experienced potential brain trauma while playing even they were not diagnosed on the sidelines as having a concussion. This failure to properly identify a concussion and failure to sideline athletes with concussion symptoms could impact the future of these athletes.

Injuries occur in all sports and are not 100% preventable. Concussions are going to continue to occur in football no matter how many safety regulations are implemented. Therefore, it is important that coaches implement as many preventative measures as possible. These preventative measures can include tackling techniques and less player-to-player contact in drills during practice. It is important that the coaching staff and athletes understand what concussions are and how they should be handled. It is important that the healthcare practitioner is involved when an injury occurs so that the safety of the athlete is always prioritized above everything else (Kroshus et al., 2015).

Soccer

Soccer is one of the most popular sports in the world and one of the fastest growing sports worldwide. There are approximately 12.5 million to 18.2 million people participating in soccer each year. Soccer is a sport that is not traditionally identified as high risk for concussions like football is. However, 22% of all soccer injuries include concussions (Levy et al. 2012).

O'Kane et al. (2014) looked at concussions among female middle-school soccer players. The purpose of this study was to look at frequency and duration of concussions in female youth soccer players and to determine if concussions resulted in stopping of play and seeking medical

care. In this study, there were 351 soccer player participants in which 59 concussions were reported. There was a total of 43,742 athletic exposure hours in which players could suffer an injury and in those 43,742 exposure hours only 13% of the exposure hours resulted in concussion injuries. Heading the ball caused 30.5% of the concussions sustained. Players who displayed symptoms of sensitivity to light, emotional stability, noise sensitivity, memory loss, nausea, and concentration problems had a longer recovery time than those who did not experience these concussive symptoms. On average, symptoms lasted up to 4 days. It was also found that 58.6% continued to play with concussive type symptoms. The researchers found that concussion rates were higher in young female soccer players compared to older female players, but the young female soccer players were less likely to seek medical treatment for their symptoms.

Levy et al. (2012) looked at concussions in soccer. The purpose of the study was to look at the causes of concussions in soccer. They found that the direct causes for concussions in soccer were from direct contact from person-to-person or head-to-ball. The study found a correlation with contact to the head and concussions. Throughout the study there was a strong indication between heading the ball in a single season and the degree of cognitive impairment of the brain function. Along with these findings, the researchers also looked at preventive concussion measures. They looked at the size of the soccer ball (the size of the ball varies by age) for certain age groups and also having players wear headgear. Headgear is a wide padded headband that fits onto the athlete's head and was designed to cushion or protect the players head when making contact with either the ball or another player. In spite of these preventative measures, researchers found that concussions continued to occur and concluded that the protective gear measured to be insufficient in protecting the athlete's brain from injury.

Maher, Hutchinson, Cussimano, Comper, and Schweizer (2014), also looked at concussions caused by soccer players heading the ball. The purpose of this study was to investigate the mechanism of a concussion in soccer and analyze the short- and long-term neurocognitive effects of heading in soccer. In this study, they found that females sustained concussions at a higher rate than males. It also showed that the most frequent mechanism for concussions was from player-to-player contact for both genders. In terms of short term and long-term effects of a concussion injury, it was seen that neurocognitive function was only temporarily disrupted following a concussion. They recommended that more research be done on long term effects of concussion in soccer (Maher et al., 2014).

Comstock, Currie, Pierpoint, Grubenhoff and Fields (2015) looked specifically at high school soccer players getting concussions from heading the ball. The purpose of this study was to identify injury mechanism commonly leading to concussions and then comparing those mechanisms to one another. The researchers looked at a total of 1,393,753 athlete exposure hours. They found that 627 concussions occurred during those exposure hours. From this they found that the most common injury mechanism was player-to-player contact and that heading the ball was most common sport-specific mechanism for concussions. From the findings the researchers indicated that grade school soccer players should not "head" the ball because it will reduce the overall number of concussions. Furthermore, reducing the amount of player-to-player contact allowed in the sport of soccer would most likely be the most effective way to reduce concussions in soccer (Comstock et al., 2015).

Broglio et al. (2010) looked at concussion occurrence and knowledge in soccer. The purpose of this study was to investigate concussion history, knowledge, injury identification, and management strategies among soccer athletes. This study showed that majority of concussions

went unreported. Athletes have confirmed symptoms of a concussion but did not think it was serious enough to report to medical personnel. It also showed that coaches did not fully understand the signs and symptoms of a concussion. Therefore, they allowed the athlete to continue playing with concussion-type symptoms. The researchers indicated that athletes and coaches could benefit by taking educational courses about concussions to further understand the signs and symptoms and the possible side effects of playing with a concussion (Broglio et al., 2010).

These five studies went in depth on the occurrence of concussions in soccer. Concussions are going to continue to occur in soccer no matter how many safety regulations are implemented. It is important that coaches implement as many preventative measures as possible. These preventative measures can include less player-to-player contact in drills during practice and proper heading technique. Therefore, preventative measures need to be addressed and implemented into practices and in games so that the number of concussions sustained by athletes will decrease (Levy et al. 2012).

Interventions

In order to prevent concussion type injuries, it is important that regulators of the sports address the physical demands of football and soccer. Sport regulators need to adopt newer and safer interventions in order to reduce the risks of a concussions in football and soccer. Football rule regulators have recently added new rules in which concussive type hits or plays will be penalized if they occur. Even though there are rules against concussive type hits, the hits still

occur. In order to solve this issue, adopting and teaching different tackling techniques, such as the rugby-style tackling technique would help to decrease the amount of concussions in football.

One intervention that has been implemented into football is a rugby style tackling method. In rugby, the players are not allowed to wear protective equipment. Therefore, rugby players tackle differently than football players would. Football players are required to wear protective gear or equipment to participate in the sport. This equipment is designed to help prevent injuries and allows the football players to use their entire body as a potential weapon. Football players wear helmets which gives these athletes the sense that their head is protected. They are accustomed to tackling by using their head. Rugby players do not have the protective equipment; therefore, they use a different tackling technique to tackle the opponent without using their head. Hendricks and Lambert (2010) stated that proper rugby tackling style is to tackle an opponent while protecting your head. An example of a rugby tackling technique is to avoid another's body with your head and use your shoulders to make the impact and to wrap one's arms around the opponent. This puts the impact on the player's shoulder rather than on the player's head. Another example of rugby tackling is to grab and roll. This technique is when a player goes to tackle an opponent, and they grab the opponent by wrapping their arms around them and then roll towards the opponent's legs. This technique may injure the opponent's legs but prevents head-to-head contact. If football adopted the rugby-style tackling style, it would prevent the head-to-head contact (Hendricks & Lambert, 2010).

A second intervention for football is rule changes. Football has added numerous of rules to the game over the past decade. More specifically, rules were added for the safety of the players. The rules added for the safety of the players that coincide with concussion prevention include targeting, hitting a defenseless player, and tackling with the crown of the helmet.

Targeting is when a player uses their head, shoulder, and or forearm to the head or neck area of another player. This results in a fifteen-yard penalty, automatic first down, and automatic ejection from the game. Hitting a defenseless player is when the player is in a vulnerable state in which they cannot protect themselves from an oncoming hit. This results in a fifteen-yard penalty and an automatic first down. Tackling with the crown of the helmet is when a player tackles another player with the forehead of their helmet to another player's helmet. This results in a fifteen-yard penalty and an automatic first down. These new rules were implemented to make the game safer for the players. It allows them to feel more protected than once before. Even though these rules were implemented, the dangerous hits still occur. Therefore, further rules like these still need to be looked at and evaluated.

The sport regulators have not yet adopted any new rules in order to protect the head area in regard to heading the ball. They do have dead ball fouls when unnecessary body-to-body contact is made on the ground and in the air. The player to commit the foul has the potential to get a warning or get ejected from the game depending on the severity of the foul. Even though there are dead ball fouls in the sport it does not prevent any direct blows to a player's head. Therefore, it is up to engineers and medical professionals to come up with ways to protect athlete's heads. The device that was invented to help protect soccer athlete's head is call head gear. According to Niedfeldt (2011), head gear is protective padding that is worn on a soccer players head to decrease the forces that occur during the game. The purpose the head gear was to cushion the contact of the ball and or the contact of another player to the head. Niedfeldt (2011), looked at the use of head gear in soccer athletes. In his study, it was found that head gear was not an effective device for preventing concussions when heading the ball. He found that when an athlete headed a ball with the head gear, that the ball still made contact with the player's head.

The head gear showed no significant different than not wearing a head gear therefore, newer and different interventions need to be developed to protect the player's heads.

Possible Solutions

Concussions are an injury that can potentially affect the cognitive function of an athlete long after they have suffered from one. The effects may not show in the time being but can develop into long term effects. As previously stated, long term effects can develop into CTE which causes erratic behavior. From the knowledge and research that is known about concussions right now, it is important that sports adopt safer and more preventative ways to reduce the risk of a concussion. More specifically, looking at possible solutions for concussion prevention in football and soccer.

Football is a violent sport. There are many body-to-body collisions in this sport. Over, a period of time the sport adopted safer and more advanced protective equipment. This equipment protects the athlete from a lot of injuries but is not guaranteed to prevent any injury especially with concussions. Every football helmet has a label on it stating that it cannot guarantee the prevention of a spinal or concussion type injuries. From all of the information stated about concussions it is important to continue to find possible solutions to reduce the risk of concussions in this sport.

One possible solution to reduce the risk of a concussion is to ban all head-to-head contact. Head-to-head contact is one of the most common mechanisms of injury for a concussion in football. Therefore, if the sport eliminated head-to-head contact in all aspects of the sport the risk of concussions will go down. In order to adopt this type of rule in football it needs to go through a trial phase. The trial phase should consist of grade school, high school, and college football athletes. The game will have to be taught in a whole new way. Players will not be

allowed to use their head and if a player uses their head they will be penalized. The players will have to learn how to use their arms, body, and legs to play the game. The game has evolved into a fast-paced high impact game but lacks the old fashion fundamentals of the sport. Fundamentals are proper techniques in doing certain football type activities. An example of a football fundamental is blocking by using hands, arms, and feet to be able to block an opposing player. By implementing this rule into the game, the athletes will rely solely on the fundamentals of the sport. This will require coaches to teach the players more on safety and how important safety is. The trial will examine concussions diagnosed throughout the trial and report the findings. The finding should be compared to modern day football. If the findings are significant, more trials should be started so that there is more significant data to plead the case of implementing the new rule.

A second possible solution to reduce the risk of concussions in football is to slow down the speed or pace of the game. In today's football, the teams play at a fast pace no huddle type offense. No huddle type offense is when a team on offensive does not huddle up on the field and runs the team's offensive plays at a fast pace. The purpose of the fast pace offense is to tire out the opposing team on defense. From this the defensive players became exhausted throughout an entire game. This type of football may attract the viewers but is dangerous to the athletes. It is dangerous to the athlete because when a football player is tired, they start to make mistakes. The mistakes that are commonly made in football is the lack of fundamentals when tackling. The defensive players become lazy and start to tackle the offensive players improperly. These improper tackles put the player at a higher risk of injury. Therefore, the speed or pace of the game should be slowed down. If the pace of the games is slowed down it allows both the offensive and the defensive teams to use proper football techniques. With proper techniques the

risk of injury decreases. Therefore, the speed or pace of a football game and concussions need to be further examined.

A soccer game lasts a total of ninety minutes. The game is played in forty-five minute halves with a fifteen-minute halftime break in between. This means that a soccer player has a lot of exposure time which can put the player at a risk of injury. As previously stated, concussions in soccer occur from player-to-player contact and heading the ball. These mechanisms of injury can occur at any time during a ninety-minute soccer game. Therefore, possible solutions to reduce the risk of concussions in soccer needs to be explored.

One possible solution to reduce the risk of concussions in soccer is to eliminate heading of the ball. Heading occurs frequently in soccer and is a major part of the game. Heading the ball is the second most common mechanism of injury in soccer. Heading the ball gives players another tool to allow them to be able to control the ball. It allows them to move the ball in the direction they want it to when it is in midair. The soccer ball is kicked at varies velocities and angles throughout the game. This puts the players at risk for a concussion. From this the intervention of wearing head gear was developed but, head gear did not show any significant improvement in concussion reduction. Therefore, soccer players would need to adapt to play the game differently without using their heads. They would have to position themselves to where they can reach the ball with their body, legs, and feet instead being able to use their head. The game will be more technical and more challenging. The players will develop more technical skills with their body, legs, and feet. To determine if this solution would reduce the risk of a concussion, research needs to be done. The research would look at normal soccer league to the modified eliminated heading soccer league. If the study finds significant reduction in concussions the rule change should be strongly encouraged.

A second possible solution to reduce the risk of concussions in soccer is make the game into four quarters. The four quarters would be twenty-two minutes and thirty seconds a piece. There would be a five-minute break in between the first and second quarter and the third and fourth quarter. There would still be a fifteen-minute break at halftime. By breaking the game up into quarters, it allows the players to receive more rest. This allows the players to play with solid soccer fundamentals. From this it will help prevent players from making errors due to fatigue. Not only does this benefit the players with fatigue it allows the team to strategize more. It gives a team more opportunity to talk about the game with their coaching staff and to make adjusts for the game. To determine if this solution would reduce the risk of a concussions, research needs to compare the two different game settings.

Summary

There is no universal agreement upon the definition of a concussion. It can be defined in multiple ways. One definition is that a concussion is a mild traumatic brain injury from a blow to the head, neck, or body area. An athlete has the possibility to sustain a concussion at any time during a football or soccer game (Brady & Brady, 2011). This is possible because the sports of football and soccer have multiple mechanisms of injury that can occur which can result in a possible concussion. This is why concussion diagnostics tools were created. The SCAT and ImPACT tools allow for a healthcare practitioner to create baselines for athletes and to use the baselines as guidelines to assess normal cognitive function compared to impaired cognitive function. Once the healthcare practitioner has diagnosed the concussion, the athlete is put into return-to-play protocols. The protocol is set up so that athletes do not return to practices or games prematurely and prevents additional brain damage from occurring during the healing process. The athletes playing football and soccer accumulate a lot of exposure time in which they

are susceptible to a concussion. From the football and soccer articles, it was inconclusive, on which sport was more susceptible to a concussion. But both sports are at risk of sustaining a concussion. Therefore, interventions and possible solutions are needed for both sports. The interventions and possible solutions can help reduce the risk of concussions going forward in both sports.

Chapter Three: Conclusions and Recommendations

In summary, in the United States from 2010 on there are approximately 1.6 to 3.8 million cases of sports-related traumatic brain injuries that occur each year over time (Makdissi et al., 2010). Concussions can occur in all sporting events, but the highest incidences come from football and soccer (Harmon et al., 2013). Playing football and soccer both can result in head injuries. The athletes playing football and soccer accumulate a lot of exposure time throughout a season. This exposure can lead to multiple injuries. Injuries can range from chronic to acute. Chronic injuries are from repeated trauma and acute injuries occur suddenly. Among all these injuries, a concussion is one of the most a concerning injuries. Untreated concussions and repeated blows to the head can lead to permanent brain damage which will affect an individual for the rest of their life. An example of this is retired NFL football players. These players have had repetitive head trauma for approximately 20 to 25 years of their lives. From this trauma these athletes are having memory issues, emotional instability, and loss of motor function. Other body parts that get injured throughout an athletic career have surgical options to help repair them. Athletes that suffered a concussive injury throughout their playing career do not have surgical options to repair the brain damage that occurred.

Based on the existing literature it has been concluded that it is inconclusive on which sport an athlete plays, football or soccer, is at more risk of suffering a concussion. From looking at the research, there was no significant evidence that pinpointed either sport to being more susceptible to a concussion. The research suggests that athletes playing football and soccer are put at risk for sustaining a concussion. The athletes playing football and soccer accumulate a lot of exposure time in which they could potentially lead to head trauma. This puts both sports at a high risk of sustaining a concussion. Therefore, it is suggested that when determining to play

either football or soccer, it is important to look at all of the possible risk factors of the sport. Athletes in these sports accumulate significant injuries and none of that should be taken lightly when determining which sport to play.

From all of the information presented, this study made connections with concussion education, inventions, and possible solutions in football and soccer. It will give coaches, parental guardians, school administrators, athletic directors, and teachers background in concussion education and management. It also gives athletes the general knowledge about concussions. This basic knowledge can help determine whether or not an athlete wants to play one sport or another. Going forward it is best that both football and soccer regulators adapt to newer and safer rules and regulations. Football regulators have started the trend by penalizing illegal hits on the field, so that dangerous hits ~~a~~re avoided. Soccer regulators have not adopted many safety regulations into the sport yet. To reduce the risk of concussions, it's recommended that coaches adopt protective practices which can reduce the risk of concussions throughout the season. Going forward, it is important to continue to research concussions in sports. More specifically, research should be done on possible solutions on preventing concussions in contact sports. Possible solutions can include rule changes, game setting changes, and game style changes. It is also important to continue to study the side effects of concussions. The brain is not 100% understood and each concussion can result in a different cognitive impairment. Therefore, concussion research needs to continue to evolve.

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