

EXPLORING DIFFERENCES THAT MAY CONTRIBUTE  
TO HIGH SCHOOL ATHLETES' KNOWLEDGE OF CONCUSSION  
AND REPORTING BEHAVIORS

By

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## **PUBLIC ABSTRACT**

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Sport-related concussion has been identified as a public health concern and in the last decade, concussion awareness has dramatically increased. The increased awareness of concussion is likely due to the media and recent research. Current literature on knowledge of concussion among high school athletes suggests that there is still a gap that exists between what high school athletes know about sport-related concussion and what they should know.

Concussion knowledge of the signs and symptoms, as well as complications from concussions, is critical because many concussive injuries often go unidentified. Unidentified concussions and the under-reporting of concussions can lead to an increased risk of subsequent injury and long-term consequences in the adolescent athlete. **OBJECTIVE:** The current study evaluated

knowledge of concussion and reporting behaviors in high school athletes attending urban and suburban schools and schools with and without an athletic trainer (AT). **DESIGN:** cross-

sectional study **SUBJECTS:** 715 male and female high school athletes playing football, boys' and girls' basketball, wrestling, cheerleading, boys' and girls' soccer, volleyball and gymnastics from 14 different schools. **MEASUREMENTS:** A one-time survey served as the instrument.

**RESULTS:** Athletes attending urban schools have less concussion knowledge than athletes attending suburban schools; and, athletes with access to an athletic trainer have more knowledge than athletes that do not have access to an athletic trainer. Between group differences showed that white athletes have higher knowledge scores than African American athletes. The under-reporting of concussion is 55% and higher reporting percentages are influenced by school type

and access to an athletic trainer, sex and sport. **CONCLUSION:** While concussion knowledge does not appear to affect reporting, there are significant differences in concussion knowledge in urban and suburban high school athletes and differences in schools with an AT and without an AT. The presence of an AT has shown to positively affect concussion knowledge and reporting behaviors within high school athletes.

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high school athletes and differences in schools with an AT and without an AT. The presence of an AT has shown to positively affect concussion knowledge and reporting behaviors within high school athletes.

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# CHAPTER 1

## INTRODUCTION

### 1.1 Overview of the Problem

Concussion is not a structural injury, rather a function injury that affects neurocognitive performance (Collins & Hawn, 2002; Collins et al., 2002; Van Kampen et al., 2006). As a result of the functional injury, recognition of associated signs and symptoms of concussion can be difficult, especially for those that are not educated and trained to identify a concussive injury (Faure & Pemberton, 2010). Within the United States, an estimated 1.6-3.8 million brain injuries occur annually, and approximately 300,000 cases are identified as sport-related (CDC, 2013). These figures vastly underestimate the overall burden of concussion because many individuals suffering from concussion do not seek medical advice (Faul et al., 2010; Langlois et al., 2006). Concussion is the most common athletic head injury (Guskiewicz et al., 2000) and as sport participation continues to rise among high school athletes, the concern for concussion also continues to increase.

Most concussed athletes experience signs and symptoms immediately after injury, however, in approximately 20% of concussed athletes; there is a delayed onset of symptoms in which symptoms are experienced around 48 hours post injury (McCrea et al., 2003). There is also a common misconception that loss of consciousness (LOC) is necessary to sustain a concussion (Kelly et al., 1991), however, LOC only occurs in approximately 9% of all diagnosed concussions (Guskiewicz, 2003). There are approximately 22 signs and symptoms that an athlete can experience after incurring a concussion. Headache is the hallmark symptom of concussion and is the primary symptom most commonly reported by concussed athletes (Frommer et al., 2011). Although headache is present in most cases of sport-related concussion, athletes may experience less common signs and symptoms such as sleep disturbance or foggiess. Signs and

symptoms that are less common are often unfamiliar to athletes, thus, they are likely to not report those symptoms due to unfamiliarity and lack of knowledge. Moreover, there are no biological markers that exist to detect concussion and many concussive injuries show no outward visible signs, making concussion even more difficult to recognize (Ellemberg et al., 2009). Symptoms are used as criterion for concussion evaluation and management; however, many concussions go unidentified due to the variability in presentation and general lack of awareness of concussion among the athletic community (Valovich McLeod et al., 2007).

To date, two published studies have been influential in examining the behavior of under-reported concussions in high school athletes. Both studies were conducted using survey instruments. Research suggests that approximately 50% of high school athletes may not report concussions to an authoritative figure (i.e., parent, coach, athletic trainer) (McCrea et al., 2004; Register-Mihalik et al., 2013). Unreported concussions among high school athletes may be due to lack of understanding of concussion and psychosocial factors that influence behavior (Register-Mihalik et al., 2013). Register-Mihalik and colleagues (2013) used a survey to investigate knowledge of concussion among high school athletes and found that athletes with increased knowledge of the associated signs and symptoms of concussion are more likely to report potential injuries to an authoritative figure. A limitation to these studies is the influence of school type (urban versus suburban) on knowledge of concussion and reporting behaviors among high school athletes. The school type often affects resources provided at school and many urban schools do not have generous resources to support athletics. Additionally, the school type is often reflective of the socioeconomic status of the student body population. Resources and socioeconomic status differences may contribute to high school athlete knowledge of concussion and reporting behaviors.

Increased sport participation and sport-related concussion incidence has led to an emphasis of having an appropriate medical professional, like nurses, doctors, and athletic trainers, available to high school student athletes. The medical professional best suited to provide medical care to high school athletes is a certified athletic trainer (AT) (Valovich McLeod et al., 2013). ATs are typically individuals that provide daily on-site coverage of practices and competitions. The presence of an AT is critical to early recognition and care of athletic injuries specifically the recognition of sport-related concussion. The National Athletic Trainers' Association (NATA) estimates that only 42% of high schools across the United States have access to an AT (NATA, 2008). Access to an AT may influence the reporting of sport-related concussion in the high school athletic population; however, little is known about how the presence of an AT affects concussion knowledge, prevention, and recognition. Without an AT, high school athletes have to report any injury to a coach or parent. McCrory et al. (2013) states that in the event that any athlete sustains a suspected concussive injury, the initiation of medical care is a role of the coach, however, coaches do not have the same medical training as ATs, or other medical professionals, and may not recognize when an athlete is experiencing signs and symptoms of a concussion. Additionally, coaches may experience a conflict of interest regarding benching or playing an injured player.

Current literature on knowledge of concussion among high school athletes suggests that there is still a gap that exists between what high school athletes know about sport-related concussion and what they should know about concussion. Results from Register-Mihalik et al. (2013) suggest that high school athletes are relatively knowledgeable about the general signs and symptoms of concussion (i.e. headache, confusion, and dizziness) as compared to previous studies, although athletes are still unable to recognize some of the lesser common signs and

symptoms of concussion, such as nausea, amnesia and insomnia. Increases in knowledge of concussion and concussion symptoms have shown to positively affect reporting, but increases in knowledge does not equate to a change in behavior (Register-Mihalik et al., 2013). The proposed study aimed to further investigate knowledge of concussion and reporting behaviors of high school athletes by examining more specific factors that influence reporting of concussion.

## **1.2 Significance of the Problem**

In the last decade, concussion awareness has dramatically increased. Sport-related concussion has been recognized as a public health concern among young athletes and several consensus statements have been developed to provide the most up-to-date and accurate research to inform the public on the recognition, evaluation, and management needed to care for a concussed athlete. The increased awareness of concussion is likely due to these consensus statements, as well as increased awareness created by the media and recent research. As awareness of the general public continues to improve, it is important that athletes, coaches, parents, and school administrators are educated regarding the detection of concussion through recognition of signs and symptoms and guidelines for safe return to play (McCrory et al., 2013). Concussion education and knowledge transfer is critical because many concussive injuries often go unidentified. Unidentified concussions and the under-reporting of concussions can lead to an increased risk of subsequent injury and long-term consequences in the adolescent athlete.

McCrea et al. (2004) reported common reasons high school athletes do not report their concussion such as not thinking the injury was serious enough to warrant medical attention, fear of being removed from play, and lack of awareness of a likely concussion. This study was conducted using a retrospective survey instrument at the end of the football season. This study was comprised of 1, 532 high school football players across 20 schools. Register-Mihalik et al.

(2013) further investigated reasons male and female high school athletes do not report their concussion using a different survey instrument, and found similar results. Athletes did not report their concussive injury for reasons such as did not think the injury was serious enough to report, did not want to be removed from play, and did not want to let teammates down. Neither study examined school environmental differences and the associated variables that contribute to differences between student body populations at urban schools versus suburban schools. School environment, the socioeconomic status of high school student athletes and race may be variables affecting concussion knowledge and reporting behaviors.

Concussion knowledge and reporting may be influenced by an athlete's school environment. High school athletes attending urban schools often have fewer resources (i.e. equivalent protective sports equipment and access to medical personnel) than high school athletes attending suburban schools and this may contribute to under-reporting of concussions due to a lack of awareness. There is a lack of research investigating differences in concussion knowledge and reporting behaviors among athletes attending urban and suburban schools. The differences between urban and suburban schools are often defined by resources provided to students and the socioeconomic status of the student body population. Most urban schools serve communities with a high percentage of low-income students that live in poverty. Urban schools are often Title I schools in which the majority of the student population qualifies for free and reduced lunch. Students living in poverty are more likely to be hungry at school, and are less likely to have health insurance (Murgia et al., 2009). Urban schools serve the majority of the nation's minority, inner-city population (Watson, 1989) and the health and well-being of athletes in urban high schools is compromised by limited calories, limited health care, limited resources, and often no AT. Moreover, African American students have reported limited awareness of

concussion and the signs and symptoms associated with concussion, and as a result of this lack of awareness, concussions may go unrecognized and unreported (Kontos et al., 2010). Limited concussion knowledge, as well as limited resources may pose a serious threat to high school athletes that experience a concussion. Athletes may continue to play while symptomatic if the injury is not diagnosed and it may place him/her at risk for further injury.

The AT is the ideal liaison between school administrators, parent, coaches, physicians, and parents (Lyznicki et al., 1999). Access to athletic training services is critical to the medical care athletes receive while participating in high school sport. ATs provide the most comprehensive on-site medical coverage for high school practices and competitions (Lyznicki et al., 1999). Currently, ATs are estimated to be present in 42% of all high schools within the United States (NATA, 2008). This presents a problem for student athletes participating in athletics that have limited to no medical coverage. In many school districts, there is limited funding to support athletes and hiring an AT cannot be sustained by the budget. However, high school administrators must ensure the safety of student-athletes by finding funds to provide appropriate medical coverage. Injury is a risk of athletic participation and concussions represent 9% of all high-school injuries (Gessel et al., 2007). The lack of an AT may contribute to the numbers of concussions that go unidentified. All 50 states have passed legislation concerning youth concussion and concussion laws provide a clear explanation for the importance of an AT to evaluate and manage concussion injuries (Valovich McLeod et al., 2013).

As high school sport participation continues to rise in the United States, and budget constraints limit resources in public schools, administrators must find a way to provide the best possible care for student athletes. Many schools have adopted a pay-to-play policy and many coaches are hired as volunteers, therefore they are less likely to be heavily involved around



school and may not have the same qualifications as physical education teachers with regards to first aid and safety training. There is limited research assessing differences in knowledge of concussion and reporting behaviors of high school athletes within different school contexts. The completed study was unique because it was the first to collectively assess knowledge of concussion and reporting behaviors of high school athletes in urban and suburban schools and schools with access to an AT and schools with no access to an AT.

### **1.3 Purpose of the Study**

The aims of this study were to assess high school athletes' knowledge and reporting behaviors of sport-related concussion and identify specific factors that influence reporting of concussion. Specifically, the primary purposes were to assess (a) high school athletes' knowledge of concussion, (b) reporting behaviors of high schools athletes that have experienced signs and symptoms of concussion and reasons why student-athletes would not report those signs and symptoms to an authoritative figure, (c) differences in knowledge of concussion and reporting behaviors between high school athletes attending urban and suburban schools, and (d) differences in knowledge of concussion and reporting behaviors between high school athletes with access to an AT compared to no access to an AT.

### **1.4 Research Questions**

1. Is there an association between school type (urban/suburban) and athlete knowledge of concussion and reporting behaviors?
  - a. Do high school athletes attending urban schools have less knowledge of concussion than high school students attending suburban schools?

- b. Do high school athletes attending urban schools less frequently report potential concussive injuries to an authoritative figure compared to high school athletes attending suburban schools?
2. Is there an association between having access to a full time AT and high school athlete knowledge of concussion and reporting behaviors?
  - a. Do high school athletes that have access to an AT have higher knowledge of concussion scores than high school athletes that do not have access to an AT?
  - b. Do high school athletes that have access to an AT more frequently report potential concussive injuries to an authoritative figure than high school athletes that do not have access to an AT?
3. What factors (ie., race, sex, age, sport) are associated with knowledge of concussion score?
4. What factors (i.e., race, age, sex, knowledge of concussion score) are associated with reporting of potential concussions in high school athletes?

### **1.5 Definition of Terms**

1. AT ACCESS – A full time employed certified athletic trainer provided by a school. AT access includes daily, on-site medical coverage of practices and competitions for high school sports.
2. ATHLETE KNOWLEDGE – Athlete knowledge is a student athlete's computed score from knowledge of concussion questions on the survey instrument assessing his/her understanding of the dangers of concussion, complications from a concussion injury, and signs and symptoms of concussion.
3. AUTHORITATIVE FIGURE – Defined as an AT, coach, school administrator, or parent.

4. CONCUSSION – An injury resulting from a blow to the head, or other part of the body that resulted in an alteration in mental status and one or more of the following symptoms: headache, nausea, sensitivity to light, memory loss, dizziness, fogginess, confusion, tinnitus, sleep disturbances, blurred vision, or LOC (McCrea et al., 2003)
5. HIGH SCHOOL ATHLETE – A student athlete enrolled in a public high school (grade 9-12) that participates in one of the following sports: football, girls' basketball, boys' basketball, boys' soccer, volleyball, wrestling, gymnastics, cheerleading.
6. KNOWLEDGE OF CONCUSSION SCORE – Total knowledge of concussion correct out of 35 questions (higher=better)
7. RACE – Assessed through a demographic question to determine whether the student athlete is white, African American, American Indian, Asian, Hispanic/Latino, or other. Student athletes are able to choose more than one race, as many students are of mixed race.
8. REPORTING BEHAVIORS – A student athletes intent to notify or not notify, or past history of notifying, or failing to notify an authoritative figure or teammate of a potential concussive injury, after experiencing a sign or symptom of a concussion.
9. SUBURBAN SCHOOL – Defined as a school located outside of a metropolitan area in which the majority of the student body population is from a higher socioeconomic background, not qualifying for free and reduced lunch.
10. URBAN SCHOOL – Defined as an inner city/Title I school in a metropolitan area in which the majority of the student body population is from a lower socioeconomic background, qualifying for free and reduced lunch.

## **1.6 Limitations**

This study was limited by: (a) all data was self-reported; (b) the fact that participants were only surveyed in the state of Michigan; (c) a selection bias due to employing a convenient rather than random sample; (d) the amount of AT access at each school varied. For example, how the AT chooses to cover events and time spent with each sport varied; and (e) the time of reporting (i.e., time frame between when injury occurs and when athlete reports injury to authoritative figure) was not be assessed.

## **CHAPTER 2**

### **REVIEW OF LITERATURE**

Concussion is an inherent risk to sport participation. Although concussion is a mild brain injury, it can be a serious health risk to high school athletes whose brains are still developing. Concussion may lead to long-term effects if not recognized and properly managed. Mismanagement of concussion could lead to catastrophic outcomes in adolescent athletes, such as second impact syndrome. Second impact syndrome is rare; however, it is an injury that can be avoided if signs and symptoms are immediately identified. It is critical that high school athletes understand the signs and symptoms of concussion and understand the importance of reporting those signs and symptoms to an authoritative figure. Not reporting signs and symptoms could jeopardize quality of life or lead to future complications. Given these effects, it is important to understand what high school athletes know about concussion and reasons that influence reporting behaviors.

#### **2.1 Epidemiology of Concussion in High School Athletics**

According to the National Federation of High School Associations (NFHS), there were approximately 7.8 million high school student athlete participants during the 2012-2013 academic school year; a rise of approximately 500,000 participants from the 2009-2010 academic school year (NFHS, 2013). Participation in high school sport continues to increase and with increased participation yields a similar increase in the number of student athletes sustaining a concussion (Gessel et al., 2007).

Concussion injuries remain a prominent and profound public health concern. According to the Centers for Disease Control (CDC), participation in sport has resulted in approximately 1.6-3.8 million brain injuries annually (CDC, 2013). Within the United States, sport

participation is the leading cause of concussion in individuals age 0-19, accounting for 30% of all diagnosed concussions (Meehan & Mannix 2010). Furthermore, over the past decade, emergency room visits for sport-related concussion among children and adolescents have increased by 60% (CDC, 2013).

Concussions represent 9% of all high school athletic injuries (CDC, 2013) and occur across a wide variety of high school sports (Marar et al., 2012). Concussions represent 5-9% of all collegiate athletic injuries (Hootman et al. 2007). Guskiewicz and colleagues (2000) examined the epidemiology of concussion in college and high school football players. Data for the study was collected from certified athletic trainers at institutions recruited through the NATA Injury Surveillance System (ISS) and NCAA schools representing all levels. Concussion rates were calculated as injury rates per 1000 athlete-exposure; the overall rate of concussion for both high school and collegiate athletes was 0.70 per 1000 athlete exposures (Guskiewicz et al., 2000). Results from this study revealed that the concussion injury rate for high school athletes (1.03 per 1000 A-Es) was twice as high as the concussion injury rate for division I collegiate athletes (0.49 per 1000 A-Es) (Guskiewicz et al., 2000). Reasons for the higher rates of concussion at the high school level was attributed to a higher percentage of high school players being exposed to contact compared to players on a division I team. Many high school players play both offense and defense positions and this accounts for more tackling and contact during practices and games. Additionally, there are a higher percentage of high school players that play both offensive and defensive positions, increasing their total exposure (Guskiewicz et al., 2000).

In 2007, Gessell and colleagues examined concussion injury rates among high school and collegiate athletes within the United States. A total of nine high school sports were studied throughout the 2005-2006 school year with 396 of the 4431, or 8.9% of the injuries reported

representing concussions (Gessel et al., 2007). The concussion injury rate was 0.23 concussions per 1000 athlete-exposures (Gessel et al., 2007). In comparing high school and collegiate injury rates, Gessel et al. determined that for the corresponding nine college sports studied, there was a higher rate of concussion in college sports (0.43 concussions per 1000 A-Es) than high school sports (0.23 concussions per 1000 A-Es). This is contrary to the findings of the study conducted by Guskiewicz and colleagues (2000) who reported a greater injury rate for high school athletes compared to collegiate athletes. However, Guskiewicz and colleagues only examined football athletes and not other sports. It is also important to note that Gessel and colleagues did conclude that concussion consisted of a greater quantity of total injuries sustained by high school athletes than by college athletes in all sports except volleyball and men's basketball (Gessel et al, 2007). Of the nine sports studied by Gessel et al. (2007), the concussion injury rate was higher in competition than in practice in full contact (football and wrestling) and partial-contact (soccer and basketball) sports (Gessel et al, 2007). Moreover, in sex comparable sports, such as soccer and basketball, concussion rates were higher in girls and concussions represented a greater percentage of total injuries among girls compared to boys (Gessel et al, 2007).

Similar to findings reported by Gessel et al. (2007), Rechel and colleagues (2008) examined epidemiology of high school sports injuries sustained in both practice and competition. Five boys' sports and 4 girls' sports were used to compare injury rates and patterns, with concussions representing 9.1% of all total injuries that incurred throughout the 2005-2006 school year (Rechel et al., 2008). Concussion incidence during competition (12.0%) was higher than concussion incidence during practice (5.9%) (Rechel et al., 2008). This was remarkably clear in boys' soccer and girls' basketball (Rechel et al., 2008) where the incidence of concussions were six times higher in competition compared to practice. Additionally, similar to findings by both

Gessel et al. (2007) and Guskiewicz et al. (2000), most high school concussions were attributed to player to player collisions (Rechel et al., 2008).

Lincoln and colleagues (2011) conducted an 11 year prospective study examining concussion trends and incidence among 12 sports in 25 public high schools. The study compiled concussion injury statistics starting in the 1997-1998 school year and ended in the 2007-2008 school year. Results among the 12 sports revealed that football accounted for more than half of all concussions (Lincoln et al., 2011). Boys' lacrosse had the second largest incidence, and baseball represented the boys' sport with the lowest incidence of concussion (Lincoln et al., 2011). Girls' soccer had the highest incidence of concussion amongst girls' sports, followed by cheerleading and basketball (Lincoln et al., 2011). In addition, the rate of concussion was twice as high in girls compared to boys in similar sports (Lincoln et al., 2011). The overall concussion rate across all 12 sports increased over the 11 year period from 0.12 per 1000 athlete-exposures in 1998 to 0.49 per 1000 athlete-exposures in 2008. This was an average of 15.5% increase each year (Lincoln et al., 2011).

The epidemiology of concussion was further investigated over the 2008-2010 school years using data from the National High School Sports-Related Injury Surveillance System (High School RIO) (Reporting Information Online). Concussion data was collected across 20 high school sports and concussion rates were compared across sport, sex, and exposure type (Marar et al., 2012). Only high schools across with United States with a National Athletic Trainers' Association affiliated certified athletic trainer were invited to participate. Over the two years, a total of 1936 concussions were reported, 1289 occurred in competition and 647 occurred in a practice (Marar et al., 2012). Most of the reported concussions occurred in football (47%), followed by girls' soccer (8.2%), boys' wrestling (5.8%), and girls' basketball (5.5%) (Marar et



al., 2012). However, the numbers are higher for football as they have more athletes participating than in other sports. When examining sports by injury rates, football had the highest injury rate at 6.4 concussions per 10,000 AEs, followed by girls' soccer (3.4 per 10,000 AEs), boys' wrestling (2.2 per 10,000 AEs, and girls' basketball (2.1 per 10,000 AEs) (Marar et al., 2012). Results of this study were consistent with findings in previous studies. Specifically, the overall concussion rate was higher in competition than practice, and girls had higher rates of concussion than boys in sex-comparable sports (Marar et al., 2012). Additionally, across all 20 sports, player to player collisions caused the majority of concussions and contact sports had higher concussion rates than non-contact sports (Marar et al., 2012). This study also noted recurrent concussions (i.e., multiple concussions); within sex-comparable sports, and, with the exception of track and field and swimming and diving, girls had a greater percentage of recurrent concussions than boys (Marar et al., 2012).

The epidemiology of recurrent and new concussions was examined by Castile and colleagues (2011) out of concern for the potential long-term and traumatic effects associated with concussion. From 2005-2010, new versus recurrent sport-related concussions were studied in high school athletes using the High School RIO system. Again, all 100 high schools in which data was collected had an athletic trainer on staff. Between 2005 and 2010, a total of 2417 concussions were reported, 2110 were new and 292 were recurrent (Castile et al, 2011). Football had the highest number of new concussions, followed by girls' soccer, boys' soccer, and girls' basketball (Castile et al, 2011). Recurrent concussions were highest in football (6.3 per 100,000 athlete exposure), followed by girls' soccer (4.1), girls' basketball (2.9), and wrestling (2.7) (Castile et al, 2011). This study also revealed that rates of recurrent concussion occur more in competition than practice in all sports except volleyball and softball (Castile et al, 2011).

Due to several reasons, estimating the true incidence and injury rates for sport-related concussion is a challenging task for both researchers and sports medicine professionals. The lack of consensus on the definition of concussion along with the reliance on athletes to self-report their symptoms (McCrea et al., 2004) has made estimating injury rates difficult. The wide range of published epidemiological findings can be attributed to methodological differences across studies including study design (retrospective vs. prospective); different sources of data collection (athletic trainers, coaches, parents); differences between sample populations (age groups, leagues, rules); different definitions of injury; and varying methods of calculating injury rates (per 100 players, 1000 athlete exposure). As researchers and clinicians improve efforts to define and detect this injury, future epidemiological studies will be more accurate in determining the incidence and injury rate of concussion.

## **2.2 Definition of Concussion**

The term concussion derives from the Latin term *concutere* and translates to mean “to shake violently.” The definition of concussion has evolved over time as concussion injuries have become better understood, and the term concussion has historically represented low-velocity injuries that cause brain shaking (McCrory et al., 2013). The brain shaking in turn results in consequent symptoms that are not characteristically related to the pathology of the injury (McCrory et al., 2013). According to the fourth consensus statement on concussion in sport, the amended definition describes concussion as a complex pathophysiological process affecting the brain, induced by biomechanical forces (McCrory et al., 2013). This definition is widely accepted across the medical community. A concussion is an injury to the brain and there are many common clinical, pathological and biomechanical injury paradigms that help to define the

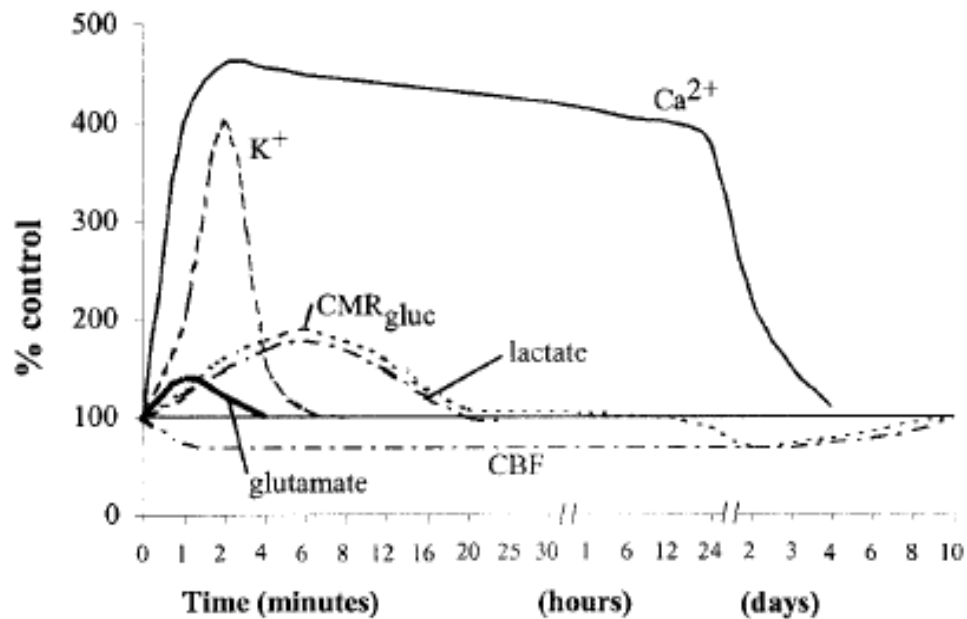
nature of a concussive injury (McCrory et al., 2013). Injury paradigms contributing to the definition of concussion, according to the 2012 Zurich Consensus statement, include:

1. A concussion can be caused by either a direct blow to the head, face, neck, or elsewhere on the body with an impulsive force transmitted to the head.
2. Concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. Signs and symptoms of the injury may develop within minutes; however, sometimes the signs and symptoms may not develop until hours after the injury.
3. Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than structural changes to the brain; and no abnormality is seen on standard structural neuroimaging.
4. Concussion results in a graded set of clinical symptoms that may or may not involve a loss of consciousness. Resolution of clinical and cognitive symptoms typically follows a sequential course. However, it is important to note that in some cases symptoms may be prolonged.

### **2.3 Pathophysiology of Concussion**

Sport-related concussion results in a cascade of ionic, metabolic, and physiological events that occur within the brain (Giza & Hovda, 2001). Prior to the current understanding of the pathophysiology of concussion, a concussion injury was initially understood to only produce a temporary disturbance of normal brain function due to neuronal, chemical and neuroelectrical changes (Cantu, 2001). Experimental and human studies have suggested that pathophysiological changes that occur in the concussed brain result in temporary neuronal dysfunction most likely resulting from ionic shifts, altered cerebral metabolism, impaired connectivity among brain

regions, and/or changes in neural transmission (Cantu, 2001). This period of neuronal dysfunction makes the brain vulnerable and can occur within minutes to days following a concussive injury (Cantu, 2001). Giza and Hovda (2001) have described these events as the “neurometabolic cascade” of concussion (See Figure 1).



*Figure 1. The Neurometabolic Cascade following Concussion. The neurometabolic cascade following experimental concussion. K<sup>+</sup>, potassium; Ca<sup>2+</sup>, calcium; CMR<sub>gluc</sub>, oxidative glucose metabolism; CBF, cerebral blood flow. From “The Neurometabolic Cascade of Concussion,” by C. Giza and D. Hovda, 2001, *Journal of Athletic Training*, 36, p. 229. Reprinted with permission*

Following the biomechanical injury causing concussion, there is an abrupt ionic transfer of potassium and calcium, as well as a release of neurotransmitters that create the acute and subacute change in neuronal cellular physiology (Giza & Hovda, 2001). Neuronal depolarization occurs when glutamate binds to the N-methyl-D-aspartate (NMDA) and potassium shifts extracellular while calcium shifts intracellular, thus beginning a physiologic energy imbalance that makes the brain vulnerable (Giza & Hovda, 2001). These ionic transfers lead to an energy

crisis within the brain as a period of hypermetabolism occurs in effort to restore the natural neuronal membrane potential (Giza & Hovda, 2001). This effort to restore natural neuronal membrane potentials overtaxes the sodium-potassium pumps and increases the need for adenosine triphosphate (ATP), which then produces an increase in glucose metabolism (Giza & Hovda, 2001). The increase in glucose metabolism generates a need for glucose as the brain is experiencing a reduction in cerebral blood flow (Cantu, 2001). The metabolic dysfunction characterized by the demand for glucose after injury, paired with a reduction in cerebral blood flow, yields an energy crisis leading to a period of vulnerability (Cantu, 2001).

After the initial period of accelerated glucose consumption, the concussed brain progresses into a period of depressed metabolism (Giza & Hovda, 2001). The increase of intracellular calcium may harm mitochondrial oxidative metabolism, and has shown to disrupt neurofilaments and microtubules impairing posttraumatic neural activity and exacerbating the energy crisis (Giza & Hovda, 2001). The unconstrained accumulation of calcium can also unequivocally lead to cell death (Giza & Hovda, 2001). Moreover, the neurometabolic cascade also includes building block components of the production of lactic acid, decreased intracellular magnesium, free radical production, inflammatory responses, and altered neurotransmission (Giza & Hovda, 2001).

The neurometabolic cascade that occurs after a concussive injury could be especially harmful to the pediatric and adolescent population. There is evidence to support that the young brain is more vulnerable to injury during periods of specific brain development (Giza & Hovda, 2001). In experimental model animal studies of concussion, the youngest rats tended to have longer apnea and became more hypotensive than adult rats after a mild percussive injury (Giza & Hovda, 2001). After severe percussive injury, the mortality rate nearly reached 100% in

immature rats (Giza & Hovda, 2001). The biomechanical injury can also potentially have lasting effects on the sequence of neurochemical and anatomical events that occur during normal development, thus leading to enduring changes in cognitive potential (Giza & Hovda, 2001). Moreover, repeated injury within a particular time frame can lead to catastrophic anatomical and behavioral impairment than two isolated injuries (Giza & Hovda, 2001).

Exact differences in the pathophysiology of concussive injury in adults versus youth are not exactly known. However, animal model studies suggest that it is imperative youth and adolescent sport participants who may be experiencing a concussive injury are closely monitored for later appearances of neurobehavioral abnormalities. It has been suggested that a second concussive injury can lead to a catastrophic neurometabolic cascade.

## **2.4 Biomechanical Aspects of Concussion**

The biomechanics of head impacts resulting in sport-related concussion have been studied in a variety of settings of sport. Impact to the head can result in many different head motions and the brain can endure a variety of mechanical responses, depending on whether the head is struck with an object or if the head strikes a surface (Meaney & Smith, 2011). The brain is a soft biologic tissue and a critical component of how concussive injury occurs when mechanical energy from an external input is transferred to the brain and its vascular tissues (Meaney & Smith, 2011). Linear and rotational head acceleration forces resulting from direct and inertial loading of the head are theorized to be the primary risk factors for concussion (Guskiewicz & Mihalik, 2010). The head acceleration produces an energy transfer; the brain moves and deforms as a direct effect of the external stimulus (Meaney & Smith, 2011). Linear and rotational accelerations of the head play an important role in producing strain patterns and thus producing diffuse injury to the brain (Guskiewicz & Mihalik, 2010).

In sport activities, there is usually some combination of both linear and rotational acceleration with direct and indirect impacts to the head. Impact typically refers to a blow that makes direct contact with the head causing injury, and an indirect impact refers to an impact that sets the head in motion without striking it (Guskiewicz & Mihalik, 2010). Examples of injurious direct impacts include helmet to helmet collisions, striking an opponent's head with a stick, or being struck in the head with a projectile used in sport such as soccer ball, baseball, or hockey puck. Injuries caused chiefly by direct contact can occur both in the area of impact and in areas distant from the site of impact (Meaney & Smith, 2011). Indirect impacts in sport are most commonly caused by tackling or body checking that results in the opponent's body being abruptly stopped from traveling in the direction it was headed, very similar to an automobile whiplash injury (Guskiewicz & Mihalik, 2010). This inertial type of load creates impulsive head motions, absent of the head striking an object, forcing the brain to move within the skull (Meaney & Smith, 2011). Both direct and indirect impacts are either linear or angular (rotational) in nature.

Ommaya and colleagues (2002) were among the first researchers to investigate the biomechanics and neuropathology of pediatric brain injury. When comparing the skull and brain structure of an average adult to that of an average developing child there is differentiation between the geometry of structures, the composition of biologic materials, and age dependent physiological response to mechanical stress (Ommaya et al, 2002). It is critical that the skull and brain structure differences are understood when examining concussive injuries among the adolescent population. The examination of pediatric head injury by Ommaya and colleagues confers that concussion can occur either by an impact or by a shaking mechanism; both of which can lead to different results (Ommaya et al., 2002). These two separate manners in which

motion of the head can occur as the product of a force applied to the brain either by translation or rotation (Ommaya et al., 2002). Translation is defined as an applied force that passes through the center of gravity of the head, and rotation is defined as the product of a moment of force from a combination of lines of action; either two equal, two parallel or two oppositely directed forces whose lines of action are distinct and then intersect (Ommaya et al., 2002). The consequences of impact are either coup or contre-coup phenomena, and, respectively, there is either injury at the site of impact or at a position distant from the location of impact (Ommaya et al., 2002). Both translation and rotation are often inevitably synchronized in many head injuries and the relative motion of the brain within the skull can also result in the rupture of vessels within the skull/brain interface, causing subdural hematomas (Ommaya et al., 2002).

Further investigation into concussion and the biomechanics of concussion and impact to the brain has been studied in helmet accelerometer research to determine an injury threshold. Guskiewicz and Mihalik (2011) cited concussion as a diffuse axonal injury that can result in disruption to centers of the brain responsible for breathing, heart rate, consciousness, as well as result in memory loss, balance disturbances, somatic symptoms and cognitive deficits (Guskiewicz & Mihalik, 2011). It was hypothesized that the biomechanical threshold for sustaining a concussive injury is intangible and that impact severity may be clinically irrelevant; the biomechanical relationships between playing position, types of play, types of concussive impacts, location of impacts, and clinical measures of concussion were comprehensively reviewed. As injury threshold is examined, it is understood that the mass of the human head has become too large for the body to overcome acceleration or deceleration forces that send it in motion regardless of the type or harshness of a particular impact, however, some direct and indirect impacts do not exceed a threshold needed to force the brain into the inside walls of the



skull that cause concussion (Guskiewicz & Mihalik, 2011). Results from an ongoing study at the University of North Carolina on concussion injury biomechanics in American football players suggest that top of the head impacts are associated with higher susceptibility to concussion than impacts that occur to the front, right or back of the head (Guskiewicz & Mihalik, 2011). Moreover, results suggest that concussion results from a wide range of impact magnitudes (60.51g-168.71g liner acceleration), and clinical measures of concussion are impartial to impact magnitude and location of impact (Guskiewicz & Mihalik, 2011). In fact, concussion can occur at lower impact magnitudes than previously thought; within the study, concussions incurred at lower impact magnitudes tended to present with just as many clinical underperformances as those sustained at higher impact magnitudes (Guskiewicz & Mihalik, 2011). Furthermore, concussion is equally the result of measures of linear acceleration as measures of angular acceleration; linear acceleration is the result of top-of-helmet impacts and these impacts are approximately six times more likely to result in impact magnitudes greater than 80g (Guskiewicz & Mihalik, 2011).

The investigation into the biomechanical variables of concussion injury has also previously been studied by Broglio and colleagues (2009) using the HITS accelerometer technology. Head impacts sustained by high school football players were examined across session type (practice, game), playing position, and location of head impact to better understand the impact biomechanics specific to younger athletes. Data were collected across one single season of football, including all preseason practices, all regular season games and practices and all postseason games and practices (Broglio et al., 2009). A total of 35 athletes participated from a single varsity level team; 68 total sessions were recorded, including 55 practices and 13 games. Results from the study showed that players sustained more impacts during games (mean  $24.54 \pm$

22.41) than practice sessions (mean  $9.16 \pm 8.64$ ) and no differences were eminent across players' ages, heights, and helmet ages, however, differences were noted across player mass and head mass (Broglia et al., 2009). The mean liner acceleration resulting from impacts from games (24.76g) and practice sessions (23.26g) was noteworthy in this study; these values were greater than results recorded at the collegiate level (Broglia et al., 2009). For example, Mihalik et al., (2007) reported an average liner acceleration value of 22.25g across all session types in collegiate football players. Additionally, Mihalik et al (2007) reported that Division I football players sustained statistically significantly higher head impacts during helmets-only practices and full-contact practices compared to head impacts sustained in games and scrimmages.

Another important finding in the Broglia et al. (2009) study was that impacts to the top-of-the head yielded the greatest linear acceleration and force magnitude. This is of elevated importance in the high school athletic population because adolescents are not as physically mature as collegiate or professional athletes and their neck musculature strength is not as developed, thus, they are unable to control head motion following impact (Broglia et al., 2009). Therefore, impact intensity to this area of the helmet not only raises the risk of concussion, but also increases the risk of a catastrophic cervical spine injury (Broglia et al., 2009).

Repetitive or subconcussive impacts to the head throughout an athletic season, not resulting in a clinically-identifiable concussion, have emerged as a biomechanical topic of concern. The sub-concussive impacts are speculated to adversely affect cerebral function (Broglia et al., 2011) and these subtle changes have been documented in high school football athletes, not experiencing signs and symptoms of concussion, as indicated in declines in visual working memory and as altered dorsolateral prefrontal cortex activation assessed through functional magnetic resonance imaging (Talvage et al., 2010). In a study assessing cumulative

sub-concussive impacts over a period of four football seasons from 2007-2010, of the 95 players enrolled for participation, the average player sustained 652 impacts per season (Broglia et al., 2011). Players sustained lower magnitude impact burdens during practices and tended to sustain higher impact burdens during games (Broglia et al., 2011). Moreover, higher percentages of sub-concussive impacts were sustained at practices than games; linemen sustained 59% of their impacts during practices, tight ends, running backs and linebacker sustained 54% at practices, and wide receivers, cornerbacks and safeties sustained 52% at practices (Broglia et al., 2011). Repetitive head trauma is thought to have pathological affects on the brain (Gavett et al., 2011; Geddes et al., 1999; McKee et al., 2009) and high school football athletes have shown to sustain greater quantities of subconcussive impacts relative to other sports in which contact with the head is common, such as hockey and soccer (Broglia et al., 2011). The cumulative effect of repetitive subconcussive blows causes tissue strain that lingers and leads to mechanical fatigue (Breedlove et al., 2012).

## **2.5 Signs and Symptoms of Concussion**

The diagnosis of concussion can include a presentation of clinical signs and symptoms, as well as behavioral changes, sleep disturbances and difficulties with cognition and balance (McCrory et al., 2013). Concussion evaluation should measure clinical signs and symptoms of an injured athlete against the information taken during a concussion history baseline exam. (McCrory et al., 2013). When an athlete sustains a concussion he or she may present any of the following on-field signs of injury: dazed and/or vacant facial expression; confusion and/or failure to remember sport responsibilities or assignments; disorientation to the game situation (e.g., score); inappropriate emotional reaction (e.g., laughing, crying); display of incoordination or clumsiness; delayed response to questions; loss of consciousness; and/or changes in typical behavior or personality (McCrory et al., 2013; Collins & Hawn, 2002; Kontos, Collins, & Russo,

2004; Lovell & Collins, 1998). Concussion has long thought to only be present when the athlete has experienced loss of consciousness, or has “blacked out”. This is a common misconception surrounding sport-related concussion and in fact, only 9% of concussions are associated with loss of consciousness (Guskiewicz either 2000 or 2003 reported that percentage).

The first step to evaluating a concussion is recognition of the injury. Concussion injury can occur from a big hit or from a subtle, less obvious impact, so the reliance on clinical signs and symptoms is a crucial in addition to mental status changes (Fazio et al., 2007). Although there are 22 signs and symptoms of concussions, many of these symptoms are not specific to concussion, therefore making it difficult to make a diagnosis (Putukian, 2011). Concussed athletes may report one or more symptoms and symptoms may present immediately after injury or within hours, days or weeks (Fazio et al., 2007) following a concussive event. Headache is the hallmark symptom of concussion (Putukian, 2011) and has been documented to occur among 86% of all diagnosed concussions (Guskiewicz, 2000). Moreover, in a study by Lau et al., (2011), headache was the most common on-field symptom observed at the time of injury in 94% of the high school aged-subjects that sustained a concussion; the least common symptom was loss of consciousness at 13.3%. Previous studies have also related the presence of headache to higher levels of additional symptomatology, memory dysfunction, and slowed reaction time (Collins et al., 2003). Specifically, Collins and colleagues studied the relationship of post-concussion headache and neuropsychological test performance in high school athletes and found that athletes that had a headache following injury experienced a larger number of additional signs and symptoms at seven days post-injury, compared to athletes with no presentation of headache. In addition, the athletes with a headache were most likely to experience on-field anterograde

amnesia and less likely to experience on-field retrograde amnesia, loss of consciousness and disorientation (Collins et al., 2003).

Headache is the most common symptom of concussion; however, there are several other symptoms that can be present with this injury. Other symptoms include nausea, vomiting, balance problems, dizziness, fatigue, trouble falling asleep, sleeping more than usual, sleeping less than usual, drowsiness, sensitivity to light, sensitivity to noise, irritability, sadness, nervousness, feeling more emotional, numbness, feeling slowed down, difficulty concentrating, difficulty remembering, visual problems, and feeling mentally foggy, or “fogginess”. This symptom of fogginess was introduced as a symptom to the Post-Concussion Symptom Scale in the 1990s after studies done with the Pittsburgh Steelers (Iverson et al., 2004). In a study conducted with high school students, athletes that experienced fogginess also were experiencing more post-concussion symptoms of concussion than athletes that did not experience fogginess (Iverson et al., 2004). Additionally, fogginess was also associated with slower reaction times, memory dysfunction, and slower processing speed (Iverson et al., 2004).

On-field signs and symptoms can be predictors of a prolonged recovery from a concussion. A study conducted by Lau et al. (2011) reported that athletes who present with on-field dizziness are 6.4 times more likely to have a protracted recovery of greater than 21 days. Dizziness is a significant risk factor, however, it can make concussion diagnosis difficult (Putukian, 2011) because dizziness can arise from multiple disturbances with other bodily systems such as cardiovascular (syncope), visual, or vestibular (vertigo) (Maskell et al., 2006).

Signs and symptoms of concussion have been investigated across sexes in high school student athletes. Frommer and colleagues (2011) used injury data from the High School Sport-Related Injury Surveillance System for the sports of football, girls’ and boys’ soccer, wrestling,

baseball, softball, volleyball, and girls' and boys' basketball to record any sex differences in symptoms reported following a concussion. Data from a total of 391 concussions were recorded from 283 males and 108 females in year one and 327 males and 94 males in year two. Among both sexes, headache was the most commonly reported symptom in year one and year two, however, males did report amnesia and confusion/disorientation more frequently than females. Female concussed athletes reported drowsiness and sensitivity to noise more frequently than male concussed athletes (Frommer et al., 2011). Amnesia and confusion are both categorized as cognitive symptoms, drowsiness is a neurobehavioral symptom and sensitivity to noise is a somatic symptom; therefore, high school males and females may have different signs and symptoms of concussion, thus their injury may present differently to health care professionals (Frommer et al., 2011).

Sex differences in concussion symptomatology have also been studied by Covassin and colleagues (2012). Results from a study identifying the role of age and sex in symptoms after concussion cited that females reported more symptoms than males at all time points tested after injury (Covassin et al., 2012). All male and female concussed athletes that participated in the study were administered the ImPACT neurocognitive battery, which includes the Post Concussion Symptom Scale (PCSS), at 2, 7, and 14 days following their concussion and results supported a between-sex difference for concussion symptoms (Covassin et al., 2012) and these results support previous research that has reported females displaying more total concussion symptoms than males.

## **2.6 Management of Concussion**

The assessment and management of sport-related concussion should be approached comprehensively and should include a clinical examination, completion of a symptom checklist, postural and balance assessment, and neurocognitive testing (Guskiewicz et al., 2004). Unlike a

visible injury such as a fracture or contusion, a concussion can be a challenge to recognize for medical professionals, the athlete, and the athlete's parents, coaches, and teammates. The first step for athletic trainers and team physicians for concussion management is to put in place a sideline concussion assessment to be included in the emergency action plan (Putukian, 2011). Additionally, a clinician's concussion management plan should include assessment preparation, follow-up testing, athlete and parent education, and a return to play criteria (Putukian, 2011). Each clinician should develop their concussion management plan based on his or her particular work setting, and components to consider are cost, time required for testing, equipment, personnel, and administrative support (Valovich McLeod, 2009).

The greatest challenge facing sports medicine clinicians is how to most effectively manage concussions and how to best treat athletes that do not follow the typical course of recovery (McCrea et al., 2013). There is variability with each individual that sustains a concussion injury, and traditionally, clinicians have relied on an athlete's self-report of symptoms to make a diagnosis. Research has also stressed that recovery from concussion is highly variable for each individual, and among younger athletes, recovery has been shown to cause more complications (Field et al., 2003). Therefore, clinical care of concussion needs to be individualized for each person depending on his or her own unique circumstances to ensure that all medical, cognitive, emotional, social, athletic, school, and family issues are addressed (Kirkwood et al., 2006).

Concussion diagnosis and appropriate management has improved among sports medicine professionals since the late 1990s (Rigby et al., 2013). Systematic evaluation and management should begin with baseline testing in the pre-participation physical examination. Obtaining baseline scores will provide sports medicine personnel with an individualized normalcy to be

used for comparison should an athlete endure a concussion injury (Oliaro et al., 2001). It is important that baseline measures be collected by the sports medicine team through a series of cognitive and postural stability tests, such as the Sport Concussion Assessment Tool (SCAT3), Standard Assessment of Concussion (SAC), Balance Error Scoring System (BESS), ImPACT, as well as a symptom checklist and a thorough history addressing any prior concussions. A preseason clinical interview should encompass a discussion on prior history of concussion include the timing and severity of each concussion, as well as the duration and intensity of any presentation of symptoms (Kirkwood et al., 2006). With this vital individualized information, sports medicine personnel can re-administer these tests and focus on the athlete's data gathered from the evaluation to make a return to play decision rather than relying on a predetermined timeline (Rigby et al., 2013).

Acute concussion recognition begins with an observation that an injury has occurred. Loss of consciousness is rare (Guskiewicz et al., 2003), however, should it occur, a primary survey must be performed to determine that there are signs of life and that there is no compromise to the airway or any circulation (Oliaro et al., 2001). Any loss of consciousness should also be treated as if a cervical spine injury has occurred (Oliaro et al., 2001, Kirkwood et al., 2006). Therefore, the sports medicine professional needs to determine if the athlete needs to be spine boarded prior to moving the athlete. Most sport-related concussion injuries present without any loss of consciousness, however, concussion is often difficult to detect because signs of the injury are often indistinguishable (Oliaro et al., 2001). If recognized by the athletic trainer, a coach, teammate, parent, or the athlete themselves, a sideline assessment should be performed. Testing should be done away from teammates and distractions from fans or sideline personnel (Oliaro et al., 2001). Sideline assessment of concussion begins with the clinical



examination, symptom assessment, palpation cranial nerve testing (Guskiewicz et al., 2004). After a clinical exam, sports medicine professionals should perform sideline evaluation tests such as the SCAT3, SAC and BESS.

In a study done by Lynall and colleagues (2013) to assess current clinical concussion diagnostic and return to play participation practices among athletic trainers working in various settings and with various sports, the clinical examination was the most commonly reported method used to assess and diagnose a concussion. However, approximately 77% of the respondents believed that standardized methods of concussion assessment are more clinically informative than the clinical examination alone (Lynall et al., 2013). The study also found that athletic trainers' use of the clinical examination and symptom checklist has decreased from 95% and 85% respectively in 2005 (Notebaert and Guskiewicz, 2005) to 71% and 38% (Lynall et al., 2013). This is a noteworthy finding because the "NATA Position Statement: Management of Sport-Related Concussion" (Broglia et al., 2014) has clearly identified that the clinical examination must be conducted to rule out more serious injury such as an epidural hematoma, subdural hematoma or cerebral contusion; and, that other testing tools such as postural stability and neuropsychological testing should be used as accessory batteries (Lynall et al., 2013). The following sections will include a discussion of the need for a comprehensive assessment that includes a symptom assessment, neurocognitive testing, and balance testing.

#### *2.6.1 Comprehensive Assessment of Concussion*

The individual components to concussion assessment and management are all valuable tools individually; however, when used in combination with each other, they are most useful to identify a concussed athlete. Current literature suggests that a multifaceted approach be used to manage concussion injury and many researchers are now supporting a 3-part concussion battery

of a symptom checklist, postural-stability assessment, and neurocognitive testing to properly identify an athlete that has sustained a concussion (Lynall et al., 2013). However, as of 2005, Notebaert and Guskiewicz (2005) revealed that only 3% of it athletic trainers were using all three areas, however, in 2013, it was noted that athletic trainers using all three recommended areas increased to 21% (Lynall et al., 2013). Individually, tests including symptom checklists, neurocognitive assessment, and balance assessment are only 60% sensitive to concussion. This further supports the idea that all objective measurements should be used collectively to manage a concussion because if they are not used in combination, many concussions may go unrecognized, which could be a leading factor to the issue of underreported concussions at the high school level.

#### *2.6.2 Symptom Assessment*

Given the absence of a diagnostic test or biomarker for concussion, one of the current cornerstones of concussion diagnosis is the presence of a constellation of signs and symptoms in association with a hit to the head or body. The assessment of these signs and symptoms are critical to the management of concussion. While some athletes experience symptoms immediately, other athletes may experience delayed symptoms that can last hours, days, weeks or months. To further complicate the diagnosis of concussion, the presence of post-concussive symptoms is highly variable across individuals; although, some symptoms do emerge more commonly than others (Ellemberg et al., 2009) symptoms. For example, headache is the most common symptom and occurs in 83% of concussed athletes; and loss of consciousness, a symptom thought to be more common, only occurs in approximately 9% of concussed athletes (Guskiewicz et al., 2003). There are over 20 symptoms that an athlete may experience after a

concussion, they include, but are not limited to, fogginess, dizziness, nausea, amnesia, photophobia and sleep problems.

An assortment of symptom forms have been developed and used with checklists to identify the presence or absence of a symptom, as well as the severity or duration of a symptom (Ellemberg et al., 2009). These checklists are critical in maintaining an accurate evaluation record because they can quantify symptoms experienced by the concussed athlete (d'Hemecourt, 2011). Furthermore, the evaluation of symptoms with a symptom checklist is a quick and cost efficient practice for sports medicine personnel to implement in their clinical evaluation of concussion (Ellemberg et al., 2009); however, the subtleness of symptoms can often lead to confusion and uncertainty in decision making (d'Hemecourt, 2011). Reliable self-reports are dependent upon the relationship and interaction between the athlete and the medical professional (Hunt & Asplund, 2010), the athlete's knowledge and understanding of the symptoms, and the athlete's desire to participate. Many athletes commonly believe that having their "bell rung" is a common occurrence in sport and do not believe it is worth reporting (Oliaro et al., 2001). Therefore, solely relying on the athlete to self report is problematic because many athletes fail to report symptoms and many concussive injuries go unreported. Moreover, there are reporting disparities between males and females that should be considered when assessing symptoms of concussion (Covassin & Elbin, 2011). Concussed females report more symptoms of dizziness, fatigue, concentration, and lightheadedness than concussed male athletes (Broshek et al., 2005; Preiss-Farzanegan et al., 2009). To accurately assess and manage concussion injury, clinicians must use caution when singularly relying on symptoms and instead follow a multifaceted approach to diagnosis and management (Hunt & Asplund, 2010).

Concussion symptoms have been clustered into four different symptom factors that combine similar individual symptoms (Kontos et al., 2012). These clusters have helped clinicians to better address, manage and treat concussion injuries. For example, if an athlete has persistent cognitive difficulties such as difficulty concentrating, he or she may benefit from a different clinical approach to treatment and rehabilitation than an athlete experiencing persistent post-concussion migraines (Kontos et al., 2012). The four symptom clusters include the following categories: cognitive (difficulty concentrating, photophobia), affective (nervousness, sadness), vestibular-somatic (headache, dizziness), and sleep arousal (drowsiness, trouble falling asleep) (Kontos et al., 2012).

### *2.6.3 Neurocognitive Testing for Sport-Related Concussion*

Included in the multifaceted approach is the inclusion of neurocognitive tools to assess and manage the treatment of a concussion. Neurocognitive testing is a valuable tool in the assessment of concussion (d'Hemecourt, 2011) and given that many athletes do not report symptoms and younger athletes may have difficulty verbalizing cognitive difficulties this data can be used to identify individual strengths and weaknesses, make differential diagnoses, and plan appropriate interventions (Meehan et al., 2011). These tests are most useful if a baseline score was established before injury (d'Hemecourt, 2011) as these scores allow the athletes to serve as their own controls in aid of data interpretation (Meehan et al., 2011).

The Standard Assessment of Concussion (SAC) measures immediate neurocognitive deficits and is designed to assess orientation, immediate memory, concentration, and delayed memory (McCrea et al., 1998). Administration of the SAC is often performed as a sideline assessment and takes approximately 5 minutes. Any deviations from baseline scores are often associated with an athlete that has sustained a concussion (Capruso & Levin, 1992). The test is

scored out of 30 with a mean score of 26.6 (McCrea et al., 1996). Studies have found the SAC to have good sensitivity and specificity (McCrea, 2001; McCrea et al., 2003), making it a useful tool for identifying the presence of concussion (Giza et al., 2013). However, the SAC is not a comprehensive neuropsychological tool and is only validated for use from the time of injury to 3 to 5 days post concussion (McCrea, 2001; McCrea et al., 2003). The SAC is a quick cognitive tool that can objectively measure cognitive function in athletic settings and when there is no athletic trainer or medical professional on the sideline, this test cannot be performed and that can further contribute to the large number of concussions going unreported.

The SCAT3 is a concussion evaluation tool designed for individuals 13 years and older. Due to its demonstrated utility, the SAC has been incorporated into this tool, which also includes the GCS, a neck evaluation and balance assessment, and a yes/no symptom checklist, as well as information on mechanism of injury and background information, including learning disability, attention deficit hyperactivity disorder (ADHD), history of concussion, headaches, migraines, depression and anxiety (McCrory et al., 2013). The precursor SCAT2 had been standardized as an easy to use tool with adequate psychometric properties for identifying concussion within the first 7 days (Barr and McCrea, 2001). The SCAT3 was developed from the original SCAT to help in return-to-play decisions (McCrory et al., 2013; McCrory et al., 2009). This concussion evaluation tool can be used on the sideline or in the health care provider's office. The SCAT3 takes approximately 15 to 20 minutes to complete.

Neurocognitive testing has become commonplace in the evaluation of concussed athletes. Moreover, computer-based neurocognitive testing has become very popular with several computer-based programs (i.e., The Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT), Concussion Resolution Index (CRI), Automated Neuropsychological

Assessment Metrics (ANAM)) now being used to manage a concussion injury. Computer testing allows for more accurate measurement of cognitive function, such as visual memory, verbal memory, reaction time and information processing speed (Meehan et al., 2011). The precision of the test increases the validity of results that detect subtle changes in an individual's neurocognitive function (Meehan et al., 2011). The number of athletic trainers using computerized neurocognitive testing has significantly increased over the past ten years. In 2005, approximately 15% reported using computerized testing (Notebaert & Guskiewicz, 2005) compared to 2013 where 44% of healthcare providers reported using computerized neurocognitive testing (Lynall et al., 2013).

ImPACT is the most popular computerized neurocognitive test battery which can be administered online and comprises three general sections. First, athletes input demographic and descriptive information through a series of instructional screens. The demographic section includes sport participation history, history of alcohol and drug use, learning disabilities, attention deficit hyperactive disorders, major neurological disorders, and history of previous concussion. Second, athletes self-report any of 22 listed concussion symptoms that are rated using a 7-point Likert scale. The third section consists of six neuropsychological test modules that evaluate the subjects attention processes, verbal recognition memory, visual working memory, visual processing speed, reaction time, numerical sequencing ability, and learning. The ImPACT battery takes approximately 25 minutes to complete.

Schatz and colleagues (2006) examined the diagnostic utility of the composite scores and the Post-Concussion Symptom Scale (PCSS) of the ImPACT in a group of 72 concussed athletes and 66 non-concussed athletes. All athletes were administered a baseline test and all concussed athletes were tested within 72 hours of incurring a concussion. Approximately 82 percent of

participants in the concussion group and 89 percent of participants in the control group were correctly classified. Thus, results revealed the sensitivity of ImPACT is 81.9 percent and the specificity is 89.4 percent.

#### *2.6.4 Balance Assessment*

Current literature also suggests that balance assessment be included in the comprehensive approach to concussion management. Due to the fact that nearly 50% of concussed athletes under-report suspected injuries (McCrea et al., 2004), objective measures from balance tests can provide clinicians with an additional piece of the concussion puzzle by uncovering less obvious symptoms (Guskiewicz, 2011). Balance is the process of maintaining center of gravity with the body's base of support and this function is central to the maintenance of fluid and body control during vigorous movement that occurs in sport (Guskiewicz, 2011). The balance system is a complex network of neural connections and centers that are related by peripheral and central feedback mechanisms (Guskiewicz, 2011). The cerebellum is likely the most important structure within the brain for controlling balance as information is received from muscles, joints, skin, eyes, ears and viscera (Guyton, 1986; Vander et al., 1990). The afferent pathways of the reflex arcs derive from three sources: the eyes, the vestibular system and the proprioceptors (Guskiewicz, 2011). Concussion is thought to cause a miscommunication between these three sensory systems causing moderate to severe postural instability in either an anterior-posterior direction, medial-lateral direction, or both; and, in many cases symptoms such as dizziness, lightheadedness, tinnitus, blurred vision, or photophobia are experienced (Guskiewicz, 2011). These symptoms can be temporary or have lasting effects depending on the structure that is involved or the severity of damage (Guskiewicz, 2011).

Therefore, in an attempt to provide a quantifiable method to assess balance in concussed athletes, researchers at the University of North Carolina at Chapel Hill developed the Balance Error Scoring System (BESS). Should an athlete sustain a suspected concussion, clinicians can use the BESS test as a sideline assessment. The BESS test is cheap and only requires a few pieces of equipment, a stopwatch and a piece of foam padding. The testing involves three different stances (double, single, tandem) to be completed twice, once on the firm ground and once on the foam padding, for a total of six trials (Guskiewicz, 2011). The test is standardized by having athletes place their hands on their iliac crests, close their eyes, and maintain balance for a total of 20 seconds for each trial. During the 20 second hold, the athlete is asked to stand motionless keeping their hands on their iliac crests and keeping their eyes closed. Should they move out of position, they are asked to make necessary adjustments and return to the testing position as quickly as possible (Guskiewicz, 2011). During the single leg stance, athletes are asked to stand on their non-dominant foot, and during the tandem stance, athletes are asked to place their dominant foot in front of their non-dominant foot. During each trial, any deviations from the upright position are scored by adding 1 error point for each error committed. Errors are calculated if the athlete removes their hands from their iliac crests, if they abduct or flex their hip past 30 degrees, opens eyes, stumble or fall, lift their toes, or remain out of the testing position more than five seconds.

The BESS test is sensitive to the effects of concussion (Guskiewicz, 2011) and in a study done on college football players, it revealed that concussed football players deviated from their baseline BESS measurements by 5.7 points when tested immediately following the game or practice in which the injury occurred (McCrea et al., 2003). Baseline measures should be taken to develop individual normative values that aid in the interpretation of the severity of injury



should a change in scores occur. A higher score denotes a greater shortfall in postural stability; however, baseline measurements highlight individual variability. In athletic environments where there is no athletic trainer on the sideline, the lack of use of this objective measurement can further lead to underreporting.

#### *2.6.5 Sport-Related Concussion Consensus and Position Statements*

The criticisms and shortcomings of management guidelines have been addressed in more recent consensus papers and position statements (Aubry et al., 2002; Guskiewicz et al., 2004; McCrory et al., 2005). One of the first position statements to come out was by the Concussion in Sport Group (CIS) group which was assembled at the 1<sup>st</sup> International Symposium on Concussion in Sport held in Vienna, Austria in 2001 (Aubry et al., 2002). This panel of medical experts, from the fields of neurology, neuropsychology, and athletic training, convened with the purpose of amalgamating current literature to form the basis of a comprehensive systematic approach for managing sport-related concussion. During the first CIS meeting this group decided to abolish all grading scales in preference to an individualized approach to managing a concussion. The CIS group currently held their 4<sup>th</sup> International Conference in Zurich, Switzerland in 2013. This consensus statement by the CIS states that any athlete that shows any signs of concussion be properly evaluated by a licensed health care provider using standard emergency management protocols within a timely manner; and, if there is no licensed medical provider available, the athlete should be removed from play immediately and referred for medical care (McCrory et al., 2013). Following the initial clinical evaluation, it is recommended that cognitive function be assessed through sideline evaluation tools such as the SCAT3 and SAC. The CIS group stresses that both the presentation of symptoms and cognitive deficits may not be noticed immediately following injury and that concussion should be treated as an evolving

injury in the acute stages (McCrory et al., 2013). Additionally, it emphasizes that no athlete with a suspected injury should be left alone following the injury because sequential monitoring is essential during the first few hours should a rapid decline occur (McCrory et al., 2013). Finally, the CIS group adamantly states that no athlete should be returned to play the same day a suspected concussion occurs (McCrory et al., 2013).

The National Athletic Trainers' Association (NATA) sport-related concussion position statement emphasizes that athletic trainers must first develop a proficient understanding of various mechanisms and presentations of traumatic brain injury that include concussion and more severe complications such as brain damage (Broglia et al., 2014). It is suggested that baseline measurements for concussion be established for each athlete and concussion assessment battery should include a blend of tests for cognition, postural stability and self-reported symptoms. They note that any athlete that shows signs of concussion or reports symptoms of concussion after an impact to the head should at the very least sustained a concussion and should be treated as such. The NATA recognizes that management of sport-related concussion is a difficult task and that recognition is key because many athletes show no outward signs of concussion. Moreover, the NATA states that the clinical examination must not be overlooked; it should be used as the most important evaluation tool and all neurocognitive and postural stability testing is accessory to the initial clinical evaluation. Following the clinical evaluation, the athletic trainer can then determine whether the athlete requires more advanced medical care or not. Athletic trainers must understand that no two concussions are the same and that each concussion should be treated individually through the assessment of data collected from objective measures such as symptom scales, neurocognitive testing, and postural stability tests.

Finally, the NATA position statement states that data measurements comparing pre-injury baseline data to post-injury data will be most useful in making a safe return to play decision.

The American Academy of Neurology (AAN) has also abandoned the use of their grading scale. Furthermore, the current evidence-based consensus recognizes that concussion severity should not be based on the absence or presence of loss of consciousness and that no athlete should be allowed to return to play in the same day the injury occurred, regardless of the duration of symptoms (Gomez & Hergenroeder, 2013). Experts of the AAN state that concussion management should be highly individualized and that multiple factors be taken into consideration, including clinician judgment following the evaluation (Gomez & Hergenroeder, 2013). It is emphasized that medical personnel administer proper standardized validated sideline assessment batteries and that any athlete with a suspected concussion be removed from play, and not allowed to return to play the same day, to minimize the risk of extending the injury (Giza et al., 2013). Finally, the AAN states that high school aged athletes should be treated more conservatively than older athletes because children and adolescents are at greater risk for concussion than adults and they take longer to recover (Gomez & Hergenroeder, 2013).

#### *2.6.6 Return to Play Criteria*

It is unanimous across all sport-related concussion consensus and position statements that no athlete with a suspected concussion injury be allowed to return to play on the same day the injury occurs (Broglio et al., 2014; Giza et al., 2013; McCrory et al., 2013). The goals to managing an athlete with a sport-related concussion is to prevent any catastrophic outcome (Cantu, 1995) and return the athlete to competition in the most judicious way that both minimizes time away from competition and minimizes potential for second impact syndrome (Guskiewicz et al., 2013) or a more severe head injury occurring (Oliaro et al., 2001). There is

no “gold standard” pertaining to return to play and criteria vary from institution to institution depending on the medical staff and resources available (Hunt & Asplund, 2010). Establishing a concussion management protocol is necessary to maintain consistency of care and ensures that proper procedure are followed when making return to play decisions (Oliaro et al., 2001). Prior to returning to play, the athlete must be symptom free at rest and with exertion (d’Hemecourt, 2011). The resolution of symptoms is typically encouraged with physical and cognitive rest, and once resolved the athlete is graduated to begin a program of exertion called the stepwise progression. Current literature is lacking on the practices and usefulness of the stepwise progression; however, the progression is well accepted and should occur prior to returning to sport (d’Hemecourt, 2011). The stepwise progression begins with a symptom free state and advances to stages of light aerobic activity, sport-specific activities, non-contact training drills, medical clearance and full contact practice, and finally, game play. The athlete should proceed to the next level if they remain asymptomatic at the current level, and each step should take 24hours. If post-concussive symptoms recur at any step, the athlete must go back one step and wait an additional 24hours or until symptoms resolve before progressing (McCrory et al., 2013; d’Hemecourt, 2011). The stepwise progression should take the athlete approximately one week to complete and they must be symptom free with aggressive exercise (McCrory et al., 2013).

In conjunction with the graduated stepwise progression protocol, each concussed athlete should return to pre-injury baseline normative values on neurocognitive and postural stability tests. All testing should be completed once the athlete is asymptomatic (Hunt & Asplund, 2010; d’Hemecourt, 2011). Testing while symptomatic is nonsense and any scores lower than baseline may reflect ongoing sequelae and return to play would not be a safe or practical option (Hunt & Asplund, 2010).

## **2.7 Recovery from Concussion**

### *2.7.1 Short-Term Recovery from Concussion*

Given the consequences of concussion that have been brought to light in current literature, a conservative approach to treating concussion is imperative to recovery. McCrea and colleagues found that an athlete's recovery time can be predicted based on his or her acute injury characteristics, symptom severity, and performance on functional tests during the acute injury phase (McCrea et al., 2013). Numerous studies have examined short-term recovery following concussion by using concussion assessment tools such as symptom checklists, neurocognitive testing, and postural stability tests. Many of the studies have compared baseline measurements with post-injury measurements to make conclusions. The majority of concussions (80-90%) resolve within 7-10 days (McCrory et al., 2013; Guskiewicz et al., 2001; Erlanger et al., 2003) as individuals return to baseline scores; however, among children and adolescents, recovery time has been cited to take longer (McCrory et al., 2005). In fact, concussed high school athletes, on average, experience neurocognitive deficits 10 to 21 days post injury, which is longer than the documented 5 to 7 day neurocognitive recovery among collegiate athletes (Covassin et al., 2012).

Research has demonstrated that 80-90% of symptoms following concussion typically resolve within 7-10 days (Guskiewicz et al., 2001; Erlanger et al., 2003; McCrea et al. 2013). In a recent study by McCrea et al. (2013), 90% of the participants' post concussive symptoms resolved within the typical 7 day recovery period. A prolonged recovery period (greater than 7 days) was observed in athletes that sustained a more severe acute injury that presented with loss of consciousness, amnesia and elevated initial symptom severity (McCrea et al.). However, it is important to note that persistent cognitive deficits have been documented to remain in athletes

that report being asymptomatic (McClincy et al., 2006). Iverson et al. (2006) found that approximately 37% of high school concussed athletes, that reported feeling asymptomatic, remained clinically impaired on two or more neurocognitive measures 10 days post concussion. This evidence specifically highlights the importance of using a multifaceted approach to determine recovery due to potentially lingering symptoms or cognitive function (McClincy et al., 2006).

Short-term recovery among high school aged athletes has also been linked to the management of the injury within the first week. Many repeat injuries have occurred within the first week and Giza and Hovda (2001) have proposed that these repeat injuries occurred due to the metabolic energy crisis occurring within the brain that leads to vulnerability (Giza & Hovda, 2001). Concussed athletes should be withheld from practice and competition until they are symptom free and all neurocognitive tests have returned to baseline (Covassin et al., 2008). Research has provided evidence that risks for a prolonged recovery were minimized the longer a player is withheld from competition and allowed a symptom free waiting period (McCrea et al., 2013). Therefore, given this evidence of prolonging recovery and the physiology of repeat injuries, it is crucial that concussions do not go unreported in order to prevent potentially dangerous outcomes.

### *2.7.2 Long-Term & Cumulative Effects of Concussion*

The long-term and cumulative effects of concussion are unclear; however, long-term complications from sport-related concussion are rarely associated with a single concussion; rather, long term complications are believed to be associated with multiple concussions (Iverson et al., 2004). A history of concussion may be associated with a prolonged recovery after succeeding concussions, and lasting effects from concussion have been documented in high

school athletes. Moser and Schatz (2002) studied enduring effects of concussion in healthy young athletes and found that high school athletes with a history of two or more concussions performed similarly on cognitive performance tests as athletes that sustained a concussion within the past week. Subjects were separated into two groups: no recent concussion (within the past six months) (n=21) and recent concussion (n=14). Subjects within the no recent concussion group that had a history of two or more concussions appeared to resemble the recent concussion group more than the no recent concussion athletes with a history of one or no concussion (Moser & Schatz, 2002). The effects of two or more concussions appeared to include decreased overall neuropsychological functioning as well as decreased mental and attention speed (Moser & Schatz, 2002).

Similarly, Iverson and colleagues (2004) found that young athletes that sustain multiple concussions reported greater numbers of post-concussion symptoms than those that have sustained their first concussion. Athletes with multiple concussions performed worse on memory function tests and information processing speed tests than athletes with no prior history of concussion (Iverson et al., 2004). Multiply concussed athletes were six times more likely to experience post-traumatic amnesia and eight times more likely to experience 5 minutes or more of mental status disturbance (Iverson et al., 2004). Findings from these studies suggest that athletes with a history of concussion are at risk for developing long-term sequelae associated with post-concussion syndrome.

Conversely, there have been multiple studies that have shown that multiple concussions have no effect on cognition, suggesting that long-term consequences have yet to be clearly established. Solomon and Kuhn (2014) assessed the relationship between concussion history and neurocognitive performances (ImPACT and Wonderlic) among potential draft picks trying to

enter active participation in the National Football League (NFL). Results from the study showed that concussion history was not related to Wonderlic scores or ImPACT composite scores, suggesting that a history of concussion may not have adverse effects on neurocognitive functioning (Solomon & Kuhn, 2014). Moreover, Guskiewicz et al (2002) determined that neither participation in soccer nor a history of soccer-related concussion was associated with impaired performance on neurocognitive function or scholastic aptitude in high level soccer players. Broglio et al (2006) administered baseline ImPACT and CRI tests to individuals with a history of concussion and individuals without a history of concussion and determined that performance on both the CRI and ImPACT did not differ between subjects reporting three or more concussions. Cumulatively, this body of literature suggests that concussion does not lead to chronic changes in cognitive functioning.

Researchers have speculated that concussion may lead to dementia-related symptoms or chronic traumatic encephalopathy (CTE); however, there is a lack of longitudinal research to address the effect concussive and subconcussive impacts have on brain health. Guskiewicz and colleagues (2005) surveyed retired professional American football players to grasp an understanding of the relationship between previous head injury and the development of mild cognitive impairments (MCI). 758 retired football players filled the survey focusing on memory problems and issues related to MCI. Results revealed that retired football players that sustained three or more concussions were five times more prevalent to being diagnosed with MCI and three times more prevalent to report significant memory problems (Guskiewicz et al., 2005). Data from this study revealed that later-life expression of dementia-related symptoms may be the result of repetitive concussions among professional football players (Guskiewicz et al., 2005).



CTE research is still in its initial stages and it is unknown whether a single blow to the head initiates the metabolic cascade that produces the clinical and neuropathologic changes characterized as CTE, or if it is the result of multiple blows to the head (Gavett et al., 2011). CTE has been described as a syndrome that manifests within one to two decades after retirement from contact or collision sports (Love & Solomon, 2014) and is mostly seen in professional football players that have had numerous exposures to head trauma. In a study done by McKee et al (2012), 85 individuals with a history of significant or repetitive head trauma were autopsied to determine any evidence of CTE within the brain. Of the 68 autopsies that revealed CTE, 50 were football players: professional (n=34), semiprofessional (n=1), collegiate (n=9), high school (n=6) and professional football players from the 2009 cohort (n=5) (McKee et al., 2012). The existence of CTE as a neuropathologic syndrome has been questioned and there is no definitive link between concussions and CTE (Love & Solomon, 2014), but the lack of complete understanding is of particular concern for individuals participating in sport at risk for concussion. Concussive or subconcussive blows to the head are unavoidable in some sports and head trauma cannot always be prevented (Gavett et al., 2011), therefore, all concussion injuries must be managed conservatively in order to minimize potential long-term consequences.

## **2.8 Knowledge of Concussion**

### *2.8.1 Athlete Knowledge of Concussion*

Knowledge and awareness of concussion among adolescent athletes is of particular concern because research suggests that younger athletes are more susceptible to concussion due to ongoing development of the brain. Knowledge is an essential step to increasing athletes' self-report of concussion to an athletic trainer, parent, coach or teammate (Gourley et al., 2010). There are very few studies that have targeted knowledge of concussion with the high school

population. McCrea and colleagues (2004) retrospectively surveyed 1,532 high school football players and reported that approximately 50% of the concussed high school football athletes did not report their concussion to a medical professional. The survey was given to athletes at the end of the season and assessed each athlete's number of previous concussions, the number of concussions sustained during the current season, whether or not those concussions were reported, to whom they were reported, and reasons for not reporting. More recently, researchers reported an observed under-reporting prevalence of approximately 40% for suspected concussions among high school athletes participating in football, lacrosse, soccer or cheerleading (Register-Mihalik et al., 2013). Methods to assess reporting in this study were slightly different than McCrea et al (2004) as reporting was assessed retrospectively by asking athletes about the concussive events, and bell-ringer events that have occurred in their high school years, and how many of those events were reported to an authoritative figure (Register-Mihalik et al., 2013). Athletes from both studies failed to report their concussion because they did not feel it was serious enough to warrant medical attention, they did not want to be removed from play, or they did not want to let their team down (McCrea et al, 2004; Register-Mihalik et al., 2013). It is concerning that athletes failed to report due to lack of understanding of the seriousness of concussion symptoms; however, it has been reported that athletes with an increased knowledge of concussion are more likely to report their potential injury to someone in authority (Register-Mihalik et al., 2013). Athletes must understand that there is potential for subsequent or catastrophic brain injury if they continues to participate while symptomatic. Studies have shown that athletes are moderately aware of the more common signs and symptoms of concussion such as headache, dizziness, memory loss, loss of consciousness and confusion; however, they are less familiar with the symptoms that occur less frequently such as difficulty sleeping and difficulty concentrating in

school (Gourley et al., 2010). Athletes may fail to recognize that a concussion has occurred if they are unfamiliar of the 20+ symptoms of concussion or only experience less commonly recognized symptoms.

Understanding the seriousness of concussion is critical to athletes reporting an injury, but knowledge alone does not guarantee behavior. Survey results from high school rugby players indicated that almost all of the participants were aware of the term concussion but only 61% indicated that they understood the meaning of concussion (Sye et al., 2006). Additionally, athletes demonstrated moderate knowledge of concussion as they were able to identify the more common signs and symptoms of concussion, but many believed that an athlete needed to have lost consciousness to have sustained a concussion (Sye et al., 2010). Moreover, the athletes' demonstrated an inability to apply their moderate knowledge of concussion symptoms to practice and game scenarios. Specifically, 27% of the athletes agreed that a player with a suspected concussion should play in an important game such as a final (Sye et al., 2010). This study further suggests that there is potential under-reporting of concussion either due to lack of recognition or to maintain a roster spot on the playing field.

High school athletes' knowledge of concussion has been reported to have increased in recent years. This increase could be the result of the high dosage of media coverage, as well as the many recent attempts to educate student athletes about concussion. Register-Mihalik et al. (2013) surveyed high school athletes and determined that high school athletes have an increased knowledge of concussion compared to previously published literature. Athlete knowledge was assessed with a series of 35 questions, including symptom recognition, complications related to multiple concussions, and general knowledge of concussion (Register-Mihalik et al., 2013). Knowledge was calculated by summing the number of correct answers out of 35 with athlete

knowledge total scores ranging from 20-35, with higher scores indicating increased knowledge (Register-Mihalik et al., 2013). Results from this study indicated that there is still a knowledge gap because many of the questions missed concerned concussion concepts that high school athletes should know, such as common signs and symptoms (Register-Mihalik et al., 2013). To provide an athlete with the best medical care in managing his or her concussion, it is critical that they have knowledge of all of the signs and symptoms of concussion because improved knowledge may give an athlete the ability to recognize that a concussion has occurred and may positively affect reporting (Register-Mihalik et al., 2013).

### *2.8.2 Coach Knowledge of Concussion*

All coaches must have adequate knowledge of sport-related concussion. Given that 49 of the 50 states have enacted legislation implementing some sort of sport-related concussion law for youth sport; many states have also mandated that youth coaches receive concussion education and training. In 2007, the state of Texas put in to place “Will’s Bill” which included a requirement that coaches receive training to learn how to recognize and manage potentially catastrophic injuries, including concussion; and, they must learn about second impact syndrome and the risks of returning players too soon from a concussion. In high school athletic settings in which there is no athletic trainer or licensed medical professional present at practices and competitions, coaches become the first line of defense to recognize and manage concussions. Thus, coaches must understand the signs and symptoms of concussion, must understand the dangerous complications of allowing a symptomatic athlete to continue participating, and must encourage athletes to seek follow-up medical care.

Very little research has focused on coaches’ knowledge of concussion; however, concussion knowledge transfer among coaches has been investigated as programs have been

initiated to educate coaches about the risks and dangers of concussion. Methods to improve concussion education to coaches have been delivered through web-based resources, educational videos, print materials, and workshops. Moreover, the Centers for Disease Control and Prevention (CDC) created *Heads Up: Concussion in High School Sports Toolkit* that included educational materials such as a video, wallet card listing signs and symptoms, posters, fact sheets, and other concussion related resources. A follow up study with coaches that ordered and received the “Heads Up: Concussion in High School Sports” tool kit from September 2005 to July 2006 was conducted to evaluate the impact of the concussion “Heads up” toolkit. Of the 333 coaches that responded to the survey, 78% were male and 78% coached at a public high school. In addition to the survey, focus groups were selected and represented a diverse geographical location and a variety of sports. Ninety percent of the coaches that responded to the survey indicated they had used at least one of the tool kit materials with the booklet being the most popular item (79%), followed by the wallet card (60%) and video (59%) (Sarmiento et al., 2010). Thirty-four percent of the coaches reported that they learned something new about concussions from the tool kit. Focus-group participants indicated that the tool kit helped them to identify the signs and symptoms of concussion, provided helpful information about the length of recovery, made them aware of second impact syndrome, and made them aware that they need to have athletes with a suspected concussion seek medical care (Sarmiento et al., 2010). In addition, 50% reported that the tool kit changed their views on the seriousness of concussion and 38% reported making changes in how they prevented and managed concussions (Sarmiento et al., 2010). Overall, the tool kit was found to have a positive outcome among high school coaches’ knowledge of concussion and how they approached the injury.

High school coaches acknowledge that players infrequently self-report concussion, therefore, making it imperative that coaches be astute in recognizing when a player is showing any signs and symptoms of a concussion (Guilmette et al., 2007). Valovich McLeod and colleagues (2007) found that coaches with previous coaching education were more likely to correctly recognize signs and symptoms of concussion. Sixty percent of coaches correctly identified amnesia, confusion, dizziness, headache and loss of consciousness as concussion-related symptoms and they were less likely to recognize symptoms such as vision problems, sleep problems, and nausea (Valovich McLeod et al., 2007).

Guilmette et al. (2007) surveyed high school football coaches in schools that either did not have an athletic trainer or did not have an athletic trainer present at practices (i.e., athletic trainer only at games) and found that most coaches reported that an altered mental status was the best indicator of concussion. When coaches were given various potential symptoms of a concussion, 95% reported that they would consult a healthcare professional if the athlete experienced a loss of consciousness and 70% reported that they would consult a healthcare professional if the athlete acted “clumsily” after a hit to the head.

Finally, male and female coaches at public and private schools were surveyed regarding their knowledge of concussion (O’Donoghue et al., 2010). Results of this study found coaches reported moderate to high knowledge of concussion. Concussion knowledge was highest in the area of recognition and lowest in the area of management; in fact, 43% of the coaches believed that all concussed athletes recover at the same rate (O’Donoghue et al., 2010).

Although there are many educational tools to help inform coaches of ways to recognize and manage concussion, coaches have reported facing hurdles regarding the management of concussions among their athletes; more specifically, hurdles involving athletes’ and parents’

views of injury as weakness, underestimating the dangers of concussion, and the family's lack of health insurance (Sarmiento et al., 2010). Therefore, in addition to numerous educational resources being made available to coaches, there must be educational resources targeting the general population made available to parents.

### *2.8.3 Parent Knowledge of Concussion*

Educational efforts must extend beyond the athletes and coaches. Parents can benefit from learning the complexities of concussion, as well as the consequences of returning back to play prematurely. For many adolescent athletes, parents are the most influential when it comes to injury and the parents' role dictates the importance of concussion management. Parents of athletes are in the best position to notice if their son or daughter may have sustained a concussion after a practice or game. Parents must know and understand the signs and symptoms of concussion in order to recognize the subtleties of a concussion, and so they can take appropriate measures to get their son or daughter immediate medical care. Sullivan et al. (2009) reported that 83% of parents of high school rugby players felt that they were able to recognize a concussion in their teenager. The parents in this study demonstrated a good knowledge and understanding of the signs and symptoms of concussion. Ninety-five percent of the parents understood that the athlete did not need to be "knocked out" to sustain a concussion and when asked specific questions regarding the management of a concussion, 96% understood that allowing their teenager to continue playing after a concussion could lead to serious health consequences (Sullivan et al., 2009).

Studies assessing the knowledge of concussion among parents have reported varying results. There is very little research assessing knowledge of concussion among high school parents, however, there are studies that have explored what parents' general knowledge of

concussion is by having them correctly identify signs and symptoms of concussion, and by having them answer questions about appropriate management of concussion. Gourley et al. (2010) reported that parents have moderate knowledge of the signs and symptoms of concussion and very little knowledge of proper concussion management. One hundred parents (39 men, 61 women) were surveyed and 80% of the parents correctly identified the hallmark signs and symptoms of concussion, including dizziness, headache, memory loss, loss of consciousness, and confusion (Gourley et al., 2010). Furthermore, 60% of the parents identified that sleep disturbances, and problems doing class work and studying as an additional symptom of concussion (Gourley et al., 2010). It was reported that parents with basic first aid certification or some type of general medical training were able to recognize more signs and symptoms of concussion, but they also had difficulty recognizing all signs and symptoms (Gourley et al., 2010). Survey questions addressing knowledge of proper management of concussion were assessed using true or false questions. Eighty-seven percent of the parents knew that concussion required that the athlete be immediately removed from a practice or game and 69% stated that an athlete should not be permitted to return to play while symptomatic (Gourley et al., 2010). Moreover, it was observed that parents may believe that once an athlete feels better he/she can return to play because less than 70% of the parents understood that an athlete should return back to play in a progressive fashion (Gourley et al., 2010).

Bloodgood and colleagues (2013) surveyed three hundred parents who completed an online survey regarding concussions. Results revealed four out of five parents reported that they had heard of concussions and 84% agreed or strongly agreed that concussions are a critical issue (Bloodgood et al., 2013). Mothers were more likely than fathers to agree that concussions are a critical issue; and parents that accessed the internet several times a day, as compared to either



every 1-2 days or every 3-5 days, were considerably more likely to strongly agree that concussions are a critical issue (Bloodgood et al., 2013). Finally, Caucasian parents were more likely to have heard about concussion than black or Hispanic parents (Bloodgood et al., 2013).

Researchers continue to emphasize the importance of providing parents with education regarding concussion, including proper recognition and management. It is important that parents understand that medical attention should be sought immediately for an athlete displaying signs and symptoms of concussion. Educational programs have shown to increase knowledge in coaches, thus programs designed appropriately to target parents would be a benefit to parents of high school athletes playing a sport. As educational programs are designed for parents, it is also of added value to consider methods of improving knowledge transfer. Many parents have reported obtaining concussion information from the internet (Bloodgood et al., 2013), thus providing parents with online concussion tools and information may help to further increase knowledge of concussion.

## **2.9 Benefits of an Athletic Trainer at Every High School**

Approximately 55% of secondary high school students now take part in interscholastic athletics with two million high school student athletes in the United States sustaining an injury each year (Robinson, 2009). Increased sport participation and sport-related injury incidence suggests that a greater focus be placed on providing appropriate medical care to student athletes participating at the high school level. Though most high school sport-related injuries are minor, it is important that personnel with satisfactory training are present at practices and games to ensure that all injuries are attended to in a timely manner (Lyznicki et al., 1999). Injuries that are recognized early and immediately treated and allowed to heal properly will reduce the risk of re-injury or a more serious injury from occurring (Lyznicki et al., 1999). It has been recommended

that school administrators ensure safe interscholastic athletic program participation by providing medical coverage for all high school sports (DeWitt et al., 2012). The health care professionals best positioned to provide effective and efficient medical care to high school athletes are certified athletic trainers (ATs) (Valovich McLeod et al., 2013). ATs work under the direct supervision of a physician and provide services that encompass the prevention, diagnosis and treatment of emergency, acute, and chronic medical conditions (Valovich McLeod et al., 2013). The AT serves as an important liaison between the team physician, coaches, parents, and athletes (Lyznicki et al., 1999).

In 1991, the American Medical Association recognized athletic training as an allied health profession (AMA, 1998) and candidates for certification as an AT must have a bachelor's degree in athletic training. Bachelor's degree coursework includes extensive academic and clinical experiences that include human anatomy and physiology, kinesiology, biomechanics, psychology, personal and community health, nutrition, exercise physiology, first aid and emergency care, therapeutic modalities, therapeutic rehabilitation, health care administration, and evaluation of athletic injuries and illnesses. The American Medical Association supported ATs' provision of daily medical care for high school athletes in its resolution H-470.995 states that organizations sponsoring athletic programs should have established medical care for participants (AMA, 2013). Additionally, the "Appropriate Medical Care for the Secondary School-Aged Athlete" consensus statement specified what constitutes appropriate medical care, and further, recommended that ATs are the most qualified and educated members of the medical community that can provide daily on-site health care (Almquist et al., 2008). These recommendations laid the framework for secondary schools to establish or improve health care; health care delivery to high school student-athletes should include site readiness or the presence

of an AT at both practice and competitive events (DeWitt et al., 2012). Currently, only 42% of secondary schools in the United States employ an AT. However, all secondary schools in Hawaii employ an AT by law; and, it is reported that 86% of secondary schools in Wisconsin employ an AT, followed by 79% in Florida (Valovich McLeod, 2013).

Access to athletic training services is critical to ensure sport safety at the high school level. Not only does an on-site, employed AT benefit the health care of student-athletes, it can also be a larger benefit to the community (Valovich McLeod, 2013). Employing an AT can reduce annual costs to the school district and community by providing immediate medical care and treatment to injured athletes. In fact, Valovich McLeod and colleagues (2013) reported that within one high school with two ATs, a total of 13,766 treatments were completed; and, if those same treatments were performed at an outpatient orthopedic clinic, would calculate to an estimated \$2,753,200.00. Moreover, activation of Emergency Medical Services (EMS) occurs at an average of 1-2 times per year at schools that employ an AT (Decoster et al., 2010). This average number is likely much higher in schools without an AT because coaches and administrators then become responsible, and both parties do not have the vast medical training of an AT.

Results from a study conducted by Wham and colleagues (2010) reported that high schools in the state of South Carolina that employ an AT, either employed directly through the school, or contracted out from an outside source, provided higher levels of medical care than high schools that did not have access to an AT. Furthermore, this study found that athletic training services were associated with the medical care provided by a high school, and differences in the medical care provided by schools was not affected by proximity to a medical center, success of the school's varsity football program, school setting, region of the state, or

socioeconomic status of a school's students (Wham Jr., et al., 2010). This result supports the idea that schools can improve the medical care provided to student athletes by hiring an AT regardless of external factors beyond the control of the school (Wham Jr., et al 2010). Therefore, secondary schools that have been identified as medically underserved area, such as many rural areas, schools with lower enrollments, and schools serving a lower socioeconomic population place student athletes at an inherent risk. Injury is a risk of athletic competition; high school officials must address efforts to provide medical support to treat injury, and reduce the total number of sport-related injuries (Lyznicki et al., 1999).

Due to budget restrictions, many secondary schools are unable to find funding to provide athletic training services to student athletes (McLain & Reynold, 1989; Lindaman, 1992). Without athletic training services, coaches often assume responsibility for first aid and injury care (Lyznicki et al., 1999). Many states require that coaches receive first aid training; however, schools that require coaches to assume the added responsibility of caring for sport-related injuries must also consider the potential impact on the school system and athletic program should a single lawsuit settlement arise because a standard of care was not delivered (Lyznicki et al., 1999). Standard of care is a law of negligence. Negligence occurs when care is not provided in a way that an educated individual practicing in that profession would have provided in that same circumstance to protect an individual from harm or further harm. Coaches that inherently provide athletic training services could be held to the standard of care expected of a BOC-certified athletic trainer (Lyznicki et al., 1999). In 1992, *Jarreau v. Orleans Parish School Board*, a coach and the school district were found guilty of contributory negligence by the Louisiana Supreme Court after failing to refer a high school football player to an orthopedic doctor until the end of the football season. The athlete complained of wrist pain in the middle of the season and

the court states that coaches must recognize their limitations, and seek medical services for their athletes and that coaches are not expected to diagnose the extent of the injury (Cotton & Wolohan, 2003, p. 127).

Many states require that coaches receive basic first aid training; however, there are many school districts that allow coaches to be involved in an athletics program without any first aid training. DeWitt et al. (2012) revealed that some public school districts did not have a large number of their coaching staff certified in first aid or CPR. This is even further alarming because many high schools that participated in the study also did not have access to AT services. Ransone and Dunn-Bennett (1999) assessed first aid knowledge and decision making among high school athletic coaches and found that coaches who passed their first-aid test tended to return injured starters to the game, and coaches that failed their first-aid test decided to keep players out of the game. Coaches must have basic first aid training to best protect their athletes, but they must also understand the consequences of returning an injured athlete to practice or competition.

To minimize liability for athletic injury, school administrators must ensure that an emergency action plan (EAP) is established, all athletic equipment is maintained properly, facilities are safe and constructed properly, a risk management plan is put into place, and that there are qualified medical personnel available to student athletes. *Kleinknecht v Gettysburg College* declared that schools have an affirmative obligation to use reasonable care to protect their athletes from foreseeable harm and part of that duty is to provide prompt medical care for an injured athlete engaged in a school-sponsored athletic activity (Wong, 2002). This case directly questioned the EAP and lack of appropriate safety certification held by coaches. More recently, DeWitt et al. (2012) established that 59% of the high school administrators in the study

stated that there was no established EAP at their school. Standards of care must be a prerequisite for interscholastic athletics (DeWitt et al., 2012). Parents, school officials, and citizens should be concerned about the quality of medical care provided to student athletes to ensure that high school athletics is a safe environment (DeWitt et al., 2012). ATs can have an important role in the development and implementation of an EAP and can provide continuous and comprehensive on-site medical coverage during practices and competitions (Lyznicki et al., 1999). The importance of providing the best medical coverage was recognized in Hawaii, and within the state of Hawaii, legislature elected to provide funding for an AT to be placed in each public high school (Wham Jr et al., 2013).

The argument to hire an AT in each high school is further supported by the concussion-management laws. All 50 states have now passed laws recognizing the importance of care of youth sport-related concussion. Concussion legislation provides a clear explanation for the importance of an AT to evaluate and manage concussion injuries (Valovich McLeod et al., 2013). In schools that do not provide student athletes with athletic training services at practices and games, student athletes are not receiving the same quality of care as student athletes that attend schools with an AT. By hiring a BOC-certified athletic trainer, school administrators support the medical needs of all student athletes. Parents, coaches, and school officials can be assured that there is an individual on staff that has the knowledge and skills to provide the best quality of care to ensure each student athletes' health, safety and well-being (Lyznicki et al., 2012)

## **2.10 Urban and Suburban School Districts**

With increasing budget cuts in public school districts, high schools are losing funding to support their athletic programs. Some school districts have seen declines in funding more than

others. The National Interscholastic Athletic Administrators Association (NIAAA) surveyed high school athletic administrators and found that 82% of schools are experiencing athletic budget cuts that are primarily related to a lack of school district funds (Anonymous, 2007). Additionally, 83% of the athletic administrators that responded to the study reported that their athletic department budgets represent two percent or less of the total school district budget (Anonymous, 2007). The lack of district support is causing high school athletic departments to seek funding through booster clubs, revenue from student activities, sports tickets, and gate receipts (Anonymous, 2007). Seeking such additional funding is easier in school districts that serve students of higher socioeconomic status, and school districts in which there is also more parental support. Declining funding to support student athletes is problematic in all school districts; however, in urban school districts that serve student athletes of lower socioeconomic status, the decline in funding, as well as other key differences between urban and suburban communities, could pose several risks should a student athlete sustain a concussion.

Characteristically, there are environmental, organizational, and economical differences between urban and suburban schools (Hannaway & Talbert, 1993). Urban schools are situated within larger cities and within larger school districts, whereas suburban schools operate in smaller districts in more intimate communities (Hannaway & Talbert, 1993). Typically the size of urban and suburban schools is similar, but urban schools typically operate in districts that are on average eight times larger than suburban school districts (Hannaway & Talbert, 1993). Resources are allocated differently in each district; in larger districts resources are trivial compared to suburban school districts, and principals in urban high schools have less autonomy when it comes to matters of school policy, personnel decisions and resource allocation (Hannaway & Talbert, 1993). Decreased funding and less autonomy with resource allocation

has led many urban schools to cut sports that are not culturally popular within urban communities, cut junior varsity and freshman rosters across all sports, and make personnel cuts (i.e. coaches, athletic trainer). Conversely, within suburban school districts, the power of decision making is placed in the hands of principals and school boards (Wayson, 1972).

The socioeconomic composition of students within urban schools is much different than the socioeconomic composition of students within suburban schools. The clientele of suburban schools are wealthier and better educated than the clientele of urban schools, and over 80% of urban schools serve populations with socioeconomic backgrounds that are lower than half of the population within suburban schools (Hannaway & Talbert, 1993). Urban school districts serve much of the nation's poor and minority inner-city students (Watson, 1989) and the urban school district faces problems inherent in poverty, inadequate and crowded housing, unequal opportunities, and prejudice (Wayson, 1972). Tax funds are used to support school systems (Weldon, 1993) and in cities across the United States, neighborhood decline within the inner cities due to decreased property values and related taxes has contributed to the weakening and demise of schools (Patterson & Sullivan, 2013). Schools depend on municipal resources to provide quality educational and interscholastic programs, therefore schools that serve students within failing neighborhoods are at a disadvantage and perceived as suffering (Patterson & Silverman, 2013).

Approximately 25% of children within the United States live in inner city, urban communities and approximately 18% of American children under the age of 18 live in poverty; thus, if urban youths are more common than suburban youths to live in poverty, it is important to understand the implications of the difference (Murgia et al., 2009). Urban youths that live in poverty are less likely to have health insurance and are more likely to be hungry at school



(Murgia et al., 2009). Many urban community schools are classified as Title I schools. Title I schools serve low income students in which the majority of the student population qualifies for free and reduced lunch. The differences between urban and suburban schools trickle down to equal resources provided to student athletes and these socioeconomic differences could be problematic for student athletes at urban schools. Health and physical well-being of urban youths suffer as a result of poverty. Urban students that are participating in after school sports with limited health care, limited calories, limited resources, and no medical personnel are at greater risk than suburban students should an injury occur.

Another difference between urban and suburban schools is the level of parent support. Suburban, or academically successful schools, are more likely to have higher levels of parental support than less successful, urban schools (Hannaway & Talbert, 1993). Low income, urban parents often have more time and energy constraints and many urban parents are single parents (Hannaway & Talbert, 1993). These socioeconomic disparities make it more difficult for single parents to get involved within the school and attend after school athletic events. With little to no parent involvement, urban youths heavily rely on peers for support. In densely populated urban communities, students are in contact with their peers inside and outside the school setting and this constant single-group contact has a powerful effect on urban students' personal goals and behavior (Holmes, 2006). Urban students with single-group contact are at a higher risk of peer pressure (Holmes, 2006); however, there is a reduction of "at risk" behavior among youth living in urban environments that participate in after school programs (Fuller et al., 2013). Given the concern that minority boys in low income communities are at risk of negative behaviors and outcomes (i.e. juvenile arrests, violence, drug use), after school sports has appeared to be an

appropriate vehicle for positive youth development that gives urban students a sense of belonging (Fuller et al., 2013).

Current policies and budget constraints placed on school districts has diminished opportunities for all student athletes to participate in school sports (Kanters et al., 2013); however, urban school districts have seen more drastic cuts than suburban school districts and these budget cuts could have negative effects on inner city communities. Economic hardships due to reduced high school athletic budgets may serve as a barrier to after school participation (Kanters et al., 2013). Some high schools have started to require funding from participants to pay for uniforms, travel expenses, equipment, and participation fees (Kanters et al., 2013). Student athletes from higher socioeconomic backgrounds are able to endure these costs. In urban communities with higher percentages of students from lower socioeconomic backgrounds these additional costs would only further limit participation (Kanters et al., 2013). Moreover, given that inner city, urban youth are vulnerable to their environment, and sport participation has a positive effect on urban youth development, it is important that urban school districts provide funding for inner city youth to participate in after school sports. With declines in funding comes loss of opportunity for many students to participate in after school sports, less funds to provide appropriate medical care and supervision to student athletes, and potentially an increase in underreporting of sport-related injury. This has significant negative implications should an athlete sustain a sport-related concussion. Seeing as though all 50 states within the United States have laws regarding youth concussion, it is critical that appropriate resources are allocated to all student athletes participating in after school sports to ensure their safety. In schools without an AT, sport-related concussion awareness is likely low and underreporting of concussion symptoms is likely higher. Without an AT, student athletes must turn to coaches and parents

when they are experiencing concussion symptoms. Student athletes within urban communities may refrain from reporting concussion symptoms to a parent or coach for fear of losing playing time, not understanding the signs and symptoms of concussion, lack of health insurance, or because they believe their sport is a means to get an athletic scholarship. Fisher et al. (1996) reported that 52% of inner city males and 20% of inner city females participating in high school sport believed he/she would “definitely” or “probably” receive an athletic scholarship, and nearly one-third of all students thought they would become a professional athlete.

As resources for public education continue to diminish, school administrators will face challenges when allocating money to school sport programs (Kanters et al., 2013). High school sports have a positive effect on youth development and student athletes, thus all socioeconomic backgrounds need to be provided with equal resources for their safety and protection.

To date, all research on knowledge, awareness and reporting behaviors of concussion among high school student athletes is limited to high schools that are equipped with an AT. There is currently no research that examines the difference in knowledge, awareness, and reporting behaviors among student athletes from urban and suburban schools or in schools with an AT versus schools without an AT. This research aims to examine those differences.

## **CHAPTER 3**

### **METHODS**

#### **3.1 Purpose**

The aim of this study was to assess high school athletes' knowledge and reporting behaviors of sport-related concussion and factors that influence this process. Specifically, the primary purposes were to assess (a) high school athletes' knowledge of concussion, (b) reporting behaviors of high schools athletes that have experienced signs and symptoms of concussion and reasons why student-athletes would not report those signs and symptoms to an authoritative figure, (c) differences in knowledge of concussion and reporting behaviors between high school athletes attending urban and suburban schools, and (d) differences in knowledge of concussion and reporting behaviors between high school athletes with access to an athletic trainer compared to no access to an athletic trainer. This section will discuss the methodology including research design, participants, instrumentation, procedures and statistical analysis.

#### **3.2 Research Design**

This study was a cross-sectional study of high school athletes across nine sports. Data was be collected from September 2014- March 2015. The survey instrument acquired data on knowledge of concussion and reporting behaviors in high school athletes. Completion of the survey instrument took place at the school within each sport athletic season, and involved the subjects answering questions concerning concussion. Knowledge questions were centered around knowledge of concussion symptoms, management of concussion and consequences of concussion. Behavioral questions examined athlete reporting of concussion symptoms to an AT, coach, parent, or teammate. The independent variables were race (i.e., African-American,

Caucasian, Hispanic/Latino, Asian), school (Urban/inner city, Suburban) and AT (certified AT, no AT). The dependent variable was knowledge of concussion score.

### **3.3 School Selection Procedures**

Fourteen high schools within the state of Michigan were recruited to participate. All urban and suburban schools had to surround a metropolitan area (defined as) and all urban school had to be Title I schools. All suburban schools could not be Title I schools. Moreover, schools with and without an AT were recruited. Schools were selected by targeting student body populations that met inclusionary criteria. Schools and districts were first contacted via email, and then a follow up telephone call. Some districts required face-to-face meetings with district administrators, and separate contract agreements were then be completed to gain access to those schools. After all school and district approvals were obtained, contact with either the athletic director or AT was made at each school.

### **3.4 Participants**

The study population of interest was comprised of approximately 715 high school male and female student athletes from the state of Michigan. A total of 14 schools were recruited to participate. The schools recruited for the study will be located within the Lansing and Detroit metropolitan areas, and surrounding suburb communities. Of the 14 schools recruited to participate, 9 schools were classified as urban schools, and 5 will be classified as a suburban school. All urban schools were Title I schools. Out of the 14 schools, seven had a full-time AT employed, and seven did not have an AT employed.

Student athlete recruitment first began by making contact with the athletic director at each school. In high schools that had an AT, all communication with coaches and parents was directed through the AT. The AT was employed as a full-time AT. The AT assisted the principal

investigator in setting up meetings with coaches and the teams. At schools without an AT, all communication was set up through the athletic director and individual team coaches.

#### *3.4.1 Inclusionary Criteria*

Male and female high-school student athletes were enrolled at the school, and had to be a participant on one of the following sport teams to be eligible to participate: football, girls' and boys' basketball, wrestling, volleyball, gymnastics, cheerleading and boys' soccer. All student athletes at each school had the opportunity to voluntarily participate.

A pilot study was conducted in the Fall 2013 in three urban/inner city high schools. Out of the 300 student athletes recruited, 175 participated with a 58% response rate. Each student athlete that participated received a \$5.00 gift card to Subway. The gift card incentive proved to be a useful recruitment method in an urban school setting. Therefore, for this study, each participant in each school setting was given a \$5.00 gift card to Subway following return of the parent consent form.

#### *3.4.2. Exclusionary Criteria*

Participants were not excluded for any pre-existing learning disabilities, ADD/ADHD, or any previous history of concussion. Participants were only excluded if they were not enrolled in the aforementioned sports.

### **3.5 Operational Definitions**

AT – Full-time employed medical professional that holds certification by the Board of Certification (BOC).

CONCUSSION – An injury resulting from a blow to the head, or other part of the body that resulted in an alteration in mental status and one or more of the following symptoms: headache,

nausea, sensitivity to light, memory loss, dizziness, fogginess, confusion, tinnitus, sleep disturbances, blurred vision, or loss of consciousness (McCrea et al., 2003)

KNOWLEDGE OF CONCUSSION SCORE – Total knowledge of concussion score out of 35 questions (higher=better)

RACE – Assessed through a demographic question to determine whether the student athlete is white, African American, American Indian, Asian, Hispanic/Latino, or other. Student athletes are able to choose more than one race, as many students are of mixed race.

REPORTING BEHAVIORS - A student athletes intent to notify or not notify, or past history of notifying, or failing to notify an authoritative figure or teammate of a potential concussive injury, after experiencing a sign or symptom of a concussion.

SIGNS AND SYMPTOMS OF CONCUSSION – Includes the list of 22 published signs and symptoms that are consequences of a concussion injury.

SUBURBAN SCHOOL - Defined as a school located outside of a metropolitan area in which the majority of the student body population is from a higher socioeconomic background, not qualifying for free and reduced lunch.

URBAN – Defined as an inner city/Title I school in a metropolitan area in which the majority of the student body population is from a lower socioeconomic background, qualifying for free and reduced lunch.

### **3.6 Instrumentation**

A single survey served as the primary instrumentation used for the study. The instrument was developed by Register-Mihalik and colleagues (2013) and was pre-tested for face validity by three content experts. The survey is separated into sections that include athlete demographics, knowledge of concussion, self-understanding of concussion, and reporting behaviors. To

determine reliability of the instrument, Register-Mihalik and colleagues pilot-tested the survey at four high schools with athletes participating in boys' lacrosse, girls' soccer, and boys' ice hockey. Test-retest reliability was assessed with 50 high school athletes; each athlete completed the survey instrument at two test times that were 20 minutes apart and set up in a different order. The athletes took the test twice in one day to minimize any acquired concussion knowledge and discussion among subjects. For athlete data, Kappa tests of agreement were run to assess agreement across test session for categorical responses. The purpose of the Kappa statistic was to adjust for agreement that is due to chance alone. If there was a possibility for multiple responses for questions, each response was treated as a separate variable. For Likert scale questions, the mean difference for each question response was calculated. A paired samples t-test was also used to assess if there was a significant difference in responses across the two test sessions. Demographic questions were not used in the pilot analyses.

All categorical data on the athlete questionnaire yielded a Kappa statistic of 0.35 or higher, which indicates at least fair agreement. All but two Likert scale questions yielded no significant mean difference across the two test sessions. The agreement across test times for all knowledge (yes/no) items used in the questionnaire ranged from 0.60 to 1.00. The Cronbach  $\alpha$  calculated for knowledge construct was 0.80. Therefore the concussion knowledge and reporting behaviors questionnaire was considered valid and reliable (Register-Mihalik et al. 2013).

Athlete knowledge of concussion was assessed through a series of 35 questions in which participants were asked to recognize signs and symptoms of concussion, identify complications related to multiple concussions, and answer questions pertaining to general knowledge of concussion. Total knowledge was calculated by summing the number of correct answers out of



the 35 knowledge of concussion questions. Scores could range from 0 to 35 with a score closer to 35 representing a greater amount of concussion knowledge.

Additional demographic questions and reasons why athletes would or would not report their concussion were modified from the original validated survey. However, these questions were not included in the knowledge of concussion score. A total of 5 demographic questions were included in the questionnaire, including race, age, sex, grade in school, and sport. The entire questionnaire included a total of 83 questions. AT access was assessed with a question asking if there was an AT at the school. This was further corroborated with the primary investigator whom also recorded which schools had an AT. Reporting behaviors were assessed by questions that asked athletes reasons why he/she would not report concussion symptoms to an AT, coach, parent, or teammate, or why he/she chose to report concussion symptoms. Reporting behavior questions were assessed at the end of the concussion history section. Athletes were asked how many times he/she did report any bell ringer events to a medical professional, AT, or coach. Following that question, he/she answered a question asking if he/she knew of anyone that had a concussion but did not tell anyone. The last reporting behavior question asked student athletes to choose reasons why he/she chose not to report any possible concussion signs and symptoms to an AT, coach, parent, or teammate. There were a total of 13 choices listed. In previous studies assessing reporting behaviors among student athletes, the top reasons for not reporting signs and symptoms was due to athletes not wanting to miss playing time, and not thinking the signs and symptoms were serious enough to warrant medical attention (McCrea et al., 2004; Register-Mihalik et al., 2013); therefore, those two choices were included. The remaining choices include: not wanting to appear weak to teammates and/or coaches, not wanting the coach to get mad, not wanting to miss any playing time due to the end of a season or

making it to the playoffs, not wanting to let the team down, not knowing the signs and symptoms were a concussion at the time of the injury, trying to get a college scholarship, lack of health insurance, and not wanting to go to the doctor. Finally, at the end of the survey, the last two questions assessed reporting behavior by asking each athlete if he/she ever continued to play in a game, or continued to participate in practice even though he/she was experiencing signs and symptoms of concussion.

The final section of the survey included 7 Likert scale questions that asked each athlete to rate the importance of knowledge of concussion and the importance of reporting signs and symptoms of concussion. For example one question asked each athlete to rate on a scale of 1-7 how important he/she thought it was to be informed about how concussions happen.

### **3.7 Data Collection Procedures**

Institutional Review Board approval was obtained from Michigan State University. Approval from each school and/or district was obtained before the start of the study. Upon approval at each school, school information forms were completed at each school by a designated school contact (either athletic director or certified AT) serving as the research contact at each school. School information forms included the athletic director, AT, contact information for the athletic director and AT, and school contact information. The school contacts helped to arrange dates to pass out parent consents and survey distribution. The principal investigator attended most parent meetings and all survey distributions at each school. Survey distribution took place during the sport season. All meetings were performed using a standardized script to ensure similar instructions for all participants. Parent meetings and survey distribution occurred during each sport season at each school: football, volleyball, boys' soccer in the fall, wrestling, girls' and boys' basketball, and gymnastics in the winter.

Parental consent forms had to be signed and returned for a student athlete to be able to participate. For all student athletes at each of the 14 schools that returned the parent consent (whether the parent agreed to allow the child to participate or not) a \$5.00 gift card to Subway was be given. Gift cards were purchased using grant money received by the Pentacost Foundation and Blue Cross Blue Shield of Michigan Foundation. It was standard procedure at Michigan State University to give all participants in the study the incentive if the consent is returned, regardless of what the parent allowed. On the same date of survey distribution, child assent was obtained prior to the student-athlete completing the survey. The questionnaire was a one-time administered paper and pencil survey. It took participants approximately 10-15 minutes to complete. Participants were allowed to skip questions and were able to withdraw at any time.

### **3.8 Data Analysis**

General descriptive (i.e., means, standard deviation, and frequencies), and inferential statistics were used to summarize all demographic data, independent variables, outcome variables, and athlete knowledge of concussion scores. Knowledge of concussion scores were determined by adding the total correct responses to the 35 questions (1 point each correct answer). The knowledge construct included correct responses assessing symptoms of concussion, LOC and concussion, asymptomatic return to play, structure injury (i.e. brain, skull, face, etc.), complications of multiple concussions, and complications of returning to play too soon. A higher score indicated increased knowledge of concussion. Frequencies were used to summarize student athletes' reporting behaviors, and reasons why athletes would or would not report signs and symptoms of concussion. The following reporting outcomes will be used for reporting analyses: (1) athletes reporting concussion events; (2) athletes reporting bell-ringer events; (3) proportion of concussion/bell-ringer events in games; (4) proportion of concussion/bell-ringer

events in practices; (5) proportion of concussion only events; (6) athletes indicating participating in games while experiencing concussion symptoms; and (7) athletes indicating participating in practices while experiencing concussion symptoms. The statistical significance level was set at and *a priori* alpha level  $p < .05$  for all analysis. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) software.

### *3.8.1 Research Questions & Statistical Analysis*

1. Is there an association between school type (urban/suburban) and athlete knowledge of concussion and reporting behaviors?

- a. Do high school athletes attending urban schools have less knowledge of concussion than high school students attending suburban schools?

Data will be analyzed using a t-test to determine differences between groups.

- b. Do high school athletes attending urban schools less frequently report potential concussive injuries to an authoritative figure compared to high school athletes attending suburban schools?

Data will be analyzed using a linear regression model with Generalized Estimating Equations (GEE's). Ancillary reporting behavior analysis will be analyzed using linear regression models and will be used to analyze reporting behavior.

- c. Data will be analyzed using a multiple regression model to determine the influence of school type and access to an AT on knowledge of concussion score.

2. Is there an association between having access to a full time AT and high school athlete knowledge of concussion and reporting behaviors?

- a. Do high school athletes that have access to an AT have higher knowledge of concussion scores than high school athletes that do not have access to an AT?  
Data will be analyzed using a t-test to determine differences between groups.
  - b. Do high school athletes that have access to an AT more frequently report potential concussive injuries to an authoritative figure than high school athletes that do not have access to an AT?  
Data will be analyzed using a linear regression model with Generalized Estimating Equations (GEE's). Ancillary reporting behavior analysis will be analyzed using linear regression models and will be used to analyze reporting behavior.
3. What factors (ie., race, sex, age, sport) are associated with knowledge of concussion score?  
Data will be analyzed using a multiple regression model.
4. What factors (i.e., race, age, sex, knowledge of concussion score) are associated with reporting of potential concussions in high school athletes?  
Data will be analyzed using a multiple regression model. Ancillary reporting behavior analysis will be analyzed using linear regression models and will be used to analyze reporting behaviors.

## CHAPTER 4

### RESULTS

The purpose of the current study was to determine differences in knowledge of concussion between high school athletes at urban and suburban schools, and high school athletes with access to an AT and without an AT. This chapter reports demographic information, knowledge of concussion, symptoms of concussion, self-reported understanding of concussion and reporting behaviors.

#### 4.1 Demographic Information

There were a total of 715 high school athletes that participated in the study. High school athletes that participated were enrolled as a full time student at one of the participating high schools and were a team member on one of the selected sports. The return percentage for athletes was approximately 26%, averaging 200 eligible athletes per school. Due to individual school enrollments, some schools had fewer than 200 athletes eligible to participate and some schools had more than 200 athletes eligible to participate. Descriptive statistics are presented in Table 1 which reports the total number of student athletes at urban and suburban schools, and student athletes at a school with an AT and without an AT.

*Table 1. Total Population by School Type and AT Access*

School Type	AT at School	No-AT at School
Urban	223	245
Suburban	215	32

There were a total of 503 male and 212 female athletes between the ages of 13-19. For statistical analyses, subjects age 13-14 were grouped together and subjects 18-19 were grouped together due to a limited number of 13 and 19 year olds. The majority of athletes were African

American (372=, 52.1%), followed by White (205=; 28.7%), and Mixed (73=; 10.2%). See Table 2 for remaining demographics. Student athletes that identified two or more races were grouped together into a mixed racial category. A summary of demographic data for sex, age, race, and grade can be found in Table 2.

Table 2. Athlete Demographics for Sex, Race, and Grade by School Type and AT Access

	Urban		Suburban	
	<i>AT</i>	<i>No-AT</i>	<i>AT</i>	<i>No-AT</i>
<b><i>Sex</i></b>				
Male	152	210	124	17
Female	71	35	91	15
<b><i>Race</i></b>				
White	24	3	149	29
African American	120	220	31	1
American Indian	1	5	3	0
Asian	7	2	3	1
Hispanic/Latino	21	1	6	0
Other	6	6	2	0
Mixed	44	7	21	1
<b><i>Age</i></b>				
13-14	52	12	29	2
15	49	54	61	5
16	44	84	57	11
17	64	74	39	7
18-19	14	21	29	7
<b><i>Grade</i></b>				
9 <sup>th</sup>	74	25	46	2
10 <sup>th</sup>	44	54	74	7
11 <sup>th</sup>	42	76	43	12
12 <sup>th</sup>	63	87	52	11

The majority of the athletes played football (357=; 49.9%) followed by volleyball (103=; 14.4%) and boys' basketball (89=; 12.4%). A summary of the breakdown by sport can be found in Table 3.



*Table 3. Number of Athletes from Each Sport by School Type and AT Access*

Sport	Urban		Suburban	
	<i>AT</i>	<i>No-AT</i>	<i>AT</i>	<i>No-AT</i>
Football	105	163	73	16
Volleyball	43	11	34	15
Girls' Basketball	20	13	34	0
Boys' Basketball	34	28	27	0
Wrestling	14	0	7	0
Gymnastics	0	1	7	0
Girls' Soccer	1	0	9	0
Boys' Soccer	0	19	15	1
Cheerleading	0	10	2	0
Other	6	0	7	0

## 4.2 Knowledge of Concussion

Athlete total knowledge of concussion scores (out of a possible 35) ranged from 11-35 (mean =  $27.50 \pm 4.185$ ). Scores closer to 35 indicate more concussion knowledge. A frequency breakdown of correctly answering each knowledge question is summarized in Table 4.

*Table 4. Frequencies of Each Variable Included in the Knowledge of Concussion Score*

Athlete Knowledge Item	Frequency Answering Correctly (%)
<i>Symptoms</i>	
Abnormal Sense of Smell	653 (91.5%)
Abnormal Sense of Taste	639 (89.4%)
Memory Loss	550 (77.0%)
Joint Stiffness	608 (85.2%)
Blurred Vision	585 (81.9%)
Black Eye	635 (88.9%)
Bleeding from Ear	572 (80.1%)
Bleeding from Mouth	655 (91.7%)
Bleeding from Nose	607 (85.0%)
Confusion	573 (80.3%)
Fever	621 (87.0%)
Dizziness	575 (80.5%)
Headache	634 (88.8%)
Sleep Problems	332 (46.6%)
Loss of Consciousness	547 (76.6%)
Nausea	405 (56.7%)
Numbing or tingling of arms	557 (78.0%)
Skin Rash	694 (97.2%)
Sharp burning pain in neck	505 (70.7%)

Table 4 (cont'd)

Weakness in neck movements	436 (61.1%)
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***General Knowledge***

Loss of consciousness and concussion	469 (65.9%)
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Return to play with symptoms	454 (63.5%)
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Body part injured	567 (79.3%)
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***Complications of Multiple Concussions***

No complications exist	678 (94.8%)
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Increased risk of further injury	423 (59.2%)
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Brain damage	600 (83.9%)
--------------	-------------

Joint problems	621 (86.9%)
----------------	-------------

Memory problems	549 (76.8%)
-----------------	-------------

I don't know	605 (84.6%)
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***Complications of Returning to Play to Soon***

No complications exist	681 (95.2%)
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Increased risk of further injury	462 (64.6%)
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Paralysis	448 (62.7%)
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Brain damage	527 (73.7%)
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Joint problems	612 (85.6%)
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I don't know	583 (81.5%)
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*RQ1: Do high school athletes attending urban schools have less knowledge of concussion than high school students attending suburban schools?*

Research questions were analyzed using independent t-tests. Results indicated significant differences between knowledge of concussion scores between high school athletes at urban and suburban schools ( $t_{(2, 525)} = -3.687, p = 0.000$ ). The mean and standard deviation for knowledge of concussion scores for urban and suburban schools can be found in Table 5.

*RQ2: Do high school athletes that have access to an AT have higher knowledge of concussion scores than high school athletes that do not have access to an AT?*

Independent t-test indicated significant differences between knowledge of concussion scores between high school athletes attending a high school with an AT and athletes attending a high school without an AT ( $t_{(2, 713)} = 4.765, p = 0.000$ ). The mean and standard deviation for knowledge of concussion scores for athletes with and without an AT can also be found in Table 5.

*Table 5. Athlete Knowledge of Concussion Scores by School Type and AT Access*

	Knowledge of Concussion	
	<i>Mean</i>	<i>SD</i>
Urban	27.10	4.225
Suburban	28.28	4.002
AT	28.09	4.101
No-AT	26.58	4.156

*RQ3: What factors (ie., race, sex, age, sport) are associated with knowledge of concussion score?*

The results from the multiple regression revealed no statistical significance with race, sex, age and sport not predicting knowledge of concussion scores in high school athletes ( $F_{(4,705)} = 0.545, p = 0.703$ ). However, results from a multiple regression examining the influence of the presence of an AT at school and school type (i.e., urban/suburban) revealed that the presence of an AT and school type predicted increased knowledge of concussion scores ( $F_{(2, 712)} = 13.342, p = 0.000$ ). Suburban schools that employ an AT are influential on concussion knowledge.

Although not part of the research question, race was further explored using a one-way ANOVA to compare knowledge of concussion scores between races. Results revealed significant between group differences in knowledge of concussion by race ( $F_{(6,707)} = 6.477, p = 0.000$ ). The most significant differences were between white and African American high school athletes ( $p = 0.000$ ) and there was a trending difference between African Americans and Hispanic/Latinos ( $p = 0.053$ ). No other between group differences were observed for race. The minimum, maximum, mean scores, and the standard deviation for each race is summarized in Table 6.

*Table 6. Race Differences in Knowledge of Concussion Scores*

<i>Race</i>	<i>N</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Mean</i>	<i>SD</i>
White	205	13	35	28.70	3.796
African American	372	11	34	26.72	4.348
American Indian	9	23	33	28.78	3.193
Asian	13	20	34	26.54	4.390
Hispanic/Latino	28	20	34	29.07	3.265
Other	14	22	34	29.00	3.464
Mixed	73	14	35	27.33	3.969

#### **4.3 Additional Items on Survey Not Part of Knowledge of Concussion Score**

There were additional items on the survey instrument that were not included in the knowledge of concussion score from the validated survey instrument. In addition to the 20 signs and symptoms of concussion included in the knowledge of concussion score, fogginess, chest pain, stiff back, sensitivity to light, ringing in the ears, difficulty breathing and nosebleed were also included within the signs and symptom section. Table 7 summarizes the number of high school athletes in each setting who correctly identified each sign and symptom. The table includes the 20 signs and symptoms that were calculated into the knowledge of concussion score, as well as the 7 signs and symptoms that were added.

The frequency of high school athletes who correctly identified the seven signs and symptoms added to the survey were: fogginess (n=55.2%), chest pain (n=92.4%), sensitivity to light (n=74.6%), nosebleed (n=87.0%), difficulty breathing (n=83.9%), stiff back (n=87.4%),

and ringing in the ears (n=70.9%). Additionally, Chronic Traumatic Encephalopathy (CTE) was added to the survey and was listed as a complication of multiple concussions. CTE was also not used as a variable to determine knowledge of concussion score. Only one third of participants in the study correctly identified CTE as a complication due to multiple concussions (n=234; 32.7%)

*Table 7. Number of Athletes that Correctly Identified Each Sign and Symptom by School Type and AT Access*

Signs and Symptoms	Urban		Suburban	
	<i>AT</i>	<i>No-AT</i>	<i>AT</i>	<i>No-AT</i>
<b><i>Signs &amp; Symptoms Included in Knowledge Score</i></b>				
Abnormal Sense of Smell	209	228	186	30
Abnormal Sense of Taste	199	225	185	30
Memory Loss	181	163	181	25
Joint Stiffness	193	216	171	28
Blurred Vision	187	181	190	27
Black Eye	204	230	172	29
Bleeding from Ear	185	204	157	26
Bleeding from Mouth	208	239	178	30
Bleeding from Nose	192	218	170	27
Confusion	187	170	188	28
Fever	193	221	179	28
Dizziness	193	169	183	30
Headache	212	199	193	30
Sleep Problems	101	84	134	13
Loss of Consciousness	180	150	189	28
Nausea	127	93	163	22
Numbness or tingling of arms	169	219	146	23
Skin Rash	216	239	207	32
Sharp burning pain in neck	161	194	128	22



Table 7 (cont'd)

Weakness in neck movements	131	168	121	16
<i>Signs &amp; Symptoms Not Included in the Knowledge Score</i>				
Fogginess	125	81	166	22
Sensitivity to light	173	139	191	30
Nosebleed	202	223	168	28
Difficulty breathing	189	217	165	28
Chest Pain	207	225	194	32
Stiff Back	200	222	175	27
Ringling in the ears	164	144	176	22

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#### 4.4 Self-Reported Understanding of Concussion

There were a total of four Likert scale questions that asked each athlete to self-report their understanding of the nature of concussion, return to play criteria, and their understanding of the signs and symptoms of concussion. Each question was scaled from 1 indicating the athlete disagreed completely to 5 indicating agreed completely. Table 8 summarizes the frequency statistics for the four questions across the entire sample population.

*Table 8. Frequency and Percentage of Self-Reported Understanding of Concussion*

Question	1 – Disagree Completely	2 – Somewhat Disagree	3 – Neither Agree Nor Disagree	4 – Somewhat Agree	5 – Agree Completely
I understand the dangers of concussion.	9 (1.3%)	15 (2.1%)	37 (5.2%)	219 (30.7%)	434 (60.8%)
I understand the signs and symptoms of concussion.	45 (6.3%)	64 (9.0%)	101 (14.2%)	325 (45.6%)	176 (24.7%)
If I am hit in the head and have a headache, it is OK to continue to play, as long as I didn't lose consciousness.	240 (34.0%)	130 (18.4%)	153 (21.7%)	134 (19.0%)	48 (6.8%)
If I think I may have a concussion, it is OK to continue to play your sport.	383 (53.6%)	136 (19.0%)	101 (14.1%)	54 (7.6%)	30 (4.2%)

#### **4.5 Reporting Behaviors Descriptives**

Of the entire sample population, 46.3 percent (n=331) of the population recalled having at least one concussive event (bell-ringer or concussion). Of the 331 subjects who recalled having at least one concussive event, 21.4% percent indicated reporting all of those concussive events to an authoritative figure. There were a total of 383 recalled concussions in practices and games among the sample and only 254 were reported. Moreover, there were a total of 1796 recalled bell-ringer events. Of which only 263 were reported to an authoritative figure.

In games only, there were a total of 1152 recalled concussions and bell-ringers, with only 284 having been reported to an authoritative figure. For practices only, there were a total of 1028 recalled concussions and bell-ringers, and only 233 were reported to an authoritative figure. In addition, 29.3% percent of the population indicated continuing to play in a game while experiencing signs and symptoms of concussion, and 25.4% percent indicated continuing to

participate in a practice while experiencing signs and symptoms. Additionally, 29.9% percent of the population indicated knowing a friend or teammate that thought they had a concussion but did not tell anyone. Table 9 illustrates the frequency of reporting values for the entire sample population.

*Table 9. Number of Recalled Bell-Ringers and Concussions Reported*

	Bell-Ringers		Concussions	
	<i>Recalled</i>	<i>Reported</i>	<i>Recalled</i>	<i>Reported</i>
Practice Events	886	114	142	119
Game Events	911	149	241	135

#### **4.6 Calculation of Ancillary Reporting Behavior Analysis**

The portion of the sample (n=331) included in reporting behaviors analyses only included subjects indicating recalled concussive events (bell-ringers or concussion). The variables that went into the recalled concussive events equation were the numbers of recalled concussions at games and practices, and the number of recalled bell-ringers at practices and games. These values were summed for each participant; however, only subjects with at least one concussive event were included in this analysis. In addition to the summed concussive events, all reported events to an authoritative figure were simultaneously summed. Reporting percentage was then calculated for all subjects that recalled at least one concussive event. The summed concussive events were divided by the summed reported events and that value was multiplied by 100 to determine each individuals reporting percentage. For example, if an athlete stated he had 3

concussive events, but only reported 1 of those concussive events he would have a percentage of 33.3% ( $1/3 \times 100$ ) of reported events. Reporting percentage values were then divided into two groups: high reporters and low reporters. High reporters were any individual that reported 50% or more of recalled concussive events and low reporters were any individual that reported fewer than 50% of recalled concussive events. In the entire reporting population, there were 97 high reporters and 228 low reporters. A total of 55.3% percent of the reporting group did not report any recalled events to an authoritative figure. Table 10 summarizes the percentage of high reporters and low reporters by school type and access to an AT.

*Table 10. Number of High and Low Reporters Identified by School Type and AT Access*

	Urban		Suburban	
	<i>AT</i>	<i>No-AT</i>	<i>AT</i>	<i>No-AT</i>
High Reporters	30	30	30	7
Low Reporters	55	90	68	15

#### **4.7 Demographic Factors and Reporting Behaviors**

Using the above calculations for reporting behaviors, additional statistics were calculated to analyze differences in reporting across the sample population. Independent t-tests were used to determine differences in reporting between males and females, and results revealed that there were significant differences in reporting between males and females ( $t_{(2, 88.565)} = -3.164, p = 0.002$ ). Specifically, female athletes ( $n = 67$ ; 46.4%) report a higher percentage of their concussive events than male athletes ( $n = 264$ ; 26.2%).

Additionally, a one-way ANOVA examining sport and reporting percentage was conducted and results did show significant differences ( $F_{(9,321)} = 2.888, p = 0.003$ ). Specifically gymnastics and girls' basketball sports were significantly higher than football and wrestling.

*RQ1b: Do high school athletes attending urban schools less frequently report potential concussive injuries to an authoritative figure compared to high school athletes attending suburban schools?*

Results from the linear regression indicated no statistical significance ( $F_{(1,329)} = 1.161, p = 0.282$ ) between school type. Thus, school type does not predict reporting percentage in high school athletes.

*RQ2b: Do high school athletes that have access to an AT more frequently report potential concussive injuries to an authoritative figure than high school athletes that do not have access to an AT?*

Results from the linear regression indicated no statistical significance ( $F_{(1,329)} = 3.119, p = 0.078$ ) however, having an AT is a trending predictor of reporting percentage.

*RQ4: What factors (i.e., race, age, sex, knowledge of concussion score) are associated with reporting of potential concussions in high school athletes?*

Results from this multiple regression model indicated that the overall model was significant; however, only sex was a significant predictor of reporting percentage ( $F_{(4,324)} = 3.502, p = 0.008$ ). Sex positively influences reporting percentage and females demonstrate higher reporting percentages than males. To further investigate this relationship, a one-way ANOVA was conducted to confirm the relationship between sex and high and low reporters. There is a significant relationship between sex and high and low reporters ( $F_{(1,323)} = 8.637, p = 0.004$ ) revealing that females have higher reporting percentages compared to males.

#### *4.7.1 Reasons for Not Reporting a Concussive Event*

Of the total 13 reasons for not reporting a recalled concussive event, the top reason for not reporting were not thinking the injury was serious enough to warrant medical attention (33.7%), not wanting to lose playing time (26.0%), not wanting to let the team down (19.9%), and not wanting to go to the doctor (14.7%). Table 11 summarizes the 13 reasons for not reporting a recalled concussive event and the frequency of which each reason was selected across the entire sample population. Table 12 further breaks down those percentages and illustrates the number of subjects who chose each reason by school type and access to an AT.

*Table 11. Frequency and Percentage for the 13 Reasons for Not Reporting a Concussive Event*

Reason for Not Reporting	Frequency (%) Across Population
I did not want to lose playing time.	185 (26.0%)
I did not think it was serious.	241 (33.7%)
I thought my teammates would think I'm weak.	78 (10.9%)
I thought my coach would think I'm weak.	82 (11.5%)
I thought my coach would get mad.	56 (7.8%)
I did not want to have to go to the doctor.	105 (14.7%)
I thought my parents would be upset.	35 (4.9%)
It was the end of the season and I didn't want to miss games.	99 (13.8%)
My team was going to the playoffs when this happened.	50 (7.0%)
I was trying to get a scholarship to play in college	49 (6.9%)
I did not want to let my team down.	142 (19.9%)
I did not know at the time it was a concussion.	124 (17.3%)
I do not have health insurance and could not go to the doctor.	18 (2.5%)

*Table 12. Number of Athletes that Indicated Each Reason for Not Reporting and Reasons for Reporting a Recalled Concussive Event by School Type and AT Access*

Reason for Not Reporting or Reporting	Urban		Suburban		Total
	<i>AT</i>	<i>No-AT</i>	<i>AT</i>	<i>No-AT</i>	
I did not want to lose playing time.	48	78	52	13	191
I did not think it was serious.	66	89	70	16	241
I thought my teammates would think I'm weak.	15	32	26	5	78
I thought my coach would think I'm weak.	16	35	27	4	82
I thought my coach would get mad.	8	24	20	4	56
I did not want to have to go to the doctor.	26	47	22	10	105
I thought my parents would be upset.	4	18	10	3	35
It was the end of the season and I didn't want to miss games.	22	38	28	11	99
My team was going to the playoffs when this happened.	7	25	13	5	50
I was trying to get a scholarship to play in college.	9	25	12	3	49
I did not want to let my team down.	33	64	35	10	142
I did not know at the time it was a concussion.	35	50	30	9	124
I do not have health insurance and could not go to the doctor.	2	11	5	0	18

Table 12 (cont'd)					
<i>Reasons for Reporting</i>					
I was scared.	19	26	12	5	62
I thought I had a concussion.	39	34	45	5	123
I wanted to get out of practice or a game.	2	17	4	0	23
I felt the same way I did when I had a previous concussion.	13	15	12	1	41
I did not want to have any further damage to my brain.	39	36	33	4	112
Other	22	26	30	1	79

#### 4.7.2 Reasons for Reporting a Concussive Event

Descriptive statistics were also analyzed to determine reason why high schools athletes did report all or some of their concussive events to an authoritative figure. The top reasons high school athletes reported their recalled concussive events were because he/she thought he/she had a concussion (17.2%) and he/she did not want further brain damage (15.7%). Table 13 represents the reasons why and the frequencies high school athletes reported a concussion for each reason. Refer to Table 12 for the cross-tabulation between each reason for reporting and school type and access to an AT.



*Table 13. Percentage of Athletes that Indicated Reasons for Reporting*

Reason for Reporting	Frequency (%) Across Population
I was scared.	62 (8.7%)
I thought I had a concussion.	123 (17.2%)
I wanted to get out of practice or a game.	23 (3.2%)
I felt the same way I did when I had a previous concussion.	41 (5.7%)
I did not want to have any further damage to my brain.	112 (15.7%)
Other	85 (11.8%)

## **CHAPTER 5**

### **DISCUSSION**

#### **5.1 Overview**

This chapter will provide an overview of the results of the present study and discuss them in relation to relevant literature on sport-related concussion. First, the findings from the knowledge of concussion scores will be reviewed and discussed. Second, reporting behavior results will be compared and contrasted with similar studies that have evaluated reporting behaviors in high school athletes. Third, results demonstrating demographic differences between sex and race with regard to knowledge of concussion and reporting behaviors will be discussed and subsequently compared and contrasted to previous studies that have examined sex and racial differences associated with knowledge of concussion and/or reporting behaviors. Finally, clinical implications of these findings and directions for future research will be proposed.

#### **5.2 General Demographics and Knowledge of Concussion**

This study examined knowledge of concussion and reporting behaviors in 715 athletes across 14 high schools from urban and suburban communities among two metropolitan areas within the state of Michigan. Athlete knowledge scores were moderate in this study, with a mean of approximately 27 out of 35 questions answered correctly. This finding indicates that there is still a gap between what high school athletes know about concussion and what they should know about concussion. These findings are similar to previous studies that have also shown high school athletes have either moderate to inadequate knowledge of concussion (Register-Mihalik et al., 2013; Courneyer & Tripp, 2014). Unlike previous studies that have investigated concussion knowledge in high school athletes, a lower percentage of athletes correctly identified the most common signs and symptoms of a concussion. For example, previous studies have shown that

headache, dizziness, and confusion were correctly identified 90-97% of the time (Courneyer and Tripp, 2014); however, high school athletes in this study only identified headache, dizziness, and confusion 80-89% of the time. This finding is of concern because headache is the most prominent sign and symptom and is a symptom athletes experience upwards of 94% of the time following injury (Lau et al., 2011). Moreover, athletes who experience post-concussion headache are more likely to experience a larger number of additional signs and symptoms (Collins et al., 2003). Furthermore, dizziness is also a common symptom and the best on-field predictor of a delayed recovery after injury in concussed football players (Lau et al., 2011). Therefore, it is alarming that approximately 20% of high school athletes were unable to recognize dizziness as a symptom of concussion.

Aside from common signs and symptoms such as headache, dizziness, and confusion that have previously shown to be correctly identified by a large percentage of athletes, memory loss (77%), LOC (77%), sleep problems (47%), nausea (57%), and fogginess (55%) were signs and symptoms that were also poorly recognized by this sample of high school athletes. In fact, approximately 70% of this sample reported that they agreed they at least somewhat understood the signs and symptoms of concussion, however, a large percentage of the athletes were unable to correctly identify many common signs and symptoms. Memory loss and LOC are signs and symptoms that have shown in literature to be more familiar to high school athletes (Gourley et al., 2010); however, the present results indicated that many athletes were moderately aware of these two signs and symptoms. On the contrary, sleep problems and nausea are symptoms that have notoriously been reported at very low percentages by high school athletes. Register-Mihalik and colleagues (2013) and Courtney and Tripp (2014) have also reported an apparent lack of knowledge of nausea and difficulties related to sleep as symptoms of concussion. Nausea is a

symptom that can be associated with a multitude of medical issues and this may be the reason why it is difficult for high school athletes to recognize that this symptom is associated with concussion or a brain injury (Register-Mihalik et al., 2013). Sleep problems were the sign and symptom that the majority of the sample was unable to identify as a symptom of concussion. Additionally, foggiess was a symptom that was unfamiliar to approximately 45% of our sample. Foggiess is an emerging symptom of concussion and has been described as feeling mentally foggy or mentally “slowed down.” Foggiess has been identified in the literature as one of the more prominent symptoms and athletes that experience foggiess more commonly experience a larger number of concussion symptoms (Iverson et al., 2004). We suspect that athletes did not understand the term and these findings truly represent the knowledge gap in what high school athletes know about concussion and what they should know about concussion. Findings in this sample suggest that high school athletes are comparatively knowledgeable about the signs and symptoms of concussion as it relates to published studies that have similarly investigated sign and symptom recognition in high school athletes (Register-Mihalik et al., 2013; Courneyer and Tripp, 2014; Kurowski et al., 2014). Future concussion education initiatives need to address all signs and symptoms of concussion with high school athletes and explain what each symptom means so athletes are familiar with words and definitions to help young athletes connect signs and symptoms with potential concussive injuries.

In addition to the sign and symptom recognition, results from this study illustrated that high school athletes had moderate knowledge of the complications associated with multiple concussions and returning to play too soon after a concussion. Some of the questions that were most commonly missed in these sections were tied to the understanding that complications of multiple concussions and complications of returning to play prematurely. A large percentage of

athletes did not know that multiple concussions could lead to an increased risk of further injury, or that returning to play too soon after a concussion injury could lead to brain damage. These findings are similar to results by Courneyer and Tripp (2014) in which varsity football players were moderately able to identify long-term consequences of concussion and often improperly identified risks of improper care of concussive injuries. The results of the current study observed that only 80% of high school athletes were able to identify that concussion was an injury that affects the brain. We believe that this could have led to the inability for many athletes to associate brain damage, increase risk for further injury, and memory problems with a concussion injury. Due to 20% of high school athletes not being able to recognize that a concussion is an injury that affects the brain, suggests that high school athletes are in drastic need for more concussion education. This finding could also be related to the fact that different types of schools were surveyed and students at schools of lower socioeconomic status have less knowledge. Another complication of multiple concussions that was unrecognized by approximately 67% of the sample was Chronic Traumatic Encephalopathy (CTE). CTE is an intimidating medical term that has been heavily publicized within the media about professional football players. Although much research is still needed to better understand the consequences of CTE as a result of sport, it is a term that high school athletes should be more familiar with. Long-term consequences of concussion such as Parkinson Disease, Alzheimer Disease, and amyotrophic lateral sclerosis (ALS) have been studied and mortality rates for these neurodegenerative diseases have been shown to be three times higher in former NFL players than that of the general public (Lehman et al., 2012), therefore, educational efforts towards high school athletes need to also address all long-term consequences of concussion.

### **5.3 Knowledge of Concussion by School Type (Urban or Suburban)**

Results of this research indicated that knowledge of concussion scores significantly differed between high school athletes attending urban and suburban schools. The current study found that concussion knowledge score was lower for urban athletes than suburban athletes. Although this is the first study to examine knowledge of concussion by school type, literature does support drastic differences in academic achievement, standardized test scores, and reading abilities between urban and suburban students (Sandy & Duncan, 2010; Willie, 1991; Herbers, Supkoff, Heistad et al., 2012). The knowledge of concussion differences seen in this study could be reflective of these academic differences.

Much of the achievement gap between urban and suburban students is explained by the high concentration of disadvantaged students at urban schools (Sandy & Duncan, 2010). The U.S. Department of Education has acknowledged the achievement gap as a result of larger numbers of minority students and low-income students attending urban schools. Lower measured achievement is well documented in urban schools and the vast majority of the students are eligible for the Free and Reduced Lunch Program. This program is an indicator of poverty status (Sandy & Duncan, 2010) and schools with high percentages of students on the Free and Reduced Lunch Program are classified as Title I schools. Moreover, Title I urban schools are documented to have considerably lower percentages of students testing at a proficient level in reading, math, science, and writing (Sandy & Duncan, 2010). The socioeconomic characteristics of students at urban and suburban schools has been linked to differences in scores on the Scholastic Assessment Test (SAT) and the Armed Services Vocational Aptitude Battery (ASVAB) (Willie, 2001; Sandy & Duncan, 2010). Specifically, as family income decreases, test scores on these assessments similarly decrease. Moreover, reading fluency in elementary education is

documented to be much lower in urban students living in poverty compared to students not facing the same challenges; and, these elementary scores are highly predictive of poor reading fluency in later grades (Herbers et al., 2012). This literature helps to explain the observed differences in knowledge of concussion scores between urban and suburban students and provides insight into how education efforts need to be addressed in urban communities. If students in urban schools are poorer readers and/or have less access to health knowledge, concussion education initiatives need to be tailored to meet the needs of the students within those communities.

Concussion education efforts cannot be homogeneous in every community. Not only are high school athletes in suburban schools better readers, better test takers, and documented to have higher concussion knowledge, but differences in knowledge of concussion may also be the result of resources provided to athletes at suburban schools that are not provided to urban athletes. The economical differences between urban and suburban schools are implicit by the limited tangible resources for athletes at urban schools (Hannaway and Talbert, 1993), but these resources also include family and parental support (Sandy & Duncan, 2010; Willie, 2001; Hannaway & Talbert, 1993). Family and parents support characteristics, including income, parent education, family size, and parent involvement in a school, are resources to high school athletes that explain much of the achievement gaps between urban and suburban students (Sandy & Duncan, 2010). Parental support and involvement benefits student achievement and test scores, and may also support exposure and retention to concussion knowledge. Suburban schools have more parental support (Hannaway & Talbert, 1993) and the parental support may benefit from concussion education efforts delivered to high school athletes. Traditionally, suburban parents have higher levels of education (Hannaway & Talbert, 1993) and they are more aware of

concussion and the signs and symptoms of concussion because they have been shown to actively seek out concussion information (Bloodgood et al., 2013). Unfortunately, due to fewer resources, less quality education, and broken family environments, urban athletes face an experience that does not support higher achievement, and may inappropriately foster concussion education initiatives.

These results demonstrate the need for further concussion education in urban high schools. There has been no prior research on concussion knowledge within urban and suburban communities, therefore, these results indicate that educational efforts must address the needs of the students within the school community. Community and family-based efforts coordinated with school-based approaches may be essential to increase concussion knowledge in urban communities and efforts should target ideas that will get both athletes and their parents involved. Concussion education cannot be delivered through print materials or materials that require lengthy and thorough reading to be understood. On the contrary, education initiatives need to be delivered via methods such as interactive games, ecological models of learning, after-school programs, oral presentations, social media, and videos.

Similar approaches have been made to improve health and academic achievement among urban youth (Ickovics, Carroll-Scott, Peters, et al., 2014). The health and physical well-being of urban youths often suffer as a result of socioeconomic factors (Murgia et al., 2009). Adolescents who are African American or Hispanic (Fisher et al., 1996) or of lower socioeconomic status are less physically active than adolescents who are White and from higher socioeconomic status (Kanters et al., 2013). For adolescents facing these challenges, it has been suggested that after-school programs have been a promising strategy to increase intramural sport participation to get youth more physically active (Kanters et al., 2013). Additionally, an ecological model that used



the HBO show *The Wire*, a show that depicts many urban health issues within the city of Baltimore, cited the video to be a useful tool to teach urban health issues through representation of people that reflect a similar environment (Buttress, German, Holtgrave & Sherman, 2012). Finally, using social media networks such as Facebook and Twitter has been shown to be a valuable tool to increase public awareness (Provvidenza et al., 2013). Social media has proven to be an attractive learning tool that appeals to the emerging generation and could be used in addition to face-to-face education to deliver accurate concussion information (Provvidenza et al., 2013).

#### **5.4 Knowledge of Concussion and Access to an Athletic Trainer (AT)**

Previous published research conducted with high school athletes to determine knowledge of concussion was done in schools that had access to an athletic trainer (AT), therefore, this study is the first to examine knowledge of concussion in high school athletes with access to an AT and without an AT. The current findings indicate that high school athletes with access to an AT have significantly higher concussion knowledge than high school athletes without access to an AT. ATs are the best health-care professional suited to provide effective and efficient medical care to high school athletes as they are highly educated and have had concussion specific education and training (Valovich McLeod et al., 2013). The National Athletic Trainers' Association Position Statement on sport-related concussion emphasizes that the AT should play an active role in educating athletes, coaches and parents about the signs and symptoms associated with concussion as well as potential risks of playing while symptomatic (Broglia et al., 2013). Moreover, the presence of an AT allows for baseline concussion testing to occur and as athletes go through baseline testing there may be a learning effect that occurs as athletes gain exposure to potential signs and symptoms and methods of testing. For example, administration of

the Standard Assessment of Concussion baseline testing, and ImPACT computerized neurocognitive baseline testing exposes athletes to the signs and symptoms during the demographic sections when they are asked to rate their current symptom status. In schools without an AT, athletes often do not get baseline testing and often get little to no concussion education.

In schools without an AT, concussion education falls on the coaching staff and school administration. There are several concussion education programs available to coaches such as the Centers for Disease Control (CDC) “Heads Up” program, however, not all coaches access this information. Of high school coaches who have accessed concussion education programs, only 50% reported that the educational program changed their views on the seriousness of concussion, and only 84% of the coaches noted that they had used their information to educate their athletes about preventing and managing concussions (Sarmiento et al., 2010). This finding demonstrates that coaches cannot be relied on to educate athletes about concussion and an AT is a beneficial asset to a high school athletic program. Moreover, all 50 states have now passed concussion legislation and many high school athletic associations are requiring schools to send home concussion information print materials for athletes and parents to read. Many forms are sent home for parents to read and sign, however, many simply get signed and returned without given proper attention. Having an AT at the school may help disseminate those materials and further educate the athletes about the seriousness of concussion.

### **5.5 Factors that Predict Knowledge of Concussion**

The current study investigated factors that may predict knowledge of concussion illustrated that age, sex, race, and sport did not influence knowledge of concussion score in high school athletes. This finding contrasts with prior knowledge of concussion research that have

shown that older age and female sex were associated with improved concussion knowledge (Kurowski, Pomerantz, Schaiper, & Gittelman, 2014; Bagley, Daneshvar, Schanker et al., 2012). Our results may differ from previous work because previous studies only surveyed knowledge in suburb schools, and their sample sizes were considerably smaller than ours. Results showing no association between age and knowledge of concussion were surprising and could be due to all age groups having moderate knowledge in concussion. Furthermore, many athletes are getting exposed to concussion information in earlier years of sport participation (i.e., youth sport), therefore the older and younger high school athletes may have had equivalent exposure to concussion information and education.

Although race was not a predictor of knowledge of concussion score, further statistical investigations indicated that there was a difference between race and knowledge of concussion scores. There is very little empirical research that has provided any evidence of racial differences as it relates to sport-related concussion. Results from our study found statistical significance in knowledge of concussion scores between white and African American high school athletes. White high school athletes had higher knowledge of concussion scores than African American high school athletes. In contrast to the majority of other studies, this sample had a higher percentage of African American athletes (52%) compared white athletes (29%). There were no other between group differences between knowledge of concussion and any other races; however, there was trending difference in knowledge scores between African Americans and Hispanic/Latino students. Hispanic/Latinos had more knowledge than African Americans. Similar to the present study, Kontos and colleagues (2010) found that concussed high school African American athletes had limited awareness of concussion, and the associated signs and symptoms, compared to concussed white high school athletes. Moreover, Bloodgood and

colleagues (2013) found that African Americans and Hispanic youth were significantly less likely to have heard of concussion than White respondents.

The racial differences in our study could be related to the association between school type and knowledge of concussion score rather than race alone. The majority of the African American subjects in this study attended an urban school, and education literature has documented that achievement scores of African American and White students are more often influenced and affected by the context within which learning occurs and is not necessarily tied to race (Willie, 2001). The socioeconomic characteristics of schools in which African Americans and Whites attend are more predictive of achievement scores and African American students who attend more affluent-concentrated schools have demonstrated vastly higher scores than African American students attending poverty-concentrated schools (Willie, 2001). Similarly, White students who attend affluent-concentrated school have higher achievement schools than White students attending poverty-concentrated schools (Willie, 2001). Therefore, the racial differences observed may be more related to the fact that the majority of the African American athletes in this sample attended an urban, Title I school.

There needs to be much more research that investigates the relationship between race, socioeconomic status, as well as school environments as it relates to sport-related concussion in high school athletes. This finding alone is very disquieting because many African American athletes could be at a huge disadvantage due to their socioeconomic conditions.

## **5.6 General Demographics of Reporting Behaviors**

The under-reporting of concussion was found to be as high as 55% in this study. Literature has cited the under-reporting of concussion to be as high as 40-50% (McCrea et al., 2004; Register-Mihalik et al., 2013) therefore, the 55% resulting from this study shows that the

under-reporting of concussion is likely much higher than previously reported. Comparative to other studies, this study was done across different demographics and the sample size was much larger than previous studies.

All of the information was self-reported and most of the recalled concussive events were classified as bell-ringers. Unreported bell-ringer events totaled 1,796, with the majority of these being reported to have occurred in games. Of the 1,796 bell-ringer events, only 233 (13 %) were reported to an authoritative figure. The difference between the number of reported bell-ringer events and number of concussion events was substantial, as only 383 concussions were recalled from practices and games. The difference in the proportion of recalled concussions and bell-ringers draws attention to athletes' misunderstanding of these two terms and their inability to associate the terms bell-ringer and concussion (Register-Mihalik et al., 2013). This finding parallels findings from Register-Mihalik and colleagues (2013) as the majority of the events reported in that study were also bell-ringer events. The term bell-ringer was used to help examine the number of events that occurred, however, according to the NATA position statement on sport-related concussion, the colloquial term should not be used to describe a sport-related concussion because it minimizes the seriousness of the injury (Broglia et al., 2013). All of the bell-ringer events in this study may not have been concussions, but recalled events should have been reported and evaluated by a medical professional to determine if an injury did occur. Moreover, if an athlete shows concussion like signs and symptoms after a contact to the head, the athlete, at the very least sustained a mild concussion and should be treated as such (Guskiewicz et al., 2004). Occasions in which these events are not reported, athletes are likely to continue playing in a potentially vulnerable state that could potentially lead to second impact syndrome.

Only 14.6% of the recalled bell-ringers were reported and 66.3% of concussions recalled in this study were reported to an authoritative figure. In addition to those figures, upwards of 30% of the athletes indicated that he/she continued to play in both practices and games while experiencing signs and symptoms of a concussion. These numbers represent gross under-reporting of concussive injuries and highlight the prevalence of unreported injuries in high school athletics. Contradictory to these numbers, approximately 52% of the athletes indicated that they at least somewhat disagreed that it was okay to continue playing with a headache after a blow to the head as long as consciousness was lost and approximately 73% indicated that they at least somewhat disagreed that it was okay to continue playing if they thought they had a concussion. Chrisman et al. (2013) found similar results with many athletes reporting that they know concussions were dangerous, however, the majority of the athletes indicated that they would continue to play in a game with a concussion. The differences in understanding and reporting underline the vast discrepancy about what athletes know and how they behave. There is a disconnect, and although more athletes are indicating they understand the dangers of concussion, there does not appear to be a behavior change. Increased knowledge does not equal behavior (Register-Mihalik et al., 2013) and it is disconcerting that such large percentages of athletes are staying on the playing field while symptomatic.

The most common reasons athletes alluded to for not reporting possible concussions was not thinking the injury was serious enough to seek medical attention, not wanting to lose playing time, and not wanting to let the team down. These results align with previous research and these three reasons have been cited as being the top reasons athletes did not report concussions over the past decade (McCrea et al., 2004; Register-Mihalik et al., 2013). Chrisman et al. (2013) eluded to under-reporting through qualitative interviews with athletes who explained they would

not want to stop playing their sport because they felt the signs and symptoms would go away and they did not want to be pulled from the game. Our study looked at under-reporting across a variety of different male and female sports unlike McCrea et al. (2004) who only examined under-reporting in football players and Register-Mihalik et al (2013) who looked at under-reporting across four different sports (i.e., football, lacrosse, soccer and cheerleading). In contrast to other studies, a large number of participants in our study indicated that they did not report their concussion because they did not want to have to go to the doctor. This percentage is likely higher due to concussion legislation and regulations that require a physician clearance note in order to be cleared to return to play.

### **5.7 Reporting at Urban versus Suburban Schools**

Overall, the findings from this study suggest that there are no significant differences in reporting behaviors of high school athletes attending urban or suburban high schools. This was the first study to examine school type differences that may influence reporting behaviors. Despite the organizational and economical differences between urban and suburban high schools, reporting behaviors are likely not related to the socioeconomic status differences high school athletes' face. All high school athletes appear to have difficulty recognizing a concussion injury because symptoms are often non-specific and could be due to other etiology such as dehydration or viral illness (Chrisman et al., 2013). Moreover, high school athletes do not want to be wrong about being concussed and do not want to suffer negative consequences such as being pulled from a game (Chrisman et al., 2013). Our study shows that barriers to reporting affect all demographics and many athletes have reported that they feel it is unacceptable to leave a game with non-specific symptoms of concussion because it would make them look weak (Chrisman et al., 2013).

## **5.8 Reporting at Schools with an AT Versus No AT**

Results from this study showed that there is a trending difference in reporting behaviors between high school athletes attending a school with an AT compared to high school athletes attending a school without an AT. Although there was no statistical significance, the results indicate that the presence of an AT had a positive effect on the reporting behaviors. The presence of an AT allows for more injuries to be recognized and treated because ATs are thoroughly educated in their academic curriculum about new concussion assessment methods and tools that improve clinical identification and management of concussion (Covassin, Elbin, Stiller-Ostrowski, 2009). The NATA has reported that only 42% of high schools in the United States have access to an AT, therefore, results from this study may generalize that over 50% of high school athletes are not reporting their concussive events. Funding for an AT is often difficult for low-income school districts; however, results from our study indicate that the presence of an AT could eliminate unreported concussive events and allow athletes to receive the medical care they need to prevent catastrophic outcomes from playing while symptomatic. In the event that there is no AT available to high school athletes, all reporting must be done to a coach or a parent. Reporting to a coach is much different from reporting to a medical professional and unless a coach has basic first-aid knowledge, they do not have the foundation for making decisions or helping athletes get the medical care they need (Ransone & Dunn-Bennett, 1999). Athletes have been found to rely on their coaches for guidance regarding which symptoms to report and many athletes feel that their coaches will remove them from a starting position if they report symptoms (Chrisman et al., 2013). This may be a conflict of interest for coaches because taking care of injuries is not a part of their job.



## 5.9 Factors that Predict Reporting Behaviors

Results from our study compared and contrasted with reporting behavior literature. Factors we found that did significantly predicted reporting were sex and sport. These two findings somewhat parallel each other because the sports that had the highest reporting percentages were female sports: gymnastics and girls' basketball. The sports that had the lowest reporting percentages were football and wrestling. Sex positively influenced reporting and females are more likely to report their concussive event to an authoritative figure than males. Kurowski et al. (2014) similarly found that female sex was associated with increased reporting. Females have a higher rate of concussion than males (Lincoln et al., 2011), are more at risk of concussion because of lower amounts of head stability, and less neck muscle activation (Tierney, Higgins, Caswell, Brady et al., 2008), experience more symptoms than males (Covassin et al., 2013; Frommer et al., 2011; Broshek et al., 2005) and may be more likely to be more cautious when dealing with a concussion (Rechel et al., 2008). These findings may strongly contribute to the higher reporting percentages found in females.

Similarly, sport was a predictor of reporting behavior. McCrea et al. (2004) studied football players and found that only 50% of concussed football players reported their injury to a medical professional, and our study similarly revealed that football is the sport that demonstrated the lowest percentage of reporting. Other studies have found that soccer athletes demonstrate better self-reported behaviors (Kurowski et al., 2014; Chrisman et al., 2013). This finding may suggest that the culture of reporting may be different among various sports and future studies should consider the culture created within each sport context.

We did not find that age or concussion knowledge score statistically predicted reporting behaviors, however, there are other studies that have demonstrated that age and knowledge

influence reporting. Younger aged athletes have been shown to have better self-reported behaviors than older athletes (Kurowski et al., 2014); however, we did not see this demonstrated in our sample. Similar to our results, Kurowski et al. (2014) and Chrisman et al. (2013) found that increased knowledge was not associated with better self-reported behaviors. There has been a contrast in the literature with regards to knowledge being a predictor of reporting because Register-Mihalik et al. (2013) and Bramley et al. (2014) did find that increased knowledge and/or concussion education positively affected reporting. The contrasting findings indicate that there needs to be more educational programs that address behavior interventions for athletes.

### **5.10 Limitations**

This study is not without limitations. The interpretation of the findings is bound by the fact that there were more male participants than female participants. Secondly, many athletes played multiple sports, therefore, our distribution of various sports may be inaccurate due to many athletes taking the survey during a fall sport season. For example, we have a larger number of football players than other male sports and this was due to the fact that many football players also played basketball and/or wrestled. Additionally, we did not have a strong representation of suburban schools without an AT. Finding schools with these qualifications was difficult and there were not many available to recruit for research. Next, all testing sites presented with different environments and all participants did not take the survey in the same location. Finally, due to the nature of survey instrumentation, we assumed that participants were truthful and answered the questions honestly, however, this is not a guarantee.

### **5.11 Future Research in this Area**

Future research in this area should further investigate urban schools to determine the best methods to increase concussion knowledge. A study that provides an educational intervention

through a game (i.e Bingo or Jeopardy) would be an idea to propose to target urban schools with limited resources to educate athletes about the signs and symptoms of concussion, and the dangers of concussion. Future research could determine if interventions positively affect concussion knowledge, and give insight into how education can change behavior. Given that many of the urban schools in this study were predominantly composed of African American high school athletes, future research should also investigate the relationship between race, socioeconomic status, grade point average, and parent education, and how those factors may influence concussion knowledge. In schools and communities of low socioeconomic status, giving the knowledge of concussion survey verbally may eliminate potential reading comprehension difficulties.

Additionally, a qualitative study conducted to determine some barriers to concussion knowledge, education and reporting in urban schools would be beneficial to understand the culture in which many athletes are playing. Research within urban communities is often difficult, but due to the success of this study in that context, it would be a good idea to understand some of the barriers high school athletes in urban schools face. Interview questions would center around current concussion knowledge, where their knowledge is coming from, their family and home environment, the culture of their neighborhood, the culture of their sport, and the societal pressure they face being an athlete.

Finally, looking at coach knowledge of concussion and correlating coaches' knowledge with athletes' knowledge may contribute to the understanding of a culture of a sport, team, or community, especially in schools without an AT. The next step to concussion knowledge and education should be geared to changing behavior. Understanding what coaches know compared

to what athletes know, and understanding the culture of a sport program will help researchers tackle the underreporting issue.

## **5.12 Conclusions**

This is the largest study to date to examine knowledge of concussion and reporting behaviors. While concussion knowledge does not appear to affect reporting, there are significant differences in concussion knowledge in urban and suburban high school athletes and differences in schools with an AT and without an AT. Knowledge does not equal reporting behaviors, however, concussion knowledge is critical to the immediate care of a potential concussive event. It is critical that athletes understand the signs and symptoms of concussion and that they understand the dangers of playing while experiencing symptoms. Should high school athletes not fully recover from a single concussion and a second injury occur, there could be catastrophic complications. Moreover, during the recovery process it is important that athletes do not participate in activities that trigger or worsen symptoms. Current literature suggests that physical and cognitive exertion can change the metabolic activity of the brain (Dalsgaard et al., 2004), which can cause harmful effects to an athlete suffering from a concussion. Injury to a youth's brain can be a hindrance for their daily functioning at school and their social life (Gioia, 2012). The concept of physical rest is typically well understood by athletes, coaches, and parents, however, cognitive rest is often a difficult concept to implement when managing a concussion injury (Master et al., 2012). Sport-related concussion has a negative effect on cognitive functioning during the initial stages of recovery (Valovich McLeod, 2009) and cognitive rest includes no school attendance, no homework or school work, no reading, no video games, no texting, no computer and no television (Master et al., 2012). Performing high-level cognitive activities following a concussion may exacerbate symptomology similar to a high-level physical

activity and prolong recovery (Sady et al., 2011). High school athletes who experience a concussion would benefit from a controlled return-to-learn approach because cognitive demands that involve reading and information processing have been reported to increase the severity of concussion symptoms (Covassin et al., 2013). These findings strengthen the importance of high school athletes understanding the consequences of concussion because athletes who choose not to report a concussion are not only vulnerable in an athletic setting, but also in an academic setting. Academic accommodations for concussed athletes are best communicated through the AT at the school. The AT plays a unique role in the process of concussion management because the AT is usually the first person among all school staff to identify if a concussion has occurred and the AT can then notify key members of school staff, including the guidance counselor, teachers, as well as parents and physicians (McGrath, 2010). The presence of an AT has shown to positively affect concussion knowledge and reporting behaviors within high school athletes. Schools must find the resources to employ an AT because an AT can better recognize when an athlete is experiencing signs and symptoms of concussion compared to coaches.

Urban schools and schools that have a larger percentage of African American students must address efforts to increase concussion education. Our study has been the first to study this context and it has shed a light on what may be emerging issues in high school athletics. All athletes need concussion education; however, not all concussion education is created equal. Concussion education programs geared towards urban communities and communities with more African Americans must be designed in way that can effectively create a knowledge transfer.

Despite all of the media attention directed towards concussion, and the many dangers of the injury, as well as all the educational efforts, we have not seen a change in reporting behaviors among high school athletes. Under reported concussions still rank as high as 55% and this is

unacceptable. Aside from concussion education, behavioral interventions must be addressed. Underreporting is a multidimensional problem and there are many potential injuries that go unreported. There are some differences between sports and sex when it comes to reporting and those cultural and sex differences need to be addressed further to fully understand why athlete are not reporting their injuries.

## **APPENDICES**

## Appendix A

### Survey Instrument

#### KNOWLEDGE & AWARENESS OF CONCUSSION AND REPORTING BEHAVIORS

The questions below are organized to ask you what you know about concussions, your concussion history, and how you report them to others. Please read each question carefully and answer honestly to the best of your knowledge. All of your answers will remain anonymous.

**What is your sex?**

Male                  Female

**How old are you?**

13                  14                  15                  16                  17                  18                  19

**What grade are you in?**

9<sup>th</sup>                  10<sup>th</sup>                  11<sup>th</sup>                  12<sup>th</sup>

**What is your race?**

White      African American      American Indian      Asian      Hispanic/Latino      Other

**What sport are you currently playing?**

Football      Volleyball      Girl's Basketball      Boy's Basketball      Wrestling      Gymnastics

Girl's Soccer      Boy's Soccer      Cheerleading      Other \_\_\_\_\_

**Is there an athletic trainer at your school?**

Yes                  No

**Has anyone ever discussed information about concussions with you? (circle all that apply)**

Athletic trainer      Coach      Parent      Doctor      No one

Other: \_\_\_\_\_

**In your lifetime, how many concussions have you had? \_\_\_\_\_**

**In your lifetime, how many concussions have you had caused by playing sport? \_\_\_\_\_**



**I understand the dangers of concussions.**

1	2	3	4	5
Disagree Completely	Somewhat Disagree	Neither Agree Nor Disagree	Somewhat Agree	Agree Completely

**I know the signs and symptoms of a concussion.**

1	2	3	4	5
Disagree Completely	Somewhat Disagree	Neither Agree Nor Disagree	Somewhat Agree	Agree Completely

**High School Concussion History (9th-12th grade)**

1. In your high school years, how many concussions do you think you have experienced?

During games?   During practices?

2. How many of the possible concussions you experienced in high school have you reported to a medical professional (doctor, athletic trainer, etc) or coach?

\*put 0 if you did not have any to report or if you put 0 to the above question\*

During games?   During practices?

3. In your high school years, how many times have you had your "bell rung" or been "dinged"?

During games?   During practices?

4. Of the times you got your "bell rung" or were "dinged" in high school, how many have you reported to a medical professional (doctor, athletic trainer, etc) or coach?

\*put 0 if you did not have any to report or if you put 0 to the above question\*

During games?   During practices?

**On your current high school athletic team(s), do you know of anyone who thought they had a concussion but did not tell anyone? (circle your answer)**

Yes                      No

**Mark an X next to each one of the reasons below why you have not reported a possible concussion, or when you got your “bell rung or dinged” during your high school sport(s) to the athletic trainer, coach, parent or teammate.**

\_\_\_\_\_ I have reported all of my concussion symptoms (go to next question now)

\_\_\_\_\_ I did not want to lose playing time

\_\_\_\_\_ I did not think it was serious

\_\_\_\_\_ I thought my teammates would think I’m weak

\_\_\_\_\_ I thought my coach would think I’m weak

\_\_\_\_\_ I thought my coach would get mad

\_\_\_\_\_ I did not want to have to go to the doctor

\_\_\_\_\_ I thought my parents would be upset

\_\_\_\_\_ It was the end of the season and I didn’t want to miss games

\_\_\_\_\_ My team was going into the playoffs when this happened

\_\_\_\_\_ I was trying to get a scholarship to play in college

\_\_\_\_\_ I did not want to let my team down

\_\_\_\_\_ I did not know at the time it was a concussion

\_\_\_\_\_ I do not have health insurance and could not go to the doctor

**Why did you choose to report your signs and symptoms of concussion to someone?**

\_\_\_\_\_ I was scared

\_\_\_\_\_ I thought I had a concussion

\_\_\_\_\_ I wanted to get out of practice or a game

\_\_\_\_\_ I felt the same way I did when I had a previous concussion

\_\_\_\_\_ I did not want to have any further damage to my brain

\_\_\_\_\_ Other \_\_\_\_\_

**A concussion only occurs if you lose consciousness “black out”?**

True          False          I don’t know

**If you are experiencing any sign or symptom of a concussion following a blow to the head or sudden movement of the body, you should not return to play?**

True                      False                      I don't know

**A concussion is an injury to the:**

Skull    Neck    Brain    Face    None are correct                      I don't know

**Of the following, what are possible complications of having multiple concussions? (check all that apply)**

- ☐ No complications exist
- ☐ Increased risk of further injury
- ☐ Brain damage
- ☐ Chronic Traumatic Encephalopathy (CTE)
- ☐ Joint Problems
- ☐ Memory Problems
- ☐ I don't know

**Of the following, what are possible complications of returning to sporting activity while still experiencing possible concussion symptoms? (mark an X next to all that apply)**

- ☐ no complications exist
- ☐ increased risk of further injury
- ☐ paralysis
- ☐ brain damage
- ☐ joint problems
- ☐ I don't know

**If I am hit in the head and have a headache, it is OK to continue to play, as long as I didn't lose consciousness (ie., black out).**

1	2	3	4	5
Disagree Completely	Somewhat Disagree	Neither Agree Nor Disagree	Somewhat Agree	Agree Completely

**If I think I may have a concussion, it is OK to continue to play your current sport.**

1	2	3	4	5
Disagree Completely	Somewhat Disagree	Neither Agree Nor Disagree	Somewhat Agree	Agree Completely

**In the list below, please select the items you think are signs or symptoms of a concussion by marking them with an X:**

- |  |   |
|--|---|
| <input type="checkbox"/> sensitivity to light    | <input type="checkbox"/> abnormal sense of smell        |
| <input type="checkbox"/> nausea                  | <input type="checkbox"/> sharp burning pain in the neck |
| <input type="checkbox"/> abnormal sense of taste | <input type="checkbox"/> bleeding from ear              |
| <input type="checkbox"/> black eye               | <input type="checkbox"/> sleep problems                 |
| <input type="checkbox"/> nosebleed               | <input type="checkbox"/> memory loss                    |
| <input type="checkbox"/> blurred vision          | <input type="checkbox"/> weakness in neck movements     |
| <input type="checkbox"/> loss of consciousness   | <input type="checkbox"/> confusion                      |
| <input type="checkbox"/> dizziness               | <input type="checkbox"/> ringing in your ears           |
| <input type="checkbox"/> fogginess               | <input type="checkbox"/> chest pain                     |
| <input type="checkbox"/> difficulty breathing    | <input type="checkbox"/> numbness or tingling in arms   |
| <input type="checkbox"/> stiff back              | <input type="checkbox"/> headache                       |
| <input type="checkbox"/> joint stiffness         | <input type="checkbox"/> fever                          |
| <input type="checkbox"/> bleeding from mouth     | <input type="checkbox"/> bleeding from nose             |
| <input type="checkbox"/> skin rash               |   |

1. Rate on a scale of 1-7 how serious you think it is when you experience a headache and dizziness following a blow to the head or body.

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5      ☐ 6      ☐ 7  
not serious                      moderately serious                      very serious

2. Rate on a scale of 1-7 how important you think it is, not to participate in physical activity (game or practice) when experiencing signs and symptoms of concussion.

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5      ☐ 6      ☐ 7  
not important                      moderately important                      very important

3. Rate on a scale of 1-7 how important you think it is to be informed about how concussions happen.

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5      ☐ 6      ☐ 7  
not important                      moderately important                      very important

4. Rate on a scale of 1-7 how important you think it is to be informed about how concussions can be prevented.

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5      ☐ 6      ☐ 7  
not important                      moderately important                      very important

5. Rate on a scale of 1-7 how important you think it is to be informed about what to do if you have a concussion

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5      ☐ 6      ☐ 7  
not important                      moderately important                      very important

6. Rate on a scale of 1-7 how important you think it is to report possible concussion symptoms to a medical professional (doctor, athletic trainer, etc) or your coach.

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5      ☐ 6      ☐ 7  
not important                      moderately important                      very important

7. Rate on a scale of 1-7 your level of agreement with the following statment: In general, athletes are under-educated (don't know enough) about concussions.

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5      ☐ 6      ☐ 7  
disagree                      moderately agree                      strongly agree

8. In your high school years, have you ever continued to play in a game even though you thought you were experiencing signs and symptoms of concussion?

☐ No      ☐ Yes

9. In your high school years, have you ever continued to participate in practice even though you thought you were experiencing signs and symptoms of concussion?

☐ No      ☐ Yes

## Appendix B

### Michigan State University Institutional Board Review Letter

**MICHIGAN STATE  
UNIVERSITY**

**Initial IRB  
Application  
Approval**

October 6, 2014

To: Tracey Covassin  
105 IM Sports Circle

Re: **IRB# 14-990** Category: EXPEDITED 7  
**Approval Date:** October 1, 2014  
**Expiration Date:** September 30, 2015

Title: Assessing Knowledge and Awareness of Concussions and Reporting Behaviors in Athletes

The Institutional Review Board has completed their review of your project. I am pleased to advise you that **your project has been approved**.

The committee has found that your research project is appropriate in design, protects the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

**Renewals:** IRB approval is valid until the expiration date listed above. If you are continuing your project, you must submit an *Application for Renewal* application at least one month before expiration. If the project is completed, please submit an *Application for Permanent Closure*.

**Revisions:** The IRB must review any changes in the project, prior to initiation of the change. Please submit an *Application for Revision* to have your changes reviewed. If changes are made at the time of renewal, please include an *Application for Revision* with the renewal application.

**Problems:** If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to the human subjects, notify the IRB office promptly. Forms are available to report these issues.

Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

Good luck in your research. If we can be of further assistance, please contact us at 517-355-2180 or via email at [IRB@msu.edu](mailto:IRB@msu.edu). Thank you for your cooperation.

Sincerely,



Ashir Kumar, M.D.  
BIRB Chair

c: Jessica Wallace



Office of Regulatory Affairs  
Human Research  
Protection Programs

Biomedical & Health  
Institutional Review Board  
(BIRB)

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MSU is an affirmative-action,  
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Figure 2. Michigan State University Institutional Review Board Letter

## REFERENCES

## REFERENCES

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