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AN EXAMINATION OF THE KNOWLEDGE ABOUT AND ATTITUDES TOWARD CONCUSSION IN HIGH SCHOOL ATHLETES, COACHES, AND ATHLETIC TRAINERS

A Thesis in

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ABSTRACT

The focus of the first portion of the study (i.e., the pilot study) was to develop a comprehensive and psychometrically-sound measure of knowledge (Rosenbaum Concussion Knowledge and Attitudes Survey; RoCKAS) about and attitudes toward concussion and to use the measure in the second portion of the study (i.e., the main study) to examine and explore relationships between concussion knowledge and attitudes across four groups of participants: high school athletes, non-athletes, coaches, and athletic trainers (ATCs).

The pilot study included 698 high school students recruited from high schools in Northeastern and Central NY. Content validity, face validity, and construct validity were established for the RoCKAS. Test-retest reliability was acceptable for the RoCKAS Concussion Attitudes Index (CAI) and closely approached acceptable levels for the RoCKAS Concussion Knowledge Index (CKI). The CAI was found to be internally consistent, but due to the binary nature of the CKI items, internal consistency analyses could not be conducted.

The main study included 495 high school students, 129 high school coaches, and 148 high school ATCs. The RoCKAS was administered to each of these participants in either written or computerized form. Additionally, a sample of 142 high school athletic directors was recruited to obtain information about concussion incidence rates.

A statistically significant moderate correlation between concussion knowledge and attitudes was identified when all participants (i.e., coaches, ATCs, non-athletes, and athletes) were analyzed together.

ATCs were found to have the highest knowledge and safest attitudes followed closely by coaches, and the students showed substantially lower levels. No differences were found between athletes and non-athletes on either knowledge or attitudes.

The results also showed that schools with larger enrollment were more likely to employ an ATC than smaller schools. However, regardless of whether an ATC was on staff, at least 50% of coaches reported being the primary decision maker about return to play after concussion at both practices and games. No differences were found when concussion incidence rates were compared across schools with and without an athletic trainer on staff. However, this finding should be interpreted with caution due to methodological limitations.

These findings suggest that an important relationship between concussion knowledge and attitudes exists that has implications for educational interventions intended to improve concussion knowledge. Additionally, this finding may point to the influence that concussion knowledge has on concussion attitudes, although this conclusion cannot be definitively made due to the correlational nature of the analysis. The attitude differences found when coaches/ATCs were compared to athletes may indicate that individuals within each group possess different orientations towards sports injury. The between-group knowledge differences may be accounted for by academic training and exposure to information about concussion. The substantial differences in the knowledge and attitudes of coaches and ATCs and that of the athletes suggest that there may be relatively little transmission of knowledge or attitudes occurring among these groups. It appears that extensive educational intervention is necessary to disseminate information about concussion to athletes and to their support networks with the hope of reducing the prevalence of multiple concussion and chronic and catastrophic concussion outcomes.

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Chapter 1

Introduction

Mild traumatic brain injury (mTBI), more commonly known as concussion, is a significant problem in sports (for the purposes of the current paper mTBI and concussion will be used interchangeably). This assertion is supported by empirical evidence that shows that 6-18% of all sports injuries in college and high school are concussions (Flik, Lyman, & Marx, 2005; Covassin, Swanik, & Sachs, 2003).

Definition of mTBI. Before providing more detail about mTBI in sports, it is important to define mTBI and contrast it with more serious forms of brain injury (i.e., moderate and severe TBI). The severity of TBI is typically categorized during the acute stages of injury on the basis of the presence and duration/severity of three post-injury signs and symptoms: loss of consciousness (LOC)/coma, retrograde amnesia (i.e., forgetting information about events that occurred before the injury) and anterograde amnesia (i.e., forgetting information about events that occurred after the injury), and brain lesion(s). Thus, based on the presence and duration/severity of these signs and symptoms, a TBI is classified as mild, moderate, or severe. Moderate and severe TBIs typically involve lengthy periods (several hours or days) of LOC/coma and amnesia, and varying sizes of brain lesions.

The presentation of an mTBI is, by definition, different from these other forms of TBI. The generally accepted definition of mTBI is as follows: "…a complex pathophysiolgical process affecting the brain, induced by traumatic biomechanical forces

(McCrory, Johnston, Meeuwisse, Aubry, Cantu, Dvorak, Graf-Baumann, Kelly, Lovell, & Schamasch, 2005; p.196)." This definition also includes several additional descriptors to assist in the identification of concussion. Moreover, some sports neuropsychology experts recommend specific parameters for duration/severity of LOC, amnesia, and brain lesions. Because of their importance in distinguishing mTBI from moderate and severe TBI, these recommendations will be included in the definition of concussion in the current paper.

A concussion may be accompanied by short-term neurological dysfunction (McCrory et al., 2005) which includes LOC and amnesia. Neither of these signs needs to be present for a concussion to occur. However, in the case that LOC is present, it cannot last longer than one minute (Echemendia & Cantu, 2004), and if amnesia is present, it cannot last longer than 30 minutes when duration of retrograde and anterograde are summed together (Echemendia & Cantu, 2004). In the case that either sign exceeds these parameters, the injury would most likely be classified as a moderate TBI.

An mTBI may be accompanied by a visible, but small, lesion as detected by neuroimaging tools. However, unlike moderate and severe TBI where lesions are commonly present and relatively large, a lesion is not necessary for an mTBI to be diagnosed (McCrory et al., 2005).

McCrory et al. (2005) provide other descriptive characteristics that comprise the definition of concussion. The authors indicate that a concussion can result from a blow to the head, face, neck, or torso; sequelae of concussion are due to pathophysiological processes rather than significant structural damage; and recovery from concussion follows a common course whereby clinical signs (e.g., LOC, amnesia, disorientation, etc.) resolve followed later by diminution of cognitive signs and symptoms.

Historically, LOC and amnesia have been considered to be the primary indicators of concussion, but, as evidenced by the definition provided by the McCrory et al. (2005) consensus committee, mTBI is only sometimes accompanied by LOC and/or amnesia. Rather, signs and symptoms such as confusion, disorientation, headache, dizziness, nausea, sensitivity to light/noise, and a host of others which are listed on the Postconcussion Symptom Scale (PCSS; Lovell & Collins, 1998; Appendix A) are sufficient to warrant a diagnosis of a concussion. The presence, intensity, and duration of these signs and symptoms serve as important markers when attempting to determine the presence and severity of a concussion.

Brief description of the proposed study. The current study examined the knowledge about and attitudes toward concussion in groups of high school non-athletes, athletes, coaches, and athletic trainers using new measures that were developed throughout the course of the study.

The primary goals of the study were as follows: 1) develop psychometrically-sound and comprehensive measures of concussion knowledge and concussion attitudes; 2) identify the relationship between concussion knowledge and attitudes within athletic samples (i.e., athletes, coaches, and athletic trainers) and within the general population (i.e., high school non-athletes); 3) identify the level of influence that different sources of information (i.e., coaches and athletic trainers) have on concussion knowledge and attitudes; and 4) identify the relationship between the availability of an athletic trainer and the rates of concussions sustained by athletes at schools with and without an athletic trainer on staff.

This paper will begin with a review of the epidemiological research about concussion. Next, brief overviews of the biomechanical forces that cause concussion and of the resulting subsequent pathophysiological processes will be presented. A review of the external manifestations (i.e., cognitive problems, postconcussive symptoms, amnesia, and loss of consciousness) of the pathophysiological processes will then be provided.

Because these signs and symptoms (i.e., external manifestations of pathophysiology) may represent different severity levels, their utility as indicators of concussion severity will be described. An overview of the various chronic and catastrophic outcomes of concussion will follow.

After the review of the characteristics and sequelae of concussion, existing studies which have examined knowledge about and attitudes toward brain injury in athletic samples and general public samples will be examined. Within this section, the findings and methodological limitations of these studies as well as the limitations of the surveys used to assess knowledge of TBI and mTBI will be provided. These limitations will serve as a foundation for the final portion of the introduction: the hypotheses and exploratory questions. Following this, the methodology and a detailed description of the results will be provided. The final section will include an interpretation of the results, the limitations of the current study, and future research directions.

Epidemiology. Epidemiological studies reveal the widespread nature of concussion. Approximately 153,000-300,000 individuals are admitted to hospitals for an mTBI yearly (Thurman & Guerrero, 1999; NIH, 1999), and the number of emergency room (ER) visits per year is approximately 5-10 times this rate (1.5-3.0 million; Bazarian, McClung, Shah, Cheng, Flesher, & Kraus, 2005).

When the epidemiology of concussion is considered in high school athletes, the rates appear to be relatively high. The self-reported incidence rates of concussion were between 15.3-47.2% (Langburt, Cohen, Akhthar, O'Neill, & Lee, 2004; McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004).

Biomechanics of concussion. The process of sustaining an mTBI begins during the initial impact to the head and/or body. The most common biomechanical forces that can cause concussion are rotational acceleration, linear acceleration, impact deceleration, impact to the neck or body, or a combination of these forces. A linear acceleration injury occurs when the side of the head and/or face is impacted. This impact leads to rotation and rapid acceleration of the skull and brain, but the brain's movement is delayed relative to the movement of the skull. The delayed movement of the brain leads to a collision with the faster-moving skull. Thus, rotational acceleration injuries may damage the brain in two ways: the axonal damage that occurs due to the rapid acceleration and subsequent violent rotation of the brain, and the brain impacting the skull (Lampert & Hardman, 1984).

Linear acceleration injury may occur when the face or front of the head is struck. Typically the brain will glide against the skull in an anterior to posterior direction. The occipital region of the brain is injured because the brain slides down into the rear portion of the skull which leads to compaction of the region (Lampert & Hardman, 1984).

Impact deceleration injury occurs when either the side or back of the head impacts the ground. These injuries occur when an athlete either falls onto or is forced to the ground. The motion of the brain and skull is rapidly decelerated when the skull hits the ground. Contra-coup injuries typically result from an impact deceleration force. These injuries are characterized by one side of the brain colliding with an object (i.e., coup injury) followed by the opposite side of the brain hitting the skull (i.e., contra-coup injury; Lampert & Hardman, 1984).

Other mechanisms of injury include impacts to the neck which can lead to occlusion of the carotid artery, thus impeding blood flow to the brain. Additionally, hits to the chest or back can lead to whiplash injury, and hits to the side of the body may also lead to jarring of the head and neck (Lampert & Hardman, 1984). These forces often occur in combination, thus leading to more diffuse damage to the brain (Lampert & Hardman, 1984).

Several researchers have conducted analyses of the mechanisms of mTBI in sports commonly played by high school athletes including football (Delaney, Puni, & Rouah, 2006; Pellman, Viano, Tucker, & Casson, 2003), rugby (McIntosh, McCrory, & Comerford, 2000), soccer (Delaney et al., 2006), and ice hockey (Delaney et al., 2006). Most of the injuries resulted from an impact to the temporal region of the head and a lesser rate resulted from an impact to the frontal region of the head. There was also a small rate of concussions due to being hit in the torso or on the neck (Delaney, Puni, & Rouah, 2006; Pellman et al., 2003; McIntosh et al., 2000).

Across sports, the most common cause of concussion was contact with an opponent. The remainder of the concussions in sports are typically either due to contact with the playing surface or, in soccer, being hit by the ball (Delaney et al., 2006; Pellman et al., 2003; McIntosh et al. 2000).

Pathophysiology of concussion. Immediately after a traumatic impact occurs, the pathophysiological process commences. Most of the details in the description of this process are based on the findings of induced concussion in rats. This pathophysiological process involves a complex chemical and physiological reaction in the brain (i.e., neurochemical cascade) where cerebral blood flow (CBF) decreases (i.e., ischemia) and diffuse axonal injury occurs (DAI; Giza and Hovda, 2001).

DAI is caused by the aforementioned biomechanical forces that jar the axon. The white matter (e.g., glial cells) surrounding the axon is damaged and the axonal cytoskeleton is adversely affected. When the cytoskeleton is damaged, physiological processes inside the axon are induced which facilitates further axonal deterioration (Smith, Meaney, & Shull, 2003).

Damage to the axons also leads to physiological dysregulation in the dendrites and cell body whereby an uncontrolled release of neurotransmitters, most notably, glutamate, occurs (glutamate dysregulation occurs for about the first four minutes after injury). Glutamate binds to NMDA receptors thus activating the sodium-potassium pump in the dendrite and cell body. The influx of sodium and the efflux of potassium lead to depolarization of the cell (potassium efflux peaks at about 2-3 minutes post-injury and dissipates to normal levels by 8 minutes post-injury). Additionally, calcium enters the cell both through the NMDA channels on the dendrite and through the calcium channels on the axon. This process is fueled by adenosine triphosphate (ATP). Increased levels of ATP facilitate abnormal elevations in glucose metabolism (i.e., hyperglycolysis; glucose metabolism increases until about six minutes after injury). Moreover, CBF decreases immediately after injury and stabilizes in a diminished capacity until up to 10 days post-injury, when it returns to normal (Giza & Hovda, 2001).

Despite the greater need for energy to sustain hyperglycolosis, diminished CBF prevents the energy that is necessary to continue stimulating cell depolarization from being produced and delivered. Thus, the brain cannot sustain this level of activity, and a depression in cellular metabolism occurs. In particular, glucose metabolism decreases from 6 minutes to about 25 minutes post-injury where it stabilizes, and metabolic depression commences around 12 hours after the injury and may last for up to about 10 days. Due to the compromised ability of the neurons to repair themselves as a result of the decreased CBF, decreased oxidative and glucose metabolism, and axonal injury, the brain becomes and remains vulnerable to additional concussion, and additional injuries may lead to necrosis (i.e., neuronal death due to trauma; Giza & Hovda, 2001).

Additionally, the ionic dysregulation caused by the injury involves the persistent presence of calcium. Calcium accumulation reaches its peak at about 4 minutes after the injury and declines slightly for about two days, and then a precipitous decline occurs around 4 days post-injury, at which point it returns to normal. The presence of high doses of calcium also slows oxidative metabolism, which is already slowed by decreased CBF, and the calcium accumulates in the soma and axon. This accumulation slows neural transmission and leads to necrosis by facilitating axotomy (i.e., severing of the axon; Giza & Hovda, 2001).

Signs and Sequelae of Concussion

The external signs and symptoms of concussion are the result of the pathophysiological processes that ensue immediately after the introduction of traumatic biomechanical forces. Although they were mentioned previously, additional information is necessary to further clarify the most common signs and self-reported sequelae of mTBI: postconcussive symptoms, amnesia, and LOC. Information pertaining to objective neuropsychological testing which can identify cognitive impairments will also be reviewed.

Relative to self-reported symptoms, cognitive impairments are less observable by medical staff, teammates, or coaches, less transient than other signs of concussion (e.g., LOC, vomiting, etc.), and less susceptible to dissimulation and underreporting from an athlete who is motivated to return to play. Additionally, in the absence of signs and symptoms, lingering cognitive deficits which may be undetectable to the athlete may be apparent on neuropsychological tests, thus serving as a valuable indicator of concussion severity.

Cognitive impairment after concussion. Several cognitive domains have been found to be negatively affected by concussion as evidenced by deficits identified with neuropsychological instruments: attention/concentration (Gronwall & Wrightson, 1974; Bohnen, Twijnstra, & Jolles., 1991; Echemendia, Putukian, Mackin, Julian, & Shoss, 2001), working memory (Echemendia et al., 2001; Lovell, Collins, Iverson, Field, Maroon, Cantu, Podell, Powell, Belza, & Fu, 2003), verbal memory (Field, Collins, Lovell, & Maroon, 2003; Echemendia et al., 2001; Bruce & Echemendia, 2004; Lovell et al., 2003), visuospatial memory (Lovell et al., 2003), verbal learning (Echemendia et al., 2001; Field et al., 2003), speed of information processing (Barth, Alves, Ryan, Macciocchi, Rimel, Jane, & Nelson 1989; Macciocchi, Barth, Alves, Rimel, & Jane, 1996), reaction time (Barth, Macciocchi, Giordani, Rimel, Jane, & Boll., 1983; Voller, Benke, Benedetto, Schnider, Auff, & Aichner, 1999), and executive functions such as set shifting (Macciocchi et al., 1996; McCrea et al., 2003; Guskiewicz, Ross, & Marshall, 2001). Of course, deficits in all of these domains do not occur for every athlete. The data do, however, consistently show that one or more of these deficits typically persist for 5-10 days post-concussion (Field et al., 2003; Echemendia et al., 2001; Barth et al., 1989; McCrea et al., 2003).

Common signs of concussion. Although it was once thought to be the hallmark sign of concussion (Gasquoine, 1998; Symonds, 1962), LOC is no longer considered necessary for the diagnosis of concussion to be made, and only 6.3-9.3% of concussions involve LOC (Guskiewicz, Weaver, Padua, & Garrett, 2000; Guskiewicz, McCrea, Marshall, Cantu, Randolph, Barr, Onate, & Kelly, 2003; Pellman et al., 2004). Another commonly identified symptom of concussion is amnesia which occurs in 13-24.1% of concussions (Pellman, Viano, Casson, Arfken, & Powell, 2004; Guskiewicz et al., 2003; Erlanger, Feldman, Kutner, Kaushik, Kroger, Festa, Barth, Freeman, & Broshek, 2003). Perhaps the most commonly exhibited signs of alterations in mental status are confusion/disorientation. These are present in anywhere between about 45-95% of athletes with concussion (Erlanger et al., 2003; Macciocchi et al., 1996).

Postconcussive symptoms. The outward signs and symptoms of the neurochemical cascade and the subsequent recovery from injury have been briefly reviewed. As noted, LOC and amnesia are not necessary for a concussion to occur, but rather concussions are necessarily marked by other symptoms. These symptoms can be broken into 3 different categories: physical, cognitive, and affective. Characteristic physical symptoms are headache, dizziness, nausea, vomiting, sensitivity to light, sensitivity to noise, and drowsiness, among others. Typical cognitive symptoms are difficulty concentrating, difficulty remembering, feeling in a "fog", and feeling slowed down. The affective symptoms that are common following a concussion are irritability, sadness, and anxiety (Kelly & Rosenberg, 1997).

Headache, dizziness, difficulty concentrating, fatigue, attentional difficulties, and memory problems tend to manifest immediately after a concussion occurs (Alves, Macciocchi, & Barth, 1993; Cantu, 2001; Gouvier, Cubic, Jones, Brantley, & Cutlip, 1992; Guskiewicz, Riemann, Perrin, & Nashner, 1997; Guskiewicz et al., 2000; Rutherford, Merrett, & McDonald, 1977). These signs and symptoms often resolve within 3-14 days, with a mean duration of about 5-7 days (Guszkiewicz et al., 1997; Echemendia & Julian, 2001; Macchiocchi et al., 1996, Lovell, Collins, Iverson, Johnston, & Bradley, 2004).

Signs and Sequelae as Indicators of Concussion Severity

Each of the aforementioned signs and sequelae of mTBI are important in assessing the severity of concussion. However, the relatively low prevalence of LOC and amnesia after concussion precludes the exclusive use of these sequelae as indicators of concussion severity. Rather, length of postconcussive symptoms and duration of cognitive deficits may provide more useful data for assessing concussion severity because either, and, more frequently, both sequelae are commonly experienced after a concussion. Moreover, the resolution of these sequelae roughly corresponds to the resumption of normal physiological brain functioning (Giza & Hovda, 2001).

Loss of consciousness. As indicated, LOC was once considered by many to be the primary indicator of concussion severity, especially in the early concussion literature

(Symonds, 1962; Gasquoine, 1998). However, more recent literature suggests that an LOC duration of no longer than 20-30 minutes tends to produce cognitive deficits at levels that are similar to individuals without LOC (Barth et al., 1983; Lovell, Iverson, Collins, McKeag, & Maroon, 1999; Voller et al., 1999; Leininger, Gramling, Farrell, Kreutzer, & Peck, 1990; Erlanger et al., 2003; Collins et al., 2003; it should be noted that the mean LOC durations reported in these studies were well below 20 minutes). Thus, it appears that the presence rather than the duration of LOC (within limits) in mTBI serves as the marker of severity.

Amnesia. Reports from experts and findings from empirical studies indicate that amnesia (either retrograde or anterograde) can serve as a fair indicator of concussion severity. This is evidenced by the data showing that individuals with amnesia tend to show slower cognitive recovery than athletes without amnesia (Cantu, 2001; Hugenholtz, Stuss, Stethem, & Richard, 1988; Lawler, & Terregino, 1996; Levin et al, 1992; Lovell et al., 2003; Collins et al., 2003).

Confusion and disorientation. As indicated, these signs are considered to be indicators of alterations in mental status. Lovell et al. (2003) found that longer periods of confusion/disorientation led to longer duration of recovery of cognitive functioning after concussion. A similar pattern was reported by Collins et al. (2003), and the researchers also found that longer periods of disorientation tended to lead to more postconcussive symptoms at about two days post-injury.

Duration of postconcussive symptoms and cognitive deficits. Unlike PTA and LOC, which may serve as initial indicators of concussion severity, postconcussive signs and symptoms and cognitive deficits can be considered “real time” indicators of concussion severity. These sequelae serve as markers that something pathological is happening in the brain which is likely due to the persisting effects of concussion.

There is evidence to suggest that duration of postconcussive signs and symptoms and cognitive deficiencies may be influenced by the age of the injured individual. Research findings indicate that symptoms resolve later in high school athletes relative to college athletes (McClincy, Lovell, Pardini, Collins, & Spore, 2006; Field et al., 2003). Specifically, it appears that high school athletes tend to report persisting symptoms for about 8-14 days (Field et al., 2003; McClincy et al, 2006) , whereas college athletes, tend to report symptoms for less than one week (Guskiewicz, Riemann, Perrin, & Nashner, 1997; McCrea, Guskiewicz, Marshall, Barr, Randolph, Cantu, Onate, Yang, & Kelly, 2003; Macciocchi et al., 1996; Echemendia et al., 2001).

The results of post-concussion neuropsychological testing also reveal a similar pattern of prolonged concussion sequelae. In particular, cognitive deficits were present at one week post-injury (Lovell et al., 2003; Field et al., 2003) and even at two weeks post-injury (McClincy et al., 2006). It is important to note that the research groups who completed these three studies did not examine their concussed athlete samples until cognitive deficiencies fully resolved. Rather, the athletes received serial neuropsychological testing until either one week (Field et al., 2003; Lovell et al., 2003) or two weeks (McClincy et al., 2006) post-concussion. Thus, it is not clear when cognitive deficits tend to resolve after concussion in high school athletes. However, it is apparent that cognitive deficits tend to last for more than one week in high school athletes and may potentially persist for longer than 14 days in high school athletes.

In college athletes, cognitive deficits tend to persist for 5-10 days (Echemendia et al., 2001; Macciocchi et al., 1996; McCrea et al., 2003), and the average duration of cognitive deficits tends to be shorter (i.e., about 5-7 days) than that of the high school athletes. Therefore, the findings of studies examining symptoms and cognitive deficits in high school athletes suggest these samples of adolescents seem to be experiencing sequelae of concussion for much longer than athletes who are just a few years older. These results suggest that age may be a moderating factor in the brain's response to concussion, and there is physiological research which will be reviewed later that provides more evidence for this assertion.

Concussion grading systems

The preceding discussion pertained to the signs and sequelae of mTBI and how they could be used as indicators of concussion severity. There are currently three well-established concussion grading systems which serve to classify concussion based on four criteria: presence/absence of LOC, presence/absence and length of amnesia, presence/absence of disorientation/confusion, and length of post-concussive symptoms.

That said, a consensus committee of sports neuropsychology experts released a report in 2002 which recommended that grading systems and their corresponding return to play guidelines be abandoned largely because there did not seem to be widespread compliance with the return to play (RTP) guidelines due to their highly conservative nature and because of little empirical support for any of the guidelines (Aubry, Cantu, Dvorak, Graf-Baumann, Johnston, Kelly, Lovell, McCrory, Meeuwisse, & Schamasch, 2002). However, a more recently convened consensus committee that assembled in Prague to revise the recommendations from the 2002 report concluded that a two-grade classification should be used to assist in the management of concussion (McCrory et al., 2005).

Although the Prague report recommended this two-grade system, other authorities in sports neuropsychology, including some of the Prague committee members, recommend that the Cantu Evidence-Based system (Echemendia & Cantu, 2004) be used to classify concussion severity (R. Echemendia, personal communication, 8/23/06; Echemendia & Cantu, 2004). The use of a grading system is recommended to provide a method of mTBI classification for medical records. In the case that the athlete sustains an additional concussion, the severity of previous concussions will be apparent to the clinician to better inform RTP decisions (R. Echemendia, personal communication, 7/30/06).

Based on the consensus report and the opinions of experts, it is apparent that there is controversy in the field about which concussion grading system should be utilized. Yet, my discussion of specific concussion grading systems will include only the Cantu Evidence-Based system because it is a model system in that it relies on empirically-based criteria to inform the grading of severity.

According to the Evidence-Based Cantu grading system, a mild concussion is characterized by a short period of confusion and/or a short period of amnesia (i.e., less than 30 minutes) and/or postconcussive symptoms lasting for less than 30 minutes. A moderate concussion is defined by LOC lasting for less than one minute and/or amnesia lasting for longer than 30 minutes and/or postconcussive symptoms lasting for longer than 30 minutes. Severe concussions must involve one minute of LOC and/or amnesia lasting for 24 hours and/or postconcussive symptoms lasting for greater than seven days

(Echemendia & Cantu, 2004). Unlike previous systems which were developed to facilitate a rapid diagnosis, this system requires treatment providers to grade the concussion only after all signs and symptoms have resolved (Echemendia & Cantu, 2004).

Return to play decision criteria. Despite the controversy surrounding grading systems, there seems to be greater agreement about the recommendations for return to play decisions. Rather than the empirically-unsupported and seemingly arbitrary return to play guidelines that have been proposed to accompany other grading systems (AAN, 1997; CMS, 1991), the Prague committee recommends a highly individualized management plan (McCrory et al., 2005) that takes several factors into account. These factors include history of brain injury and the severity of the injury(ies), acute sideline evaluation, postconcussion symptom assessment, and neuropsychological testing. In the case that multiple brain injuries have recently occurred, neuroimaging is recommended, and the results are considered in the management of the injury.

It is clear that extensive resources (i.e., athletic trainer, physician, radiologist, etc.) are necessary to complete, interpret, and utilize these results to make decisions about returning athletes to play. Therefore, the use of this approach may be feasible in college and professional athletics, but it is likely to be too involved and expensive for most high schools.

In the absence of adequate medical staff (i.e., athletic trainers, physicians, etc.) at athletic events, it is recommended that coaches use the Cantu (1988) guidelines (R. Echemendia, 8/23/06) which are listed in Appendix B. After a single mild or moderate concussion, athletes should remain out of competition until postconcussive symptoms have resolved at rest and during exertion for one week and for two weeks after two mild or moderate concussions during the same season. An athlete with a single severe concussion should return to play no earlier than one month after the injury and at least one week after postconcussive symptoms resolve at rest and exertion. After two severe concussions within the same season, athletes should not be returned to competition during that season (Cantu, 1988). These guidelines are recommended because of their conservativeness in the prescription of time before returning to competition. Conservativeness is indicated in adolescent and young adult populations due to the relatively longer cognitive deficits and postconcussive symptoms exhibited by athletes in these populations (R. Echemendia, 8/23/06; McCrory et al., 2005; see review above).

Long Term and Catastrophic Consequences of Concussion

Utilization of RTP guidelines, monitoring of cognitive deficits with neuropsychological testing, and monitoring postconcussive symptoms are all done to prevent potentially negative and irreversible sequelae from occurring. However, before addressing these sequelae, it is important to discuss the increased vulnerability for future concussions after an initial concussion because, as will be shown later, there is a linear relationship between number of concussions and the likelihood of chronic and catastrophic outcomes.

Vulnerability to future concussion. Research indicates that individuals who have sustained one concussion are about 1.5-6 times more likely to sustain another concussion than individuals who have never had a concussion (Zemper, 2003; Gerberich, Priest, Boen, Straub, & Maxwell, 1983; Guskiewicz et al., 2000; Guskiewicz et al., 2003).

Athletes with two or more concussions are about 2.5-3.0 times more likely to sustain another concussion than athletes with no concussions (Guskiewicz et al., 2003).

Depending on the definition of concussion used in the study, about one-tenth (Field et al., 2003; who utilized a conservative definition) to one third (Langburt et al., 2001; who utilized a liberal definition) of high school athletes sustained multiple concussions in the past. Despite the differences in reporting rates which are likely due to definitional variations, the empirical evidence suggests that a single concussion increases the likelihood for additional concussions.

Pathophysiology of vulnerability to future concussion. Giza and Hovda (2004) suggest that there are two phases of vulnerability to further concussion after an initial concussion. The first phase occurs during the acute stage of the first concussion—typically the first 7-10 days post-injury when 92% of additional concussions occur (Guskiewicz et al., 2003). This phase was discussed extensively earlier in this paper.

However, the second phase—the chronic phase—has not been discussed. This phase is characterized by the persistence of neurotransmitter dysregulation. The dysregulation leads to slower transmission within and between neurons. Although the exact timeline for the onset of the second stage of vulnerability is not provided by Giza and Hovda (2004), it is likely that this stage may last from the time that a majority of the ionic and metabolic dysregulation resolves (around 24-48 hours post-injury) and persists until postconcussive signs and symptoms and cognitive deficits resolve. Moreover, a review by Nuwer, Hovda, Schrader, and Vespa (2005) detailed the results of psychophysiological research using EEG to detect neural transmission slowing after concussion. The authors concluded that neural transmission rates in some individuals remain slower months after the concussion and are apparent well after postconcussive symptoms and cognitive deficits resolve (Nuwer et al., 2005). These results may be evidence of continued neurotransmitter dysfunction. As with the effects of an injury during the acute phase, there is a risk of more prolonged and/or permanent damage to the neurons during the chronic phase. If additional damage occurs, neural networks utilized to transmit messages throughout the brain may display further slowing.

Physiological effects of concussion in children and adolescents. There is significant evidence in the child/adolescent moderate and severe TBI literature and in the young animal mTBI literature that indicates that the physiological effects of TBI are more severe and persistent in these samples. These findings indicate that young rats have higher sensitivity to NMDA, an amino acid that is released by glutamate. Thus, when NMDA is present after concussion in young rats, neuronal depolarization tends to last longer than in adult rats (Field et al., 2003; Giza & Hovda, 2001). Additionally, as a result of the prolonged depolarization, higher accumulations of harmful metabolic byproducts remain in and around the neurons of concussed rats and in children with moderate and severe TBI (Giza & Hovda, 2001; Lang, Teasdale, MacPherson, & Lawrence, 1994). Greater accumulations of these byproducts can lead to more damage and longer periods of recovery than occur in adult rats or adult humans.

There appears to be ample evidence to suggest that the vulnerability to additional concussions is associated with these powerful pathophysiological processes, and these processes may lead to more severe sequelae in children and adolescents. These processes provide an explanation for the increased vulnerability to future concussion after an initial concussion, but also correspond with the prolonged cognitive deficits and postconcussive symptoms that tend to manifest after multiple concussions. As will be described in the following section, postconcussive symptoms may last well beyond the first few weeks post-injury. This condition is called post-concussion syndrome.

Post-concussion syndrome. Post-concussion syndrome manifests after the occurrence of a concussion (typically multiple concussions) when neuropsychological deficits are identified and at least three physical or affective symptoms are present for at least three months after the injury (DSM-IV-TR, 2000).

The physical symptoms that may be reported by individuals with post-concussion syndrome include low grade headache, dizziness, fatigue, and sensitivity to light/noise, and sleep problems. The affective symptoms include irritability, anxiety, and depression (AAN, 1997; DSM-IV-TR, 2000). Although there are no known studies reporting the incidence or prevalence of post-concussion syndrome in athletes, there have been several high profile athletes (e.g., Steve Young, Wayne Chrebet, Eric Lindros, etc.) in professional sports within the past decade who have experienced this affliction. These athletes have been forced to take extended absences and/or prematurely retire from their respective sports due to the debilitating and unpleasant effects experienced after sustaining multiple concussions.

Severity of multiple concussions. The data from studies examining the effects of multiple concussions suggests that additional concussions tend to lead to more drastic immediate alterations in mental status and longer duration of postconcussive symptoms after injury. Specifically, multiple studies have found that, relative to athletes without a history of concussion, athletes who had sustained multiple concussions in the past were significantly more likely to display amnesia (Collins, Lovell, Iverson, Cantu, Maroon, &

Field, 2002; Iverson, Gaetz, Lovell, & Collins, 2004) and LOC (Collins et al., 2002) after sustaining a concussion during the course of the study. Additionally, after sustaining a concussion during the study, only 30% of the athletes with three or more concussions displayed postconcussive symptoms for greater than one week, whereas symptom duration lasted for more than one week in only 7.4% of athletes with no previous concussion (Guszkiewicz et al., 2003).

When taken together, it appears that history of previous concussion predisposes an individual to experiencing more severe concussions as defined by increased experience of objective signs, prolonged experience of postconcussive symptoms, and both acute and long-term cognitive effects.

Cumulative effect of concussion on cognitive functioning. There is limited information pertaining to the cumulative effect of multiple concussions on cognitive functioning. Despite the limited data, important information was obtained from the results of the studies. Iverson et al. (2004) administered baseline neuropsychological testing to nonconcussed high school and college athletes. The athletes with 1-2 previous concussions performed similarly to the athletes with no concussion history, but those with three or more concussions performed significantly worse than the group with no previous concussion.

Gronwall and Wrightson (1975) compared a group of concussed non-athletes with two previous concussions to a concussed group with no previous concussions, and found that the former group performed significantly worse. Using a sample of concussed athletes, Iverson et al. (2004) found that declines in cognitive functioning between baseline and post-injury testing were more drastic in athletes with a history of three or more concussions relative to those with no concussion history.

Effects of brain injury and dementia. To date, only one known study has been conducted to address the effects of concussion on the brains of aging and elderly individuals who have been exposed to single or multiple concussions in sports. In a study of retired professional football players, Guskiewicz, Marshall, Bailes, McCrea, Cantu, Randolph, and Jordan (2005) discovered the that athletes with three or more concussions were about 5 times more likely than the former football players with no concussion history to develop mild cognitive impairment (MCI). MCI is a syndrome which is a precursor to dementia and Alzheimer's Disease (AD) characterized by objective declines in memory functioning without marked functional impairment. The results of the study also showed that former football players, regardless of concussion history, but likely with a history of multiple subconcussive blows characteristic of football, displayed onset of AD at an earlier age than the general population (typically before age 70 which is earlier than non-football playing American males).

There has also been a significant amount of research conducted on boxers—a group of athletes who sustain more sub-concussive blows and mTBIs throughout their careers relative to football players. Empirical evidence indicates that boxers are prone to developing significant neuronal damage as evidenced by post-mortem identification of neurofibrillary tangles and beta amyloid plaques distributed throughout the brain (Corsellis, Bruton, & Freeman-Browne, 1973).

Beta amyloid plaques are formed by amyloid precursor proteins which are in abundance in the brain after TBI. Once formed, neurofibrillary tangles and amyloid plaques can slow down neural transmission within and between cells and produce cell death. Furthermore, there is evidence that the cholinergic system within the brain is adversely affected (Lye and Shores, 2000; Heilbronner and Ravdin, 2004). This system is known to mediate memory (Lye and Shores, 2000). This damage to brain structures and systems in boxers is similar to what is found in individuals who have developed dementia associated with AD (Lye and Shores, 2000; Heilbronner and Ravdin, 2004), and it is likely may be that this damage may be present in the previously mentioned retired football players.

These data indicate that several concussions and blows to the head may lead to the development of structural damage and physiological dysfunction that may produce significant memory deficits akin to what is exhibited in dementia associated with AD. In the absence of empirical evidence to indicate the manifestation of these significant problems in individuals with only one or a few mTBIs, we may only speculate about what may occur. However, if the long-term effects of multiple mTBIs approach those of severe TBI and boxers, then appropriate concussion management is essential to prevent these outcomes.

Despite the findings discussed above, a recent editorial by McCrory (2007) suggests that previous research conducted on boxers may reflect cohort effects. Essentially, McCrory contends that boxers who are currently competing tend to have many fewer bouts and shorter careers than the boxers examined in the research during the 1970s and 1980s. Thus, caution should be exercised when attempting to apply findings about boxers from previous generations to today's boxers.

Cumulative effects of concussion and reserve against brain injury. Each individual responds to concussion in a different manner. Two athletes may have a similar injury, but one athlete may have symptoms that last for two days, whereas the other athlete may experience symptoms for 12 days. Several factors may account for different reactions to concussion, and some of these have already been addressed (e.g., age, time since last concussion, etc.). Other important potential moderating factors of differential reactions to TBI comprise the concept of reserve against brain injury. These theoretical constructs are as follows: brain reserve capacity (BRC), cognitive reserve (CR), and compensation.

Brain reserve capacity is essentially the total number of neurons that an individual possesses over and above the amount necessary to maintain daily functioning without deficits (Satz, 1993). The theory further states that individuals are genetically endowed with a fixed number of neurons at birth. Both organic and acquired forms of brain damage that are sustained throughout life can deplete the reserve and produce functional deficits. However, individuals with a high BRC are more protected from developing functional deficits because there are greater numbers of neurons that may be lost before functional deficits occur. Conversely, individuals with low BRC are vulnerable to functional deficits due to the relatively small number of neurons that can be lost before deficits arise (Satz, 1993). Extensive evidence to support BRC is provided in a review article by Satz (1993). Thus, each concussion that an athlete sustains diminishes BRC, and in the case that an individual has low BRC, a concussion or series of concussions may produce lasting deficits, especially if vulnerable and potentially repairable neurons are further damaged by an additional concussion.

Cognitive reserve and compensation. The primary function of these putative processes is to facilitate the brain's response to either increased task demands (as in cognitive reserve) or brain damage (as in compensation).

Cognitive reserve (CR) refers to the process by which the brain utilizes resources (i.e., cognitive networks) to approach and complete functional tasks of varying difficulty. CR is believed to mediate the efficiency of the cognitive networks as a response to cognitive challenges. Additionally, CR involves the use and availability of alternate networks to assist in effective task completion despite being challenged. Higher CR is apparent in the increased efficiency within a cognitive network on a task that is more challenging than the tasks that the network is normally used to address. An individual with higher CR may have more alternate networks to draw from to assist in the completion of a challenging cognitive task (Stern, 2002). Evidence for the presence of CR is provided by Gur, Gur, Skolnick, Resnick, Silver, Chawluk, Muenz, Obrist, and Reivich (1988) and Stern, Zarahn, Hilton, Flynn, DeLaPaz, and Rakitin (2003).

Compensation is a theoretical process that is similar to CR, but it is utilized only after the brain is damaged. As indicated, brain damage is characterized by neuronal dysfunction which can negatively influence the effectiveness of a cognitive network normally used for a particular function. The damage to the cognitive network normally used to complete a task and any corresponding visible or hidden functional deficits is remediated by other cognitive networks. These networks are necessarily used to compensate for the diminished function in the damaged network(s), rather than the conditional nature in which alternate networks may be used in the cognitive reserve process (Stern, 2002). Stern, Moeller, Anderson, Luber, Zubin, DiMauro, Park, Campbell, Marder, Bell, Van Heertum, and Sackheim (2000) study provides empirical evidence for this construct. The effectiveness of compensation is dependent on the premorbid level of CR because the level of CR influences the ability of the brain to employ compensatory processes after brain damage occurs to combat against the development or extent of functional impairments (Stern, 2002).

In sum, the primary difference between compensation and cognitive reserve is the emphasis on the way the brain copes with challenges. Cognitive reserve is a process that employs the normal network to help a healthy brain work more efficiently and may go outside of this network for assistance. Alternatively, the compensation process involves damage to the commonly used system, thus necessitating the recruitment of less affected or unaffected networks to help the brain cope and minimize the functional deficit.

Connections among constructs. The presence and extent of functional deficits that are apparent in some individuals, but not in other individuals with similar levels of brain damage can be considered a result of several factors: genetic endowment, enriched educational and social environment, and highly efficient and numerous cognitive networks. High CR (i.e., efficient processing within and between cognitive networks) may be the result of a good “head start” due to a higher number of inherited neurons (BRC). With more neurons, more synaptic connections can be made, especially in an environment that contains ample stimulation through education, social experiences, etc. More synapses will result in larger and more numerous cognitive networks (CR) that have redundant functions in case of damage to primary networks (compensation).

Connections of reserve against brain injury to concussion. These constructs have direct bearing on the effects of concussion, especially when taking into consideration the neuronal damage that occurs post-injury. As indicated, when given adequate time to heal, most individuals recover fully from concussion. However, when multiple concussions occur, axons are injured and may never recover, thus leading to necrosis. When the neuron is no longer operable, the synaptic connections are also lost, which affects transmission throughout the cognitive network and decreases the network's efficiency. However, an individual with a higher premorbid CR may have other redundant cognitive networks that can be accessed through compensation, but without the presence of numerous alternative networks, an individual with low CR may begin experiencing some deficits.

Second impact syndrome. Perhaps the most dangerous potential consequence of multiple concussions is second impact syndrome (SIS). SIS occurs when a second concussion is sustained before the effects of an initial concussion have resolved. During the process of recovery from an initial mTBI, the brain works to restore physiological regulation of neuronal conduction and CBF. However, if that process is interrupted by another injury to the brain, further dysregulation may manifest in the form of SIS.

The process of SIS involves an increase in intracranial pressure due to unregulated brain edema (swelling). The edema is precipitated by vasomotor paralysis and occlusion of the brainstem. A severe and irreversible increase in intracranial pressure (ICP) ensues, and death often occurs soon after. Although certain fluctuations in ICP can be managed by the brain, there is evidence that, once a threshold of ICP is passed, the rise in ICP cannot be reduced without surgical intervention (Saunders & Harbaugh, 1984; Cantu, 1998).

The second impact (i.e., concussion) can involve either a minor or major hit to the head or body, and the individual may appear dazed. After approximately 15-60 seconds, the individual collapses and may ultimately die (Cantu, 1998). Second impact syndrome is relatively rare (i.e., about 25 documented cases over the past 25 years), and it tends to occur more frequently in children and adolescents, but some documented cases have occurred in young adults (Cantu, 1998; McCrory & Berkovic, 1998). Despite the low prevalence rate, SIS is a serious condition and should be considered when making decisions about returning an athlete to competition after a concussion.

Abnormal patterns of brain activation and postural instability: Indicators of persistent pathological processes.

Magnetic resonance spectroscopy (MRS). MRS is brain imaging technique that appears to have much promise in detecting neuronal damage and diffuse axonal injury. Although more conventional magnetic resonance imaging (MRI) and computed tomography (CT) typically do not detect areas of damage after concussion, MRS has identified damaged areas of the brain in only a handful of studies to date (Son, Park, Choi, Kim, Choe, Lee, & Kim, & Kang, 2000; Govindaraju, Gauger, Manley, Ebel, Meeker, & Maudsley, 2004; Kriov, Fleysher, Babb, Silver, Grossman, & Gonen, 2007). However, this is likely reflective of relatively recent application of the technique with individuals with mTBI.

Unlike MRI, which is used to measure hydrogen protons that comprise water molecules throughout the brain, MRS identifies concentrations of protons within different metabolites distributed throughout gray and white matter (Bluml & Brooks, 2006). There are several brain metabolites that are examined using MRS, but the most prominent are N-acetyl-aspartate (NAA) and creatine (Cr; Bluml & Brooks, 2006).

High concentrations of NAA is a marker of neuronal/axonal health and high concentrations of Cr are indicative of effective glial cell functioning. However, in individuals with brain injuries/abnormalities (i.e., TBI, etc.), NAA and Cr concentrations in gray and white matter tend to be reduced (Bluml & Brooks, 2006).

Although much of the MRS-related brain injury research has been conducted on TBI samples, a few studies have been conducted within the past several years that have examined the effects of mTBI using MRS.

Using a sample of seven non-athlete adults with hemorrhagic contusions and a diagnosis of mTBI (i.e., Glasgow Coma Scale ranging from 13-15), Son et al. (2000), administered MRS to assess metabolic changes within seven days post-injury. Each injured participant (mean age = 33 years old; no SD reported) and 25 control participants (no mean reported; range = 25-45) underwent the MRS procedure. The region of interest was defined as the area of hemorrhagic contusion, and for six of the seven participants, the temporal lobe was examined. One participant exhibited a contusion in the frontal lobe. The injured participants underwent the MRS procedure within one week post-injury, and relative to the healthy controls, they displayed lower NAA/Cr (i.e., ratio of NAA concentration to Cr concentration) ratios. Additionally, when the injured participants were reevaluated at about two months post-injury, the NAA/Cr ratio was at levels similar to those exhibited during the acute phase of the injury (i.e., within one week post-injury). These findings were important for two reasons: 1) They established the presence of post-concussion metabolic changes and 2) they suggest that the metabolic changes may persist for up to two months after the injury.

An additional MRS-mTBI study conducted by Govindaraju et al. (2004) used concussed non-athlete participants (mean age = 31; SD not reported) and 13 healthy control participants (mean age = 29; SD not reported). The groups were compared on the basis of, among other metabolic concentrations, NAA and Cr within about one month post-injury (mean = 13.3 days post-injury; SD not reported). The results showed that both NAA and Cr were statistically significantly reduced in bilateral areas of white matter in the parietal lobe throughout the brain; thus, providing some evidence of diffuse axonal injury.

In the most recent MRS-mTBI study, thalamic metabolite levels in 20 non-athlete concussed participants (mean age = 26 years; no SD reported) and 17 matched healthy control participants (mean age = 38 years; no SD reported) were examined (Kirov et al., 2007). The MRS was administered to the injured participants within 0-7 years post-injury. The results of the study showed that thalamic NAA and Cr concentrations were significantly reduced in the mTBI group. Despite the differences between the control and mTBI groups, the authors indicated that metabolic changes found in the mTBI group were much lower relative to those found in other studies where moderate and severe TBI groups were examined.

Although the utilization of MRS in the study of concussion has not been extensive, the initial findings are encouraging. The findings provide evidence for the process model of mTBI posited by McCrory et al. (2005). Despite the absence of widespread structural damage within the brain, the metabolic abnormalities indicate the presence of aberrant physiological processes.

The findings are important because they suggest that MRS is a sensitive measure of post-concussion brain pathology that can be utilized to detect areas of damage to the brain. Moreover, the use of MRS in research settings may provide a better understanding of the pathophysiological process of concussion, and, when used in clinical settings, can serve as an additional marker of readiness to return to competition.

Functional Magnetic Resonance Imaging (fMRI). As with MRS, the research addressing the detection of brain activity patterns in concussed samples using fMRI is scant, but the existing research is promising.

Earlier fMRI studies examined non-athlete samples who had sustained mTBI (McAllister, Saykin, Flashman, Sparling, Johnson, Guerin, Mamourian, Weaver, & Yanofsky, 1999; McAllister, Sparling, Flashman, Guerin, Mamourian, & Saykin, 2001). McAllister et al. (1999) and McAllister et al. (2001) examined samples containing twelve and eighteen concussed non-athletes, respectively. Both studies included injured participants and healthy controls who were, on average, in their late 20s to early 30s. All injured participants underwent fMRI within 3-4 weeks post-injury.

While undergoing the fMRI procedure, the participants completed an auditory working memory task (i.e., n-back task). The task involved trials of minimal (i.e., control condition), mild, moderate, and high load conditions. Several different areas of the brain were examined by the researchers during the time that the participants were completing the tasks. Additionally, participants completed a brief neuropsychological battery (McAllister et al., 1999; McAllister, et al, 2001).

With the exception of slower performance on the reaction time tasks, injured participants did not exhibit any statistically significant differences relative to the controls on any of the neuropsychological measures (McAllister et al., 1999; McAllister et al, 2001).

Although, there were no between-group differences on the working memory task administered during the fMRI scan, substantially different brain activation patterns did emerge. When the differences in brain activation from the control condition to the mild load condition were compared, controls displayed substantial increases in bifrontal and biparietal activation while completing the mild load task. When activation patterns from mild to moderate load conditions were compared, controls displayed further increases in the same regions while completing the moderate load task, but the changes were not as great as in the control to mild load conditions.

Concussed participants exhibited increases in brain activation from the control to mild load conditions in the same brain regions while completing the mild load task, but the increases were smaller than that of the control participants. However, relative to controls, injured participants showed greater increases in brain activation in different regions than the controls from the mild to moderate load conditions. Specifically, while completing the moderate load task, the concussed participants displayed increased activation primarily in the right prefrontal cortex and right parietal cortex (McAllister et al., 1999).

In the McAllister et al. (2001) study, a high load working memory condition was added, and differences were again found in activation patterns. Specifically, in the mild load condition, concussed participants showed greater activation in the frontal region and less activation in parietal regions relative to controls. The moderate load condition tended to produce higher activation levels in both frontal and parietal regions in the concussed group, but in the high load condition, concussed individuals showed less of an increase in activation (primarily in the right frontal and parietal regions) than did the controls.

In both studies, the controls displayed a more organized progression of activation that was congruent with the difficulty of the task. However, the decrease in activation in the concussed group during the high load condition may suggest that damage to the dorsolateral prefrontal cortex that occurs during concussion may diminish the ability of the brain to match resources with task demands (McAllister et al., 2001). Furthermore, although gross cognitive deficits may not be apparent a month after an mTBI, it is possible that the brain's ability to process challenging stimuli, may be compromised due to damage (McAllister et al., 2001) and, perhaps, persistent physiological changes. Thus, the brain's resources may have been fully taxed in the moderate load condition, and the presence of only small increases in activation in the high load condition, especially when compared to the stepwise progression apparent in the "healthy" brains of the control participants, may be indicative of the relative lack of resources that the concussed participants had left to recruit (i.e., lower cognitive reserve; McAllister et al, 2001).

Although these studies are important, they were not conducted on an athlete population—a group at higher risk for concussion relative to non-athletes. Chen, Johnston, Frey, Petrides, Worsley, and Ptito (2004) conducted a study examining brain activation patterns using fMRI in a group of 16 concussed college athletes, many of whom appeared to exhibit post-concussion syndrome. At the time of examination, about

75% of the sample had been experiencing post-concussive symptoms for three months or longer, thus, suggesting the presence of post-concussion syndrome. Moreover, all but one of the athletes in the study had sustained multiple concussions (modal number of previous concussions = 3). Therefore, the results of this study should be interpreted with caution, as the sample appears to represent the more severe end of the concussion severity spectrum (Chen et al., 2004)

The athletes mean age was 26.9 (SD = 7.2), and there were eight age-matched controls (mean age = 27.6; SD = 5.2) included in the study. Participants were administered verbal and visual working memory tasks, but, unlike other studies, they were not administered other neuropsychological measures (Chen et al., 2004).

No statistically significant between-group differences in performance on the working memory tasks were identified. However, the fMRI results suggest significantly different underlying processes. Relative to controls, concussed athletes showed less activation in the mid-dorsolateral prefrontal cortex, and more activation in other areas, primarily in the posterior frontal lobes as well as in the parietal and temporal lobes (Chen et al., 2004).

Although these previous fMRI findings are very informative, they were conducted using adult participants. Given the differences in recovery from mTBI discussed earlier, it is important to learn more about the functioning of adolescents and young adults, especially given the increased attention and media exposure that is being given to concussion.

A recent fMRI study pertaining to mTBI provides information pertaining to this issue. The study included 28 high school and college athletes with a mean age of about

16 (SD = 2.4; Lovell, Pardini, Welling, Collins, Bakal, Lazar, Roush, Eddy, & Becker, 2007). These athletes were compared to a group of 13 non-concussed, age-matched controls (mean age = 18.3; SD = 3.5). Participants completed the fMRI protocol which involved the completion of an auditory working memory task and they were administered additional neuropsychological measures.

Unlike the previously mentioned studies, Lovell et al. (2007) administered the fMRI and neuropsychological testing to concussed participants within the first 10 days post-injury (mean = 6.6 days; SD not reported). Moreover, after the resolution of post-concussive symptoms and neuropsychological performance returned to normal (mean recovery time = 35.1 days; no SD reported), the injured group was scanned a second time (the controls underwent a similar procedure).

Neuropsychological performance of the injured athletes was well below that of the controls during the acute phase of injury (i.e., Time 1). Concussed athletes were considered recovered when their scores on neuropsychological tests approached the scores of the controls (Lovell et al., 2007).

The researchers examined the differences between the activation patterns during the control and moderate load tasks at Time 1 by combining the data from all participants (concussed and control) and identified three networks of activation: medial, frontal, and right temporoparietal gyri; right frontal and anterior temporal regions; and bilateral posterior parietal cortex.

Hyperactivation of the posterior parietal cortex was negatively correlated with decrease in post-concussion symptomatology from Time 1 to Time 2. Levels of activation in the precentral gyrus and premotor cortex were positively correlated with length of time before RTP (i.e., hyperactivation is associated with prolonged removal from competition). Injured athletes with the highest levels of activation tended to remain out of competition for about two times longer (about 25 days longer) than injured athletes with lower levels.

The findings of these four fMRI studies address several vital issues pertinent to the anatomical and functional aspects of concussion: 1) mTBI is, indeed, a “hidden” injury. The findings of the fMRI and MRS studies, taken together, consistently show that, even in the absence of significant neuropsychological dysfunction and post-concussive symptoms, there are underlying brain processes that appear to be adversely affected. 2) The studies provide evidence for cognitive reserve and compensation. Despite the fact that injured individuals tend to exhibit less activation in areas of the brain where non-injured individuals tend to show high levels of activation, cognitive functioning does not seem to be grossly affected. In fact, even in the face of altered physiological and anatomical function, the brain appears to recruit other areas to compensate for deficiencies in adversely affected areas. 3) Taken together with MRS research and other topics mentioned in this paper, it is apparent that the brain may take much longer to recover than was previously believed, especially in adolescents and young adults who, after just one concussion (see Lovell et al., 2007), display recovery times that are similar to adult athletes who have had several concussions (see Chen et al., 2004). 4) There is preliminary evidence to suggest that characteristic patterns of brain pathology and brain health exist, although the importance of individual differences in functional neuroanatomy can never be diminished. Future research is necessary to further elucidate these patterns and the activation patterns that occur during other cognitive, behavioral, and emotional stimulation.

Postural stability. Although it is a physical sign of concussion, postural stability has been shown to be adversely impaired after a concussion occurs. Deficits in postural stability are thought to indicate dysfunction in the three neural systems involved in balance: visual, somatosensory, and vestibular systems (Guskiewicz et al., 2001). Guskiewicz et al. (2001) examined the postural stability of 36 concussed college athletes and 36 healthy matched controls. Postural stability tests were conducted at 1, 3, and 5 days post-injury and controls were examined at the same intervals. Among other tests, participants were asked to sway forward and backward, and their postural stability was measured. The results of the study showed that postural stability on this particular test was impaired in most of the concussed athletes for about 1-2 days but tended to reach levels similar to that of the controls by day three post-injury.

In a review of the balance literature, Thompson (2006) indicated that much of the existing research has established that postural stability tends to return to normal within 1-3 days post-injury. Several different methods have been utilized by previous researchers to examine and identify deficits in postural stability including conditions involving eyes closed, one-leg and two-leg stances, and a moving surface underneath the participant (Thompson, 2006).

However, research using dynamic postural control procedures revealed the persistence of postural instability 10 days post-injury. Using a dynamic postural control procedure in addition to conventional eyes open-eyes closed procedures, Slobounov, Sebastianelli, and Moss (2005) prospectively examined eight concussed athletes at pre-injury baseline and at three, 10, and 30 days post-injury. Participants were asked to stand still with eyes open, stand still with eyes closed (i.e., static conditions), lean forward as far as possible with eyes open, and lean forward, then backward as far as possible with eyes open (i.e., motion conditions). Results of the study showed that postural stability on both of the static conditions (i.e., eyes open and eyes closed) was deficient when performance at baseline and three days post-concussion were compared. At 10 days, postural stability returned to baseline for the eyes open condition, but was not fully restored in the eyes closed or in either motion condition. Postural stability was fully restored in all four conditions at 30 days post-injury.

It appears that the postural sway condition introduced by Slobounov et al. (2005) detected postural stability deficits beyond the typical three day resolution period established by other researchers. Slobounov, Tutwiler, Sebastianelli, and Slobounov (2006) employed an even more challenging balance task in the examination of concussed athletes and detected postural instability in concussed participants at 30 days post-injury. The researchers prospectively examined eight injured athletes who were concussed during the course of the study. These participants completed postural stability testing at pre-injury baseline and at three days, 10 days, and 30 days post-injury. Injured athletes underwent a virtual reality procedure where they were asked to stand as still as possible in each of the following conditions: a virtual room where nothing is moving, a virtual room where the participant experiences forward-backward swaying within the virtual room, and a virtual room where the participant experiences a sideways rolling motion. Postural instability was exhibited from day three through day 30 on both motion trials, but not during the static trail.

Perhaps the most dramatic finding regarding long term brain dysfunction and postural stability was reported by Thompson, Sebastianelli, & Slobounov (2005). These researchers examined 12 concussed athletes and 12 non-injured controls at about three months post-injury. Both groups were asked to stand on both feet with eyes open for several trials and with eyes closed for several trials. Although, there were no statistically significant between-group differences in the eyes open condition, postural stability was impaired in the concussed group relative to the control group in the eyes closed condition. The authors indicated that the instability displayed by the concussed group may be due to the lack of visual inputs that may be utilized to compensate for somatosensory and vestibular deficits.

Overall, the results show that postural stability is, in fact, impaired after concussion and that, depending on the difficulty of the balance task, impairment may be detected for as few as two days or as long as about 90 days post-injury. It is quite notable that long term deficits in postural stability may occur. These findings indicate that the effects of concussion in participants not involved in litigation (where motivation to malinger may be high) may last for months after the injury, thus suggesting a longer course of recovery than was previously accepted.

Knowledge of Traumatic Brain Injury

As shown in this review thus far, concussion in sports is widespread. Although multiple concussions may have long-term consequences, a single concussion may not produce lasting effects if adequate recovery time is provided. However, athletes are highly motivated to compete and coaches are motivated to succeed. These factors may hasten return to play decisions by coaches and decrease reporting of concussion symptomatology in athletes. Given the increased likelihood of additional concussion following a first concussion, potential long term effects of multiple concussions, and potentially catastrophic outcomes associated with concussion, it is important to get an assessment of what coaches, athletes, and athletic trainers know about concussion and what their attitudes are toward the management of concussion.

At present, little is known about such attitudes in athletes and in these individuals who play such a pivotal role in the athlete's care. As indicated, a central goal of the proposed investigation is to develop a greater understanding of such attitudes in addition to the accuracy of the knowledge of concussion these individuals have. The following section will provide a review of the existing studies that have examined knowledge and attitudes about non sports-related TBI, in addition to the handful of studies that have looked at these issues in athletes.

General public. Several studies have been conducted that have examined the knowledge of TBI in the general public. These studies have targeted knowledge relevant to all TBI severity levels, but most of the items included in the surveys used to assess knowledge in these studies are more relevant to moderate and severe TBI. Despite the limitations in the conclusions that can be drawn from the results of these studies, the findings can provide a good foundation and rationale for future research on populations more frequently exposed to concussion such as athletes.

Each of the studies using similar surveys to assess TBI knowledge will be detailed in the upcoming paragraphs. The structure of the section describing these studies will begin with brief descriptions of the sample size and composition; geographic location; and method used to obtain the data. Given that each of the studies includes similar survey questions, the findings of each study will be summarized based on both general knowledge domain and specific content of the question. Additionally, comparisons based on survey item or knowledge domain will be made between samples from the general population, educators, and family members.

The first study to assess the knowledge of TBI in the general population was conducted by Gouvier, Prestholdt, and Warner (1988). These researchers created a 25-item survey that assessed five domains pertaining to TBI. Among the domains were the knowledge of the effects of LOC, knowledge of amnesia, knowledge of recovery from TBI, and knowledge about the nature and extent of brain damage after TBI. The survey was administered to 221 participants in Southern Louisiana.

Since the Gouvier et al. (1988) study was conducted, three groups of researchers have run replication studies. Willer, Johnson, Rempel, and Linn (1993), Guilmette and Paglia (2004), and Hux, Schram, and Goeken (2006) have each conducted studies in different geographical regions. The sample sizes of the Willer et al. (1993), Guilmette and Paglia (2004), and Hux et al. (2006) studies were 313, 179, and 318, respectively.

Only nine of the 25 items included in the Gouvier et al. (1988) study were used in the survey administered by Willer et al. (1993). These nine questions were deemed by a small group of neuropsychologists to be the most likely to reflect the knowledge of the participants. The criterion for inclusion of the items from the original (i.e., 1988) survey in the Hux et al. (2006) survey was that the items must have been answered incorrectly by greater than 25% of the original sample. The Guilmette and Paglia (2004) survey included eleven items from the Gouvier et al. (1988) survey, but the researchers did not provide a rationale for the selection of these items. There was significant overlap among the Gouvier et al. (1988) survey items selected for inclusion in each of the replication studies, and many of these items are shown in Table 1. The items that are included in Table 1 were chosen because the PI deemed them to be most relevant to knowledge of mTBI.

The item response rates on Table 1 indicate that the general public's knowledge of TBI may be improving in some areas but appears to be lacking in other areas related to the causes, signs and sequelae of TBI and the recovery from TBI. Specifically, individuals in the general population appeared to be developing an understanding that TBI can occur without being hit in the head or losing consciousness. This improvement is evidenced by the decreasing proportion of participants erroneously believing that whiplash alone can cause brain damage (42.3% in 1988 to 9.8% in 2006; Gouvier et al, 1988; Guilmette & Paglia, 2004; Hux et al., 2006) and that brain damage can occur without LOC (27.2% in 1988 to 1.3% in 2006; Gouvier et al., 1988; Guilmette & Paglia, 2004; Hux et al., 2006).

Table 1

Summary of Results from Studies Examining Knowledge of TBI in Different Samples

	Participants used (n)	Injury w/out LOC[1]	Whiplash cause brain damage[2]	LOC no effects[3]	2nd blow remember[4]	Amnesia but normal[5]	Trouble learning after TBI[6]	Likelihood of 2nd TBI[7]	Withstand 2nd blow[8]	Recovery & hard work[9]
Gouvier et al. (1988)	General public—Louisiana (221)	27.2%	42.3%	59.3%	45.7%	82.4%	43%	73.8%	16.7%	70.1%
Willer et al. (1993)	General public—NY (245)	Not included	Not included	Not included	37.6%	89%	51.4%	81.2%	34.3%	53.1%
	General public—Ontario (221)				39.7%	82.4%	64.7%	88.2%	32.4%	58.8%
Guilmette & Paglia (2004)	General public—Connecticut (179)	8.3%	35.7%	Not included	41.8%	75%	Not included	68.1%	36.8%	61.9%
Hux et al.(2006)	General public—Nebraska (318)	1.3%	9.8%	48.1%	28.6%	93.4%	48.5%	67.9%	29.9%	52.5%
Farmer & Johnson-Gerard (1997)*	Educators (184)	12%	24.9%	33.9%	6%	64.5%	19.1%	81.8%	32.8%	35.9%
	Rehab staff (111)	3.6%	16.2%	36%	1.8%	42.2%	10.8%	37.8%	25.2%	16.2%
Springer, Farmer, & Bouman (1997)	Families of TBI victims (51)	0%	22.9%	34%	6%	64.6%	43.1%	84%	41.7%	62.8%
Mean % Across Samples (Range)		8.7% (0-27.2%)	25.3% (9.8-42.3%)	42.3% (33.9-59.3%)	25.9% (1.8-41.8%)	74.2% (42.2-93.4%)	40.1% (10.8-64.7%)	72.9% (37.8-88.2%)	31.2% (16.7-41.7%)	51.4% (16.2-70.1%)

[1] A head injury can cause brain damage even if the person is not knocked out.
[2] Whiplash injuries to the neck can cause brain damage even if there is no direct blow to the head.
[3] When a people are knocked unconscious, most wake up with no lasting effects.
[4] Sometimes a second blow to the head can help a person remember things that were forgotten.
[5] After a head injury, people can forget who they are and not recognize others but be perfect in every other way.
[6] After a head injury, it is usually harder to learn things than it was before the injury.
[7] People who have had one head injury are more likely to have a second one.
[8] A person who has recovered from a head injury is less able to withstand a 2nd blow to the head.
[9] How quickly a person recovers from a head injury depends mainly on how hard they work.

Although there is some indication that the general public's knowledge of TBI is improving in some areas (i.e., causes for and indicators of concussion), there are also several findings which suggest that the acute and/or long term impact of TBI, especially after experiencing characteristic signs and symptoms of concussion, is not well understood. In particular, about 50-60% of the general public samples erroneously believed that after regaining consciousness, an individual would likely not experience any lasting effects from a TBI (Gouvier et al., 1988; Hux et al., 2006); about 40-46% believed that a second blow to the head can help an individual remember things that they forgot after their first injury (Gouvier et al., 1988; Willer et al, 1993; Guilmette & Paglia, 2004; Hux et al., 2006); a large majority (about 75-93%) believed that a person can have amnesia for their own and others' identities but have no other problems associated with the TBI (Gouvier et al., 1988; Willer et al, 1993; Guilmette & Paglia, 2004; Hux et al., 2006); and about 43-65% do not believe that learning new information is more difficult after TBI than it was before (Gouvier et al., 1988; Willer et al, 1993; Hux et al., 2006).

Further evidence for the lack of knowledge about the effects of concussion is apparent in the responses to questions pertaining to vulnerability to future TBI after an initial TBI. About 16-36% of the participants in the general population mistakenly believed that, after recovery from one TBI, an individual's ability to withstand another blow to the head was the same as it was before the injury (Gouvier et al., 1988; Willer et al, 1993; Guilmette & Paglia, 2004; Hux et al., 2006). Moreover, approximately 68-88% of the participants incorrectly indicated that sustaining one TBI does not increase the likelihood of sustaining another TBI (Gouvier et al., 1988; Willer et al, 1993; Guilmette & Paglia, 2004; Hux et al., 2006).

When recovery from TBI is considered, the attitudes of the general public appear to be similar to the attitudes about recovery from other orthopedic injuries. This is apparent in the responses to the question stating that recovery from TBI is dependent on the level of effort devoted to recovery. About one-half to three-quarters of the samples believed that hard work was instrumental in recovery from TBI (Gouvier et al., 1988; Willer et al., 2004; Guilmette & Paglia, 2004; Hux et al., 2006).

In sum, surveys of the general public suggest that throughout the past two decades, a broader awareness may be developing about the causes of TBI (i.e., direct blows vs. whiplash) and the initial effects of TBI (i.e., presence or absence of LOC). However, there has been little, if any, change in knowledge about the effects of TBI after the resolution of common acute signs and symptoms, the vulnerability to future TBI, and recovery after TBI.

Individuals familiar with TBI victims. As noted, other studies about knowledge of TBI have been conducted. These studies have examined relatives, educators, and rehabilitation workers. Presumably, because such individuals have greater contact with people with TBI, they should also display greater knowledge as defined by lower percentages of misperceptions about TBI.

Using nine of the items from the Gouvier et al. (1988) study (the rationale for item selection was not mentioned) in a larger survey, Farmer and Johnson-Gerard (1997) assessed the knowledge of educators and rehabilitation workers of TBI victims. The sample included 184 educators (e.g., teachers, school administrators, etc.) and 111 rehabilitation workers (e.g., physicians, physical therapists, psychologists, etc.).

Springer, Farmer, and Bouman (1997) conducted a study that examined the knowledge of 65 family members of individuals with TBI who had no previous knowledge or training and limited exposure to TBI prior to their family member sustaining a TBI. The researchers utilized the measure developed by Farmer and Johnson-Girard (1997).

There were substantial between-group differences (i.e., differences of 15% or more) on five of the nine items: 1) people can be amnestic about their identity and the identities of others, but be normal in every other way (i.e., amnesia question), 2) it is harder to learn things after TBI than it was before the injury (i.e., cognitive question), 3) sustaining a TBI makes it more likely that an individual will sustain another (i.e., vulnerability question), 4) someone who has recovered from one injury is less able to withstand a second blow (i.e., withstanding TBI question), and 5) hard work leads to quicker recovery (i.e., recovery question; Farmer & Johnson-Gerard, 1997; Springer, Farmer, & Bouman, 1997).

When rehabilitation staff misconceptions were compared to that of the family members', five substantial differences were identified, and the most drastic differences were found on the recovery question (62.8% of family members had misconceptions versus 16.2% of the rehabilitation staff) and on the vulnerability question (84% of family members versus 37.8% of rehabilitation staff; Farmer & Johnson-Gerard, 1997; Springer, Farmer, & Bouman, 1997).

Rehabilitation staff misconceptions were also substantially lower than educators on three of the items (Farmer & Johnson-Gerard, 1997). The largest disparity in knowledge was apparent on the vulnerability item where about 38% of the rehabilitation staff and about 82% of the family members answered incorrectly.

Substantial differences were identified on only two of the items when percentage of misconceptions in family members and educators were compared. The items that displayed these differences were the cognitive (43.1% of family members vs. 19.1 of educators; and recovery (62.8% of family members vs. 35.9% of educators) questions (Farmer & Johnson-Gerard, 1997; Springer, Farmer, & Bouman, 1997)

Taken together, these results indicate that relative to the other groups, rehabilitation workers are the most knowledgeable about TBI, especially in the areas of effects of amnesia, vulnerability to future TBI, and recovery from TBI. The knowledge levels of family members and educators are quite similar except in areas that are relevant to education such as cognitive/learning problems and gradual recovery from injury, where educators show superior levels of knowledge.

As shown in Table 1, there were some other items where the sample of family members displayed similarities in the percentage of misconceptions when compared to the general public. Specifically, family members displayed similar rates of misconceptions relative to the general public samples on the recovery, vulnerability, cognitive, and amnesia questions (Springer et al., 1997; Gouvier et al., 1988; Willer et al., 1993; Guilmette & Paglia, 2004). Thus, it appears that, even in family members who are close to an individual with a TBI, their understanding of TBI is comparably deficient to that of the general public in the domains of TBI sequelae and recovery.

It should also be noted that the performance of family members was superior to the general public on some of the items. Family members showed a lower rate of misperceptions on the amnesia question (64.6%) than the general public (mean % = 84.4) and the question pertaining to lasting effects after LOC (34% of family members versus mean %= 53.7% of general public; Springer et al., 1997; Gouvier et al., 1988, Willer et al., 1993; Gulimette & Paglia, 2004; Hux et al., 2006). These results suggest that family members may be more aware of the effects of TBI than the general public, especially after an individual experiences LOC and/or amnesia. It is possible that the exposure to the family member with a TBI facilitated the higher level of awareness and knowledge of TBI sequelae after LOC and amnesia.

Table 1 also shows the level of discrepancy between the percentage of misconceptions exhibited by the general public as compared to that of rehabilitation workers and educators. As noted, rehabilitation workers and educators correctly answered a higher percentage of the items than the general public. For example, less than 10 % of the educators and rehabilitation workers believed that a second blow to the head can help an individual remember information that they were unable to recall after an initial injury (Farmer & Johnson-Gerard, 1997), whereas about 40% of the general public samples had this belief (Gouvier et al., 1988; Willer et al., 1993; Gulimette & Paglia, 2004; Hux et al., 2006) Another poignant example is evident in the erroneous belief of about one-half to two-thirds of the general public sample that recovery from TBI is dependent on hard work, whereas about one-quarter of the educators and rehabilitation workers shared this belief.

When Table 1 is examined on a more general level, it provides an interesting and sobering portrayal of the knowledge of TBI in both the general public (i.e., individuals who may not be expected to have an extensive knowledge of TBI causes and sequelae) and in educators and rehabilitation workers (i.e., individuals who are more frequently in contact with persons with TBI). Despite the noted differences among the general public, family members, educators, and rehabilitation workers, significant levels of misunderstanding are present in each group. When the mean percentage of misperceptions across all groups is calculated, the full extent of the general lack of knowledge about TBI is apparent. On all but one question, at least 28% of the samples incorrectly answered the questions. Not only do individuals who are unfamiliar with the causes and sequelae of TBI show significant levels of misunderstanding about TBI, but these misconceptions are present, albeit to a lesser extent, in individuals who are typically in contact with TBI victims. These findings underscore the need for better education about TBI.

The survey items that were reviewed in these studies about TBI knowledge were chosen due to their relevance to mTBI (i.e., amnesia, LOC, vulnerability to a second injury). There is some encouraging data pointing to an increase over the past 20 years in the knowledge and awareness of some of the causes of TBI (i.e., whiplash and impacts not involving LOC). However, it is apparent that, in general, there is widespread misunderstanding that the presence of one or more brain injuries will not increase the likelihood of another. This is a crucial finding due to the noted potential deleterious effects of multiple brain injuries. Another important finding was that there was a general lack of awareness that brain injuries, when accompanied by amnesia and LOC, may have any major lasting effects beyond the loss of the memory at and around the time of injury.

Relationships among knowledge, attitudes, and risky behaviors in adolescents.

Only a few previous studies (Simonds, 2005; Sefton, 2003; Livingston & Ingersoll, 2005; Kaut et al., 2004) have examined the knowledge and/or attitudes about concussion in college athletes and only one study has examined the prevalence of underreporting of concussion in athletes (McCrea et al., 2004). Although the details of these studies will be discussed in greater detail later, the findings generally show that college athletes' knowledge and attitudes about concussion are variable. There are some domains that athletes are proficient in and others that they appear to be deficient in (Simonds, 2005; Sefton, 2003; Livingston & Ingersoll, 2004). Additionally, there is a subset of athletes whose attitudes about concussion appear to be unsafe (Simonds, 2005; Sefton, 2003). Finally, the behavior of a significant portion of athletes in reaction to concussion appears to be congruent with this unsafe attitude, as about half of the high school athletes surveyed by McCrea et al. (2004) failed to report a concussion after it occurred. Thus, although there has been some data from various studies about concussion knowledge, attitudes, and risky behaviors (i.e., playing while experiencing the symptoms of concussion), there have been no studies conducted that have examined the relationships between concussion knowledge, attitudes, and risky behaviors occurring after concussion.

Thus, in order to establish these relationships, a brief review of the literature pertaining to sexual behavior in adolescents will be conducted. Kirby (2002) reviewed the literature pertaining to outcomes of educational interventions intended to diminish unprotected sex and pregnancy rates. The researcher reviewed 73 studies conducted in the United States and Canada. The studies included samples of adolescents aged 12-18 years. Each study evaluated the effectiveness of a sex and/or HIV education program.

These programs were educational in nature and were intended to increase knowledge, alter attitudes, and influence behavior. A number of indicators of program effectiveness were examined in the review: initiation of intercourse, frequency of sexual intercourse, number of sexual partners, and contraceptive/condom use.

Participants in the studies were exposed to a particular intervention and were followed up for a period of time after the end of the intervention. The results of the interventions were promising in that about one-third of the programs measuring the initiation of intercourse contributed to a delay in the initiation of intercourse. No changes in initiation of intercourse were seen in most of the other studies. About 25% of programs addressing the frequency of sex resulted in actual reductions in the frequency of sex, and most of the other studies showed no change in the frequency of sexual intercourse. In 30% of the studies examining number of sexual partners, the number of partners decreased. As with other outcome indicators, no changes were seen in the other studies in the frequency of sexual intercourse. Participants in about 2/3 of the studies that measured changes in condom use after the end of the educational program reported significant increases in condom use, and most of the other studies reported no change in condom use. It should also be noted that the vast majority of these 73 studies either reported reductions in risky sexual behavior or no change in the frequency of the sexual practices. The lack of change in sexual practices is considered to be an indicator of an effective educational program because it is believed that the knowledge gained by students likely contributes to their decision to maintain their current sexual practices, rather than increasing the likelihood of pregnancy or the transmission HIV due to an increase in number of sexual partners or an increase in unprotected sex (Kirby, 2002).

This review begins to establish a link between the knowledge gained from the educational programs and the influence that this information may have on the diminution or stabilization of potentially unsafe and, therefore, risky sexual behaviors. However, because the study lacked direct information about the relationships between knowledge, attitudes, and behaviors, the nature of these relationships is unclear.

An additional study was conducted to address this relationship and further establish a connection between sex and HIV education programs and changes in risky sexual behavior (Kirby, Laris, & Rolleri, 2007). The researchers reviewed 83 studies, many of which were conducted in the United States. Moreover, several studies were conducted in other developed and underdeveloped countries. Thus, this study included a more diverse and, potentially, representative sample of adolescents and young adults. The age range of participants involved in studies included in the literature review was between 9-24 years of age.

The findings pertaining to risky sexual behavior were roughly similar to those found in the Kirby (2002) review. More importantly, almost all of the studies examining knowledge about sexual intercourse and safe sex practices reported increases in knowledge and about two-thirds of the studies examining attitudes about sex reported safer attitudes towards sex. About 40% of the studies examining student perceptions of sexual behavior in peers (i.e., an influential factor in the decision making of adolescents; Millstein & Halpern-Felsher, 2002) reported that students tended to believe that their peers were engaging in safer sexual behaviors. The authors concluded that the educational programs tended to increase knowledge and alter attitudes about sex and change perceptions of peer sexual behavior. These cognitive and emotional changes then influenced changes in risky behavior (Kirby et al., 2007).

These literature reviews suggest that the likelihood of engagement in a risky behavior is associated with the knowledge that an individual possesses about that behavior. Furthermore, the evidence points to a link between an individual's attitudes about risky behavior and engagement in the behavior. Although it is unclear as to how knowledge and attitudes about concussion affect the likelihood of reporting a concussion upon recognition of the symptoms or how these factors influence adherence with medical treatment recommendations after concussion, it seems possible either knowledge, attitudes, or both may lead to higher concussion reporting rates and greater adherence among concussed athletes.

Knowledge and Attitudes about mTBI

Due to the relatively high rate of occurrence of concussion in athletes, the knowledge that they possess about mTBI is vital in the recognition and subsequent report of these injuries to coaches and medical staff. Even if an athlete possesses adequate or exceptional knowledge, an athlete's attitudes may remain unsafe and lead to underreporting of concussion. There has been relatively little research devoted to examining knowledge and/or attitudes about mTBI in athletes.

Underreporting as Evidence for Attitudes and Knowledge. Before reviewing more direct measures of knowledge and attitudes (e.g., surveys, questionnaires, etc.), an analysis of concussion reporting patterns and perceptions in athletes will be conducted. These data can serve as poignant indicators of attitudes about athletic injury and concussion.

The NIH (1999) estimated that approximately 90% of concussions in sports are not reported. Research findings provide some evidence to support an underreporting bias among athletes. A survey of high school athletes revealed that 53% of concussions were not reported to a coach or medical staff (McCrea et al., 2004). Additionally, high school and college athletic trainers reported that only about 3.3-5.6% of the athletes for whom they were responsible sustained concussion (Guskiewicz et al., 2000; Zemper, 2003), whereas 15-47% of high school athletes report sustaining a concussion (Langburt et al., 2004; McCrea et al., 2004; Gerberich et al., 1983).

When asked why they did not report the concussions that they had sustained, athletes provided three primary reasons: 66.4% of the high school athlete sample indicated that they did not think that their symptoms were serious enough to be reported, 36.1% indicated that they were unaware that they had sustained a concussion (McCrea et al., 2004), and 41% indicated that they did not wish to be taken out of competition (McCrea et al., 2004).

It appears that there is significant underreporting of concussion occurring among high school athletes. The athletes' reasons for not reporting concussion appear to be due to a combination of unsafe attitudes about concussion and lack of knowledge about concussion sequelae. The lack of awareness about the presence of a concussion is likely to be related to ignorance to common signs and symptoms of concussion. The athletes who responded that they did not believe that their symptoms were serious enough to be reported may not have been aware that the experience of *any* concussion signs and symptoms should warrant evaluation, and this response also suggests that there may be problematic attitudes toward concussion whereby symptoms are downplayed in favor of continuing to compete. These attitudes are certainly apparent in the response about not wanting to be removed from competition. The response is clearly related to unsafe attitudes about continuing to compete despite experiencing symptoms of a serious injury.

Survey and questionnaire studies of knowledge and attitudes. There is no known research that has studied knowledge and attitudes toward concussion in high school athletes. However, some, albeit limited, research examining these factors in college athletes has been conducted and provided some important data.

In an unpublished dissertation, Simonds (2005) developed a survey named the Knowledge and Attitudes about Sports Concussion Questionnaire-24 (KASCQ-24). This survey was designed to measure knowledge and attitudes about concussion sequelae and return to play decision making and guidelines. The KASCQ-24 was administered to 117 participants with a mean age of 21.7. The sample included 49 football players, 46 undergraduate business students, and 22 undergraduate nursing students. This investigator also administered the Stress Profile. This measure examines health risks, stress levels, and coping resources to encounter stress and other life challenges. The researcher hypothesized that the athletes would be the most knowledgeable relative to the nursing and business students because of the higher level of exposure to concussion that athletes experience. An additional hypothesis was that athletes would have more play-promoting attitudes (i.e., views that were in favor of returning to competition, rather than views emphasizing safety).

On average, the athletes surprisingly achieved lower scores on the KASCQ-24 relative to both the nursing and business students. Lower scores indicate lower levels of knowledge and less safe attitudes toward concussion and return to play. Athletes who scored higher on the KASCQ-24 also displayed healthier attitudes and habits and more sophisticated coping skills on the Stress Profile, whereas the inverse was seen in athletes who scored lower on the KASCQ-24. The author briefly mentioned that the athletes exhibited a tendency to report that they should make RTP decisions; however, no mention was made about what percentage of athletes reported this. Additionally, the athletes indicated that coaches and athletic trainers tended to be overly protective when an athlete sustained a concussion, but the response rate was not reported for this question either.

Unfortunately, no mention was made about the relative contributions of the items addressing knowledge and attitudes about concussion and how these items influenced the scores on the KASCQ-24. Also, the correct/incorrect response rates for each item were not reported. Examination of this information could have facilitated a more detailed analysis of athletes' knowledge and attitudes.

Despite the limitations in the information that was reported by Simonds (2005), it is still possible to derive valuable interpretive information from the results. Specifically, the convergent validity between the results on the KASCQ-24 and the Stress Profile suggests that the KASCQ-24 is a sensitive measure of the healthiness and safety of athletes' attitudes. Moreover, it is possible that this sensitive attitudinal measure also displays how athletes' understanding of concussion causes, sequelae, and guidelines about RTP contribute to these attitudes. The results of other studies can help to better illuminate this relationship as there is some overlap between the items on the KASCQ-24 and the items included on the measures used by other researchers.

In a similar study that was an unpublished master's thesis, Sefton (2003) administered a survey to evaluate concussion knowledge, identify sources of concussion knowledge, and assess other important domains in a sample of college athletes, coaches, and athletic trainers. The researcher examined 457 football players, 38 coaches, and eight athletic trainers from eight universities.

The results of the study showed that athletes in the sample tended to have similar knowledge about LOC relative to the samples from the general population and those who were close to someone with a TBI. Only about 10% reported that a concussion is dangerous only when LOC occurs, and only about 6% indicated that an athlete must have LOC to sustain a concussion. However, this awareness may only be limited to LOC as about 40% of the athlete sample believed that dizziness could be “shaken off” and around 20% indicated that the likelihood of a second concussion is not increased after an initial concussion has healed. However, only about 10% reported that if symptoms of a head injury persist, a second hit is not dangerous indicating some recognition that symptoms other than LOC are important to attend to.

Given that approximately 65% of the sample indicated that a concussion could not occur unless the head was directly impacted, it appears that these athletes were unaware of the mechanism of injury in concussion. About one-third of the athletes believed that return to play could occur as soon as a headache following concussion resolved. This response reflects some deficits in the knowledge of RTP guidelines. Approximately one-third of the athletes responded affirmatively to a question asking them whether it would be okay to report a concussion after a game if the symptoms were minor. This response suggests that athletes’ knowledge about return to play is deficient, and may indicate the presence of unsafe attitudes RTP. Over 90% of coaches and athletes combined indicated that a bellringer/dinger was different from a concussion, suggesting the presence of some issues related to difficulty defining concussion. Finally, perhaps the most important finding of this study was that high knowledge levels in athletes correlated with more frequent reporting of concussion.

Knowledge of concussion in college athletes was also examined by Livingston and Ingersoll (2004). They examined a sample of 172 athletes who played different sports (the type of sports were not specified). The results of the study were reported in an abstract for a symposium presented at the 2004 National Athletic Trainers' Association conference. Thus, the information provided by the researchers was limited and it was not possible to examine all of the items or to view the response rates for all of the items.

Among the areas examined by the survey was concussion definition, knowledge of long-term concussion sequelae, and attitudes about return to play decisions. About 60% of the sample indicated that LOC must be present in order for a concussion to occur and 12% indicated that they did not know what the long term effects of concussion were. Attitudes toward return to play decision making are evident in the responses of 17.5% of the sample who indicated that the decision to RTP should solely be the athlete's decision.

Wrightson and Gronwall (1980) examined attitudes and knowledge about concussion in men who sustained a concussion. Many of the participants sustained the injury playing sports. The total sample comprised 63 participants, 31 of which were injured while playing soccer and seven who were injured playing other sports, aged 17-48 years. Participants completed a questionnaire that included items about the effects of their own concussion, information about any concussions sustained by a friend, and their feelings about the prevention of future concussion. The severity of the injuries was comparable for the athletes and non-athletes.

The results of Wrightson and Gronwall's (1980) study showed that one-third of the total sample did not express concern about the concussion. An examination of the individuals who expressed concern showed that over 75% of the individuals injured while playing sports expressed concern about the injury, whereas about 50% of the individuals who were injured in non-sport activities indicated that that they were concerned about the injury. About 30 percent of the study participants who were also soccer players appeared to take measures to decrease the likelihood of further injury by either ceasing their participation in soccer altogether, ending their participation for the year, or considering ending participation. Furthermore, because some of the athletes in this sample are more concerned about their injuries than the non-athletes, it is likely that former group may be more aware of the possible harmful effects of concussion. However, even in the group of athletes in this study, there appears to be a large portion that does not appear to be concerned about the presence of a concussion which may suggest some negative and potentially unsafe attitudes toward concussion.

Examinations of postconcussive symptom knowledge. A few studies have been conducted to identify athletes' knowledge of postconcussive symptoms. The participants in the aforementioned Sefton (2003) study were given a list of 22 common post-concussive symptoms and eight distractor symptoms (i.e., symptoms not associated with concussion). The athletes were instructed to choose the symptoms that they believed to be characteristic of concussion. About 83% correctly reported headache, followed by dizziness (79.4%), and at least 59% of the sample correctly identified the other characteristic symptoms of concussion. Despite the large portion of the athletes who correctly identified symptoms of concussion, up to 41% of the sample failed to identify some of the symptoms.

The relatively limited knowledge that athletes had about postconcussive symptoms was further exhibited in the results of the study which showed that seven of the eight distractor symptoms were also deemed by 40-50% of the athletes to accompany a concussion. Examples of these symptoms were weight loss, swollen hands, diarrhea, etc. (Sefton, 2003).

It is unclear why such high rates of symptoms not associated with concussion were endorsed, but it is possible that some of the athletes endorsed all symptoms as being characteristic of concussion, a pattern suggesting indiscriminate responding. Another possibility is that athletes truly believed that such symptoms as calf cramps and muscle weakness commonly accompanied concussion. However, it is apparent that at least some of the athletes were responding thoughtfully and displayed knowledge of concussion symptoms as evidenced by the higher rates of correctly reported legitimate symptoms, whereas other athletes may have experienced serious difficulty distinguishing true symptoms of concussion from distractors. A detailed analysis of this author’s data was not conducted, so it is difficult to provide a precise interpretation the findings.

Kaut, DePompei, Kerr, and Congeni (2003) used an open-ended self-report method to identify 461 male and female college athletes’ knowledge of concussion symptoms. Participants were asked an open-ended question requiring them to report the signs and symptoms of “head injury”. Based on a content analysis of the responses, four categories of symptoms were identified: cognitive, physical, somatic, and sensory/perceptual. It should be noted that the data that they reported were based on the number of total responses provided by all athletes and not the total number of athletes reporting the symptoms.

Within the cognitive domain, memory problems were reported most frequently, accounting for 23.2% of the total responses across all domains. The physical symptoms that were most often referred to in the responses were brain damage, death, and loss of consciousness (12.1, 6.3, and 2.7 % of the total responses, respectively). Headache (11.2%) and nausea (6.3%) were the most frequently referred to somatic symptoms, and dizziness was the most frequently referred to sensory-perceptual symptom (10.7% of total responses).

Both the headache and dizziness response rates also appear to be relatively low when compared to the results of other studies where individuals reported symptoms. Typically, headache and dizziness are among the most frequently identified symptoms of concussion (Guskiewicz et al., 2003; Guzkiewicz et al., 2000; Erlanger et al., 2003; Pellman et al., 2004).

The findings of the Kaut et al. (2003) study are important, as they may serve as a reflection of the knowledge of athletes without the benefit of forced-choice responses to symptoms (i.e., a checklist of symptoms), thus potentially leading the participants to rely more on their knowledge of concussion rather than on the items presented to them.

General review of athlete concussion knowledge and attitude study findings. The findings of these studies reveal a substantial discrepancy between the responses of two samples of athletes to a question about the necessity of LOC for a diagnosis of concussion. Sefton (2003) found that a relatively low proportion of their participants

(6%) indicated that LOC was necessary to be diagnosed with a concussion, and Kaut et al. (2003) found that only 2.7% of the total responses to a question asking about the symptoms of concussion pertained to LOC. Conversely, about 60% of the sample in the Livingston and Ingersoll (2004) study incorrectly answered this question.

The explanation for this large discrepancy between samples is not clear, but it is possible that the difference may be due to the markedly larger sample used in the Sefton (2003) and Kaut et al. (2003) studies. Moreover, the Sefton (2003) sample consisted exclusively of male football players from eight colleges, but the athletes in both the Kaut et al. (2004) and Livingston and Ingersoll (2004) samples consisted of athletes from different sports played by athletes of both genders at one university. Thus, the differences in knowledge about LOC may be due to one or more of the following factors: sample size, gender of athlete, sport played, and phrasing of survey/questionnaire items.

Sefton (2003) discovered misconceptions in athletes surrounding four key areas associated with concussion: return to play guidelines, mechanisms of injury, definition of concussion, and vulnerability to concussion. The results of the data analyses showed that about 20-60% of participants incorrectly answered questions about these domains. Moreover, the findings from Kaut et al. (2003) showing the lower reporting levels of some common postconcussive symptoms than would be expected and the findings from Sefton (2003) showing that 40-50% of the distractor symptoms were identified as legitimate symptoms suggest that athletes may not be aware of the numerous concussion sequelae. Thus, it appears that about one- to two-thirds of college athletes have some deficiencies in their knowledge of concussion. These deficits may be contributing to the unsafe attitudes that athletes sometimes exhibit.

These attitudes are somewhat apparent in the Simonds (2005) study which showed that there was a subset of athletes who displayed attitudes that favored remaining in competition despite experiencing symptoms of concussion. Further evidence for unsafe RTP attitudes was apparent in the Sefton (2003) study where approximately one-third of the sample reported that it would be acceptable to wait until the end of a game to report a concussion.

Another indicator of potentially dangerous attitudes about concussion and return to play is apparent in the findings reported by both Simonds (2005) and Sefton (2003). These researchers found that some athletes believed that they could be the sole decision maker in determining RTP. Despite these sentiments, the evidence shows that the athletes who are more knowledgeable about concussion are more likely to report their concussion to people who can help to manage their injury. It seems that the athletes who know more about concussion also know that they should not be the sole RTP decision maker. Additionally, given the subtle cognitive deficits that remain after a concussion occurs, the individual sustaining the concussion is most likely not in the best position to be sole decision maker about RTP, especially when the individual exhibits poor knowledge and/or unsafe attitudes about concussion.

Despite the apparent unsafe attitudes that are held by a subset of athletes, there is a sizeable group of athletes who appear to be conscientious and display concern about sustaining a concussion. This latter group is apparent in the Gronwall and Wrightson (1980) study where 75% of the athletes expressed concerned about their concussion as opposed to 50% of the non-athletes. This is an important finding because it suggests that athletes may view concussion more seriously than the general public.

When all of these findings about athlete attitudes toward concussion and RTP are considered together, it is clear that there are varying types of attitudes that range from very safe to highly unsafe. It would seem important, then, to identify the moderating factors that influence concussion attitudes and the knowledge that informs such attitudes.

Athletes' knowledge sources and coaches' knowledge and attitudes. There are obviously several sources from which an athlete could potentially obtain their information about concussion. Only one known study has addressed this question (Sefton, 2003). The researchers did not find a significant relationship between number of previous concussions and concussion knowledge. The sample of college football players were asked to rank several sources of knowledge about concussion, and the average rankings were as follows (from highest to lowest ranked): athletic trainer, physician, coach, teammate, television, magazines/books, and internet. Based on these rankings, the authors chose the top three, excluding physician. This knowledge source was excluded because the researchers felt that doctors would be less available for educational intervention and because of physicians' relative lack of availability for consultation about mTBI questions.

Based on each athlete's ranking of the importance of the particular source (i.e., athletic trainer, physician, and teammate) in contributing to their concussion knowledge, athletes were placed into groups. Those who ranked a certain source as an important source of knowledge were placed in the "high" importance group for that source, and those who rated the source less important were placed in the "low" importance group. Thus, high and low importance groups were created based on the athletes' importance rankings for three sources: coaches, teammates, and athletic trainers.

Knowledge levels were compared between high and low groups for each source, and the results showed that there were no significant differences between the athletes who ranked coaches or teammates as either high or low. Thus, coaches and teammates did not appear to positively or negatively affect athletes' knowledge level. However, the group who ranked athletic trainers highly was more knowledgeable about concussion. This finding is crucial because higher knowledge levels also correlated with more accurate and consistent reporting of head injuries. One other finding of import was that viewing sports on television did not significantly increase knowledge level.

Surveys of coaches' knowledge and attitudes. Very little data have been published pertaining to the knowledge and attitudes of coaches toward concussion. Even though coaches were surveyed about their knowledge of concussion, only a few notable responses were reported by Sefton (2003): head coaches' knowledge level did not significantly contribute to the likelihood of athletes reporting the presence of concussion; only 7.2% of coaches and athletes combined were aware of second impact syndrome; and about 90% of coaches and athletes combined believed that bellringers/dings were different from concussions. It is apparent based on these results that coaches may be lacking in knowledge about the definition and sequelae of concussion. However, it does not appear that the knowledge of the coach, at least at the college level, influences the athletes' attitudes about reporting concussion.

Because there are no known studies about coaches' concussion attitudes, a study will be presented that pertains to the attitudes of coaches toward sports injury (Nixon, 1994). The study also provided a snapshot of coaches' attitudes toward injury which are likely to influence their treatment of athletes with concussion and decisions about RTP.

After conducting a content analysis of Sports Illustrated articles pertaining to injury, Nixon identified themes that were used to create questions for a survey to assess coaches' attitudes. Twenty-six college coaches were recruited and assessed with a 31-item scale which was not analyzed for reliability or validity. A four-point Likert scale was used to quantify attitudes. The anchor points were Strongly Agree and Strongly Disagree, and the intermediate points were Agree with Reservations and Disagree with Reservations. The upcoming reporting rates (i.e., percentages) are based on a cumulative total of coaches who chose either "Agree with Reservations" or "Strongly Agree".

About 8% of the coaches reported that they felt that athletes should ignore pain and continue to play, and over 80% reported that coaches and medical staff should do everything possible to protect athletes (Nixon, 1994). This response pattern suggests that these coaches are aware of the well being of their athletes and wish to protect their athletes from further injury. However, responses to other questions on this survey suggest more demanding and unsafe attitudes toward injury management and recovery. For instance, just over 40% of coaches reported that they will make an athlete feel guilty if the athlete does not want to play through their pain; almost 25% indicated that athletes should never complain about an injury; 29% reported that they will push an athlete to play even if the athlete is injured if the coach feels that it is necessary that the athlete play; over 80% reported that athletes should try to recover as quickly as possible; and about 80% reported that they had greater respect for and were impressed by athletes who played through an injury.

Despite reporting that they were looking out for their athletes' best interest, it seems clear that the messages that are given to by coaches to their athletes, either implicitly or explicitly, may promote hasty RTP. After receiving these messages, athletes may be placed in a precarious position where they feel compelled to play injured to either impress or satisfy their coach. The limited existing data suggests that the knowledge that coaches may impart to athletes does not have a major effect on athlete knowledge or reporting of concussion, but it remains to be seen if coaches' attitudes have an impact on athlete concussion knowledge and reporting.

Return to play decision makers. Before beginning this section, I should note that many sources were contacted to obtain information about the availability of athletic trainers in NY and PA high schools. However, no empirical data was found regarding athletic trainer availability in these or other states. Thus, most of the following data is based on estimates made by experienced athletic trainers, school administrators, and high school athletic associations in these states.

The potential cumulative effects and catastrophic consequences of multiple concussions underscore the importance of accurate assessment and management of concussion. However, estimates from individuals familiar with availability of athletic trainers in high school indicate that 75% of high schools in PA (M. Mertz, personal communication, 8/8/06) about 33% or less of the NY public high schools have an athletic trainer on staff at least part time (L. Mott, personal communication, 8/3/06; M. Donnelly, personal communication, 8/10/06). Additionally, neither PA nor NY has requirements for athletic trainers or other medical staff (e.g., physicians, nurse practitioners, etc.) at games or practices. Thus, it is likely that some high school sporting events occur without the presence of any medical staff (G. Ryan, personal communication, 8/9/06; L. Mott, personal communication, 8/3/06).

When regional population where the high school is located is taken into consideration, there appears to be no difference in availability of medical staff in urban, suburban, or rural high schools in PA (S. Kinley, personal communication, 8/3/06), whereas in the northern region of NY, which is largely comprised of rural high schools, the rate of schools with athletic trainers is below 10% (G. Ryan, personal communication, 8/9/06, P. Harrica, personal communication, 8/10/06, M. Donnelly, personal communication, 8/10/06).

Among the experts consulted to obtain this information, there is a consensus that coaches commonly make RTP decisions in high schools that do not employ athletic trainers or other medical professionals. Furthermore, high schools with athletic trainers typically only have one on staff, thus making it impossible for that individual to attend all of each team's practices and games. This limitation in the availability of the athletic trainers and possibly other medical professionals places coaches in the position of making RTP decisions.

It appears that coaches from around 25% of high schools in PA and about two-thirds of high schools in NY do not have athletic trainers at practices, and may or may not have other medical staff available at games (L. Mott, personal communication, 7/30/06; S. Kinley, personal communication, 7/30/06). Moreover if a school has an athletic trainer and/or other medical staff who are available at games, these personnel may not always be at practices—where about one-third of concussions occur (Flik et al., 2005; Covassin et al., 2003; Booher, Wisniewski, Smith, & Sigurdsson, 2003).

Therefore, it appears that around one-third of the concussions sustained by athletes are more likely to be managed by coaches who may not have the same knowledge about sequelae and management of concussion and RTP decisions, and who might even have unsafe attitudes about RTP that could jeopardize the health of the athletel. It seems important, then, to identify what coaches know about concussion and RTP to assess these domains and provide remedial information if necessary.

Existing Surveys of Knowledge and Attitudes toward Concussion

College football head injury survey (Sefton, 2003). This survey was developed for athletes and consists of 28 items, some of which are postconcussive symptom checklists. The questions were distributed into three sections: 1) symptom checklist and definition of concussion, 2) true/false section to identify misconceptions about concussion, and 3) the sequelae of concussion and the effects of multiple concussions. The athletes were also asked about previous head injury and their amount of football experience. Separate but similar surveys were developed for coaches and athletic trainers, respectively. The sample consisted of 457 male football players, 38 coaches, and 8 athletic trainers from eight universities distributed among NCAA Divisions I, I-AA, and II. The mean age of the athletes was not reported, but the age range was between 18 and 26.

Pilot data were collected on 22 athletes and 1 coach. Also, content validity was established by presenting the athlete survey to three experienced athletic trainers and a neurologist. After the panel examined the items to determine clarity, and appropriateness of wording and content, only a handful of items were removed. The researcher conducted a test-retest reliability analysis by presenting the instrument to 18 athletes twice, and the results showed that the survey displayed adequate reliability (r = 0.87).

Internal consistency analyses were not conducted. Without these data, it is difficult to understand the relationships among items and the researcher is prevented from removing items of little relevance to the domains being assessed.

The survey contained several items pertaining to the knowledge and attitudes of the football players, their coaches, and their athletic trainers. The items included on the survey appeared to assess mechanisms of injury, vulnerability to future injury, common postconcussive symptoms, and harmful and catastrophic sequelae. However, the instrument contained only a handful of questions pertaining to knowledge and attitudes about concussion management and RTP. The measure developed for coaches also possessed these strengths and drawbacks.

KASCQ-24 (Simonds, 2005). The researcher initially developed a 52-item survey, the Knowledge and Attitudes about Sports-Related Concussion Questionnaire (KASCQ-52), which included questions from each of four domains: knowledge of concussion causes, sequelae, etc.; knowledge of return to play guidelines; attitudes about concussion; and attitudes about return to play. Each of the questions was in true/false format. The researcher intended to obtain information about the performance of the athletes in these domains and to establish the reliability and validity of the KASCQ-52.

To develop the measure, Simonds engaged in a stepwise process. A 60-item version of the KASCQ was first presented to four experts in sports neuropsychology to examine the content of the items. Next, it was administered to an unspecified number of athletes participating in non-collision sports (e.g., tennis, track, etc.) Confusing and problematic items were removed on the basis of the feedback received first from the expert panel and then the pilot sample. The revised instrument was again presented to the expert panel for final revisions and then administered to the samples of interest (i.e., athletes, nursing students, and business students) in the 52-item format.

The sample included 69 males, 45 females, and three participants who did not report their gender (117 participants total). The samples for each group were as follows: 49 football players (mean age=19.6, standard deviation=1.31), 46 business students (mean age=21.4, standard deviation=0.90), and 22 nursing students (mean age=26.9; standard deviation=8.57).

In addition to receiving the KASCQ-52, each participant was administered the Stress Profile and a demographic measure. The Stress Profile examined health risks and stress levels and coping resources to encounter stress and other life challenges. The demographic measure was included to obtain information about sex, age, concussion history, and history of participation in sports.

After the data were collected, internal consistency data analyses were conducted to establish the reliability of the KASCQ-52. Because the researcher created four separate scales, intercorrelations among the scales and internal consistency analyses were conducted on each scale. Initial internal consistency estimates were low for each scale. Most of the items with item-to-total correlations falling below 0.20 were removed from the survey.

A total of twenty-eight items were removed, and the survey was considered one unitary scale. The internal consistency of this revised KASCQ-24 was 0.82. Most of the intercorrelations between the scales showed moderate positive correlations.

As noted earlier, scores on the Stress Profile scales were compared to KASCQ-24 scores and moderate correlations were found. These results suggest that the KASCQ-24 is a sensitive measure of attitudes toward injury management, coping, and healthy lifestyles.

Due to problems with the psychometric characteristics of the individual scales on the KASCQ-52 and the lack of discrete scales on the KASCQ-24, it is unclear what contribution the athletes' knowledge and their attitudes made to their scores. However, a visual analysis of the omitted items revealed that only 17% (3 of 17) of the original items comprising the Knowledge of Concussion Scale (i.e., information about the causes and sequelae of concussion) and 45% (5 of 11) of the original items from the Attitudes about Concussion Scale (i.e., views about seriousness of concussion) were retained. Conversely, 69% (9 of 13) of the original items comprising the Knowledge of Return to Play Criteria Scale (i.e., awareness about criteria used to make return to play decisions) and 58% (7 of 12) of the original items from the Attitudes about Return to Play Criteria (i.e., views about criteria used to make return to play decisions) remained in the KASCQ-24. Thus, it appears that the items from the KASCQ-24 are more heavily weighted toward knowledge and attitudes about return to play and tend to place less emphasis on items that address knowledge and attitudes about concussion.

Despite the valuable information that was obtained from previous studies about knowledge and attitudes toward concussion, there were significant limitations related to methodology, survey content, and sample constellation. Specifically, each of these studies included only college athletes, which limits the generalizability of the results.

Furthermore, two of the studies included large samples (i.e., Sefton, 2003 and Simonds, 2005) of exclusively male football players, and, although the Livingston and Ingersoll (2004) study contained a sample of athletes from both genders and who participated on different unspecified athletic teams, their sample was only about half as large as the samples in these other studies. Despite the inclusion of other genders and sports in this latter sample, there still appears to be a lack of information about diverse samples of athletes which limits the generalizability of the findings of these studies to athletes in other sports and across both genders. More research is clearly necessary to identify potential between-sport and/or between-gender differences.

Although there are items pertaining to attitudes about concussion on each of the measures that have been reviewed, there are either insufficient numbers of items or the reporting rates for the items related to this domain were not reported by the author. Given the importance of attitudes about concussion, more information seems necessary to better understand the broad and specific elements of these attitudes.

The items included in the surveys may be insufficient to fully assess knowledge and attitudes about concussion. Specifically, in the Simonds (2005) study, the survey in the 52-item form appeared to be quite comprehensive and inclusive, but many of the initial items were excluded from the final version of the survey due to poor internal consistency. Additionally, the Sefton (2003) survey included many items pertaining to knowledge about concussion, but there were a relatively small number of items tapping attitudes. There were also no internal consistency analyses conducted to examine the survey content in this latter study.

In summary, there has been no instrument developed to date that has exhibited good psychometric properties, covered the full range of the domains associated with knowledge and attitudes about concussion and concussion management, and been updated to reflect recent research. With the current study, the researcher sought to contribute to the existing research in several ways. First, because other studies have examined only college athletes—a large majority of which were football players and male athletes from other sports—the researcher sought to examine knowledge about and attitudes toward concussion in high school athletes. Furthermore, to address any potential differences in concussion knowledge and attitudes across sports and gender, both male and female athletes from a variety of sports were surveyed. Second, the survey that was used included more detailed, precise, and extensive items than have comprised previous surveys.

The results of the current study were intended to provide valuable information about knowledge and attitudes toward concussion in high school athletes. To date, no published studies have examined these variables in a high school sample. By obtaining measurements of high school athletes and those who care for them—in addition to obtaining information from non-athlete high school students—it was possible to compare the knowledge levels and attitude patterns between the groups.

The knowledge and attitudes of high school coaches was also examined in the study. Relatively little has been published related to this topic, and it was the intention of the researcher to determine the extent of their knowledge and the typical attitudes that are seen among high school coaches. It was predicted that knowledge and attitudes about concussion would bear on the incidence of concussions in high school students. Specifically, it was believed that safer attitudes and increased knowledge about concussion would assist an athlete with better recognition, increase the likelihood of reporting, and improve their chances of having the concussion managed appropriately.

To date, limited, but promising data have been published pertaining to the importance of athletic trainers in influencing safe decisions about concussion management in athletes. Additionally, more specific data were obtained about the impact that athletic trainers' knowledge and attitudes may have on the knowledge and attitudes of athletes. An important objective of this study was to attempt to extend these findings using a significantly larger sample than was used in previous studies.

The survey was also administered to non-athlete high school students. Two objectives were achieved by surveying non-athletes: a comparison group for the athletes was obtained and information was collected about the knowledge and attitudes toward concussion in non-athletes. Like the previous studies examining knowledge of TBI in the general population, it was hoped that the results obtained from this non-athlete sample, would serve as a gauge for how family and friends of injured athletes may perceive and influence the injured athletes.

Finally, the survey used in the current study was extensively piloted and psychometric characteristics were exhaustively examined (i.e., internal consistency, construct validity, content validity, test-retest reliability, etc.). A validity scale was included in the survey to assure that adequate effort was being put forth and participants were not responding randomly. Additionally, it was hoped that a measure with good validity and reliability would be developed.

This study addressed one general hypothesis, four specific hypotheses, several associated predictions, and one exploratory question. They are as follows:

General Hypothesis: A relationship between the cognitive (knowledge) and emotional (attitude) aspects of the concussion construct will be identified, and these aspects will influence the behavioral (management & reporting) aspects of the concussion construct.

The evidence from previous literature suggests that a relationship exists between knowledge and attitudes about concussion. Furthermore, there is some evidence that points to a relationship between knowledge, attitudes, and reporting of concussion; however, the relationships were not extensively examined. Finally, it seems quite possible that thoughts and feelings about concussion are associated with concussion management, but the relationship has not been established in the previous research. This study was designed to establish relationships among these different factors pertaining to the concussion construct. The hypothesis, predictions, and questions addressed below have been formulated to examine these relationships.

Hypothesis 1: Experience with and education about concussion will be closely associated with knowledge about concussion.

Prediction 1: Athletes at schools employing athletic trainers will be more knowledgeable about concussion than athletes at schools without athletic trainers.

Because athletic trainers are familiar with concussion, they may influence the athletes with whom they work to better understand concussion. Previous research suggests that, relative to coaches and teammates, athletic trainers are the most influential information source about concussion in college athletes. Thus, it is expected that the presence of an athletic trainer at a high school will produce an increase in the knowledge of the athletes who may receive treatment and/or advice from the athletic trainer.

Prediction 2: A relationship will be identified between athletes' primary knowledge source and their concussion knowledge.

The relationships between the concussion knowledge of athletic trainers and coaches (i.e., informational sources for athletes) and that of the athletes with whom they work are important due to their proximity to and influence over the athletes. Relationships between the informational sources and their athletes will be examined. It is expected that athletes who indicate that their coach or athletic trainer are their primary knowledge source will display levels of knowledge that are similar to that of their primary source.

Prediction 3: Coaches will possess less knowledge about concussion than athletic trainers.

Because most coaches likely lack the extensive medical background and may not be as familiar with the concussion literature as athletic trainers, coaches may be less knowledgeable about concussions than athletic trainers.

Prediction 4: Athletes will have greater knowledge about concussion than non-athletes.

Due to the well-documented incidence rates of concussion in sports, it is quite likely that athletes are more likely to have been exposed to concussions and information about concussions than non-athletes. Thus, it is possible that they possess more knowledge about concussion than non-athletes.

Prediction 5: Concussion knowledge will differ based on sport played.

Previous research suggests that concussion rates vary by sport. The athletes that play a particular sport (e.g., football) may be exposed to concussion more often than athletes who compete in a different sport (e.g., cross-country). Athletes who play these high risk sports are likely to have greater exposure to concussion, and with increased exposure likely comes increased awareness about concussion which could translate into higher knowledge levels.

Hypothesis 2: Experience with and education about concussion will be closely associated with attitudes toward concussion.

Prediction 1: Athletes at schools employing athletic trainers will possess safer attitudes about concussion than athletes at schools without athletic trainers.

Prediction 2: A relationship will be identified between athletes' primary knowledge source and their concussion attitudes.

As indicated, previous research suggests that athletes who indicated that athletic trainers were their primary knowledge source were more knowledgeable about concussion. A separate study found that relative to athletes with lower levels of concussion knowledge, athletes who possessed higher knowledge levels also indicated that they would be more likely to report a concussion. If concussion reporting is representative of safe and conscientious attitudes toward concussion, then it stands to reason that the athletic trainer not only contributed to their athletes' knowledge, but may have also impacted their attitudes. Therefore, it is expected that those athletes who report that their athletic trainer is their primary knowledge source will display attitudes similar to that of their athletic trainer. Additionally, given this possible connection between knowledge sources and attitudes, it is also expected that athletes who report their coach as their primary knowledge source will display attitudes similar to that of their coach.

Prediction 3: Coaches' concussion attitudes will be less safe than the attitudes of the athletic trainers.

Athletic trainers are medical professionals, and ideally, they are likely to be more objective about concussion management and RTP. Understandably, coaches tend to be highly motivated to win, and, as empirical evidence suggests, coaches may push players to prematurely RTP after injuries. Furthermore, the research indicates that coaches tend to respect and look more favorably on athletes who play through injuries which suggests substantial play-promoting attitudes. As noted, this type of "warrior" mentality is especially problematic with concussions.

Hypothesis 3: Concussion knowledge and attitudes will be related to the rate of concussion and to concussion management practices.

Prediction 1: Relative to high schools without ATCs, high schools with ATCs will have lower rates of athletes per year who sustain concussions.

Relative to coaches, athletic trainers are in a better position to detect concussions and may be more familiar with safe concussion management practices. Thus, athletic trainers may be less likely to return an athlete to play prematurely. However, when left to make an RTP decision alone, a coach may be more likely than an athletic trainer to prematurely return an athlete to play. Unilateral RTP decisions by the coach may increase the likelihood that an athlete will sustain an additional concussion.

Prediction 2: Presence and number of concussions will influence concussion knowledge in athletes.

As number of concussions increase, symptoms typically become more intense and may last longer. Additionally, because the signs of a second concussion may be more obvious, other people may detect the concussion, which may increase the likelihood that the athlete will receive medical attention. Thus, due to the more severe and persistent symptomatology after multiple concussions and the potential increased likelihood that an athlete may receive medical attention after concussion (i.e., are exposed to more elements of concussion), as athletes receive more concussions they may become more knowledgeable. Hence, it is expected that athletes with a history of multiple concussions will have higher levels of knowledge relative to athletes with one concussion or no concussions.

Prediction 3: Presence and number of concussions will influence concussion attitudes in athletes.

Like concussion knowledge, concussion attitudes may be altered by the experience of a concussion. The experience of sustaining a concussion which includes prolonged experience of symptoms, academic difficulties, emotional problems, and, in the case of athletes with multiple concussions, being treated in an increasingly cautious manner and potentially losing additional playing time may significantly change the perception of the concussed athlete. Thus, it is expected that differences will be identified among athletes with differing concussion histories. Specifically, the researcher predicts that individuals with multiple concussions will display safer attitudes toward concussion than athletes who have sustained one concussion or no concussions at all.

Hypothesis 4: Financial resources will be associated with the presence of medical staff at practices and games.

Prediction 1: High enrollment (HE) schools will be more likely than medium enrollment (ME) and low enrollment (LE) schools to employ an athletic trainer.

Prediction 2: High enrollment (HE) schools will be more likely than medium enrollment (ME) and low enrollment (LE) schools to rely on medical staff, rather than coaches, to make RTP decisions.

Prediction 3: Coaches at LE schools will be more likely to be the primary RTP decision maker relative to ME and HE coaches.

Because LE schools tend to have fewer financial resources available, these schools will be less likely to employ an athletic trainer. Although the evidence in Pennsylvania does not suggest that this is always the case, multiple anecdotal sources indicated that this was the norm in New York. Thus, it seems possible that a trend exists whereby schools with fewer resources will be less likely to devote limited resources to medical staff and leave RTP decisions to coaches instead.

The following are the exploratory questions that were addressed by the study:

Question 1: Is knowledge about concussion related to attitudes in athletes, non-athletes, coaches, and athletic trainers?

In Sefton’s (2003) doctoral dissertation study, a positive correlation between knowledge of concussion and reporting of concussion to medical staff was found. This relationship suggests that knowledge of concussion contributes to reporting of concussion (i.e., a safe concussion management attitude). The current study was an attempt to replicate this relationship using a more psychometrically sound and comprehensive measure to provide a clearer picture of the relationship that potentially exists between these variables in high school athletes and non-athletes as well as coaches and athletic trainers.

Question 2: Are there any differences in the attitudes toward concussion in groups of athletes and non-athletes? If so, what is the nature of those differences?

To date, very little has been published pertaining to the attitudes of non-athletes about concussion. Non-athlete groups have been examined in previous research, but the data reported by the researchers was quite limited and pertains to college and graduate students. The current study examines high school students only. Thus, it is clear that there are limitations in the reporting of results and an absence of data pertaining to high school non-athletes regarding attitudes about concussion. It is hoped that the examination of this question in the current study will document and illuminate non-athletes' concussion attitudes.

Chapter 2

Method

Pilot study. As will be described later in this section, the pilot study contains several phases. The pilot study was conducted to validate and obtain psychometric information about the new survey and the supplemental forms.

Participants

Pilot study. The demographic information provided below represents the entire pool of students who participated in the pilot study. Note that the pool of participants is comprised of groups of students who participated in different phases of the pilot study. Specific data will be provided later in this section about the sample sizes used in each phase.

Participants in the pilot study were high school students in grades 9-12 who were recruited from six rural high schools in Northern New York. A total of 698 students completed at least a portion of the survey. The sample consisted of 346 males (49.6%), 342 females (49%), and 10 (1.4%) participants who did not specify their sex. Participants' mean age was 16.2 years of age (SD = 1.29 years of age; range = 13-20 years of age), and they completed an average of 1.8 years of high school (SD = 1.40 years of high school).

The racial/ethnic composition of the sample was quite limited with about 80% of participants identifying as Caucasian and about 9% not reporting their race/ethnicity. The remainder of the sample was comprised by the following racial/ethnic groups: Black

(1.1%), Hispanic/Latino/Latina (1.1%), Native American (.9%), Asian (1.3%), and about 6% biracial or other racial/ethnic groups. The racial/ethnic distribution of the sample was not representative of the national population (United States Census Bureau, 2000), and when individuals who did not provide their race/ethnicity (i.e., non-responders) were excluded, the distribution remained unrepresentative of the national population. However, when the sample without the non-responders was removed, the population distribution was quite similar to the racial/ethnic distribution in rural New York State counties (United States Census Bureau, 2000).

Athletes comprised almost two-thirds of the sample (n = 439), whereas non-athletes accounted for the remainder of the sample (n = 225), with the exception of about 5% who did not specify their athletic status.

Of the 698 students who began to complete the survey, 514 (73.6 %) satisfactorily completed the survey. A participant's survey data was deemed satisfactory if they completed at least 87% of the items pertaining to knowledge, attitudes, and social desirability, respectively. In order to provide evidence of adequate effort and responses that represented the domains being addressed, the researcher established a criterion of at or slightly below 90% completion on each of the scales. Due to the relatively small number of items on each scale (i.e., 25 knowledge items, 15 attitude items, and 33 social desirability items), omission of relatively few items can result in a completion rate well below 90%. For example, if a participant fails to complete just 3 of the 15 items pertaining to concussion attitude, their item completion rate for that scale would be 80%. Thus, with a completion rate of 80%, it would seem possible that the existing responses may not adequately represent a participant's attitudes about concussion. Additionally, a few items of minimal difficulty were included in the survey (e.g., “Cleats help athletes’ feet grip the playing surface”). These items have obvious answers, and were intended to detect poor and/or variable effort. Participants answering two of the three items incorrectly were not included in the sample used to analyze the data from the pilot study (i.e, the final pilot sample).

It is hoped that the quality control procedure used on the data above increased the likelihood that participants included in the final pilot sample provided data that represented the participants’ knowledge, attitudes, and their level of socially desirable responding.

Main study: Students. Participants in the main study were high school students in grades 9-12 who were recruited from seven rural high schools in Northern New York. A total of 95 students completed at least a portion of the survey. The sample consisted of 37 males (38.9%), 48 females (50.5%), and 10 (10%) participants who did not specify their sex. Participants’ mean age was 15.9 years of age (SD = 1.21 years of age; range = 14-18 years of age), and they completed an average of 2.9 years of high school (SD = 1.31 years of high school).

The racial/ethnic composition of the sample was quite limited with 83.2% of participants identifying as Caucasian and about 2% not reporting their race/ethnicity. The remainder of the sample was comprised of the following racial/ethnic groups: Black (2.4%), Native American (1.2%), biracial or other racial/ethnic groups (2.4%), and no Hispanic/Latino/Latina participants. As with the distribution of the pilot sample, this sample was not representative of the national population, but, with the exception of the absence of the Hispanic/Latino/Latina participants, the sample roughly approximated the local population racial/ethnic distribution (United States Census Bureau, 2000).

Just over half of the sample (57.9%; *N* = 55) was comprised of athletes, 27 participants were non-athletes (28.4%), and athletic status was not reported by the remainder of the sample (13.7%; *N* = 13).

The sample of students who satisfactorily completed the survey measures in the main study contained 88 participants from six New York State high schools. A large majority of these participants (*N* = 73; 83%) attended one of the four high schools with an athletic trainer on staff. Only 15 participants (*N* =15; 17%) attended one of the two high schools without an athletic trainer. Additionally, the same version of the survey was administered to all participants in the main study as was administered to participants in the pilot study. Thus, because the participants in the pilot study were likely more representative of the general high school student population than the small and potentially biased sample of participants from schools without athletic trainers in the main study, and because the pilot study participants received the same version of the survey, the 15 main study participants were not analyzed in favor of the pilot study participants.

The sample of 73 participants (33 males, 37 females, and 3 unreported) retained from the main study was comprised of a group of 45 high school athletes (61.6%; 23 males, 22 females) and a group of 21 non-athletes (21.8%; 9 males, 12 females).

Main Study: Coaches and Athletic Trainers. Coaches were recruited exclusively from New York State high schools, and 129 coaches satisfactorily completed the survey. Ninety-one male coaches (70.5%) and 37 female coaches (28.9%) completed the survey. Samples of coaches were recruited primarily from schools where the students were also surveyed to enable athlete-coach comparisons. The mean age of the coaches was 40.7 years of age (SD = 10.5 years of age). Coaches averaged about 14 years of experience (SD = 9.9 years of experience). The approximate number of coaches recruited to complete the survey totaled about 400. Thus, the approximate response rate was about 32%.

The athletic trainer sample comprised of 148 athletic trainers (81 males [54.7%] and 67 females [45.3%]). The mean age of the athletic trainers was 34.3 years of age (SD = 9.2 years of age). Each athletic trainer who completed the survey was certified by the National Athletic Trainers' Association and worked on either a part-time or full-time basis at high schools located primarily in New York (36.5%; n = 54) and Pennsylvania (57.4%; *N* = 85). The remainder of the sample (*N* = 9; 6.1%) worked in states other than New York and Pennsylvania. Athletic trainers in the sample averaged about 10.6 years of experience (SD = 8.3 years of experience). About 850 athletic trainers were recruited, and the estimated response rate was about 18%.

Based on the size of the school that they attended or were employed by, students, coaches, and athletic trainers were placed into one of three groups: high enrollment (HE; enrollment of 761 or more), medium enrollment (ME; enrollment of 337-760) or low enrollment (LE; enrollment of 336 or below). These enrollment parameters were based on the classifications for football teams established for 2006 by the New York State Public High School Athletic Association (NYSPHSAA) for the approximately 800 member high schools. The NYSPHSAA publishes enrollment figures for all member schools, but these figures only included students in grades 9-11. Thus, in order to create more representative school enrollment totals, the enrollment for each school in grades 9-

11 was multiplied by .20. The product of this calculation was intended to be a conservative estimate of senior class size at each high school and was added to the enrollments in grades 9-11 (20% of the enrollment in grades 9-11 was used to estimate senior class size, and this percentage estimate was based on personal communication with school administrators and their views about general enrollment trends throughout the state). The sum of this calculation was considered the estimated total enrollment in grades 9-12.

Moreover, the enrollment classification cutoffs were adjusted using the same procedure described above, and when a frequency analysis was conducted on the enrollments of all of the high schools in the state and schools were divided into 3 groups based on enrollment, the results were quite similar to the NYSPHSAA classification system. Thus, there was converging evidence that these cutoff scores could be used in this manner.

In order to examine the relationships between high school enrollment (i.e., high, medium, and low) and the availability of athletic trainers at high school sporting events (i.e., games and practices), athletic directors were recruited. The NYSPHSAA distributes schools into eleven different sections based on region of the state and classifies high schools based on size (i.e., classifications for small, medium, large, and very large; for ease of interpretation, large and very large schools were combined to comprise the low enrollment and high enrollment groups, respectively). Although each athletic section of the state includes schools that have low, medium, and high enrollments, the sections can be classified according "urban", "suburban", and "rural" areas. Athletic directors were recruited from each of the 11 sections, thus suggesting that the athletic director sample is fairly representative of rural, suburban, and urban high schools.

A total of 142 athletic directors from small (*N* = 41; 28.9%), medium (*N* = 46; 32.4%), and large (*N* = 55; 38.7%) high schools were recruited. The distribution of athletic directors across the HE, ME, and LE groups was roughly equivalent to the actual distribution of schools among the state classifications. Approximately 85% (about 670 of 778 total schools) of the athletic directors were recruited. The estimated response rate was about 20% (142 out of 670 schools). It should be noted that, in a few of the schools (less than 5%), the survey responses were provided by the school athletic trainer or the athletic director's administrative assistant.

Recruitment. Approval was obtained from the Institutional Review Board at the Pennsylvania State University for the pilot and main studies before the pilot study commenced. Upon approval, administrators and athletic directors from 16 high schools in NY were contacted and solicited for participation. Approval from the high schools was either provided by an administrator, the school board, or both. The total time from initial contact to approval ranged from three to eight weeks. Before students could be recruited, administrators and school boards mandated that parental permission be received.

Two parental permission procedures were used: active and passive consent. In the active consent procedure, parents were required to sign and return a consent form to the principal invesigator (PI) if they wished to allow their child to be recruited. Conversely, in the passive consent procedure, parents replied to the PI only in the case that they *did not* wish to allow their child to be recruited. The active consent method resulted in a much lower parental response rate (123 responses from about 2260 parents; .05%) than the passive consent where only about 1% (about 3202 out of 3290 parents did not opt out, thus allowing the PI to recruit 99% of the students from these schools) of parents opted to not allow their child to participate in the study. Six high schools used the active consent method, and six high schools used the passive consent method.

Opt out consent forms were distributed to the parents of students participating in these activities, and then students were surveyed by the researcher in person. Only .05% of parents opted not to allow their child to participate, and of the 676 students who were recruited, 661 completed part of the survey (97.8%).

Additionally, reminder postcards were sent out to about 1750 parents from three schools using active consent about three weeks after they received the initial consent form, and only two responses were received after the postcards were distributed.

The initial permission packets included a brief explanation of the project, a consent form, and a business reply return envelope. The follow-up postcards included a reminder about the project and gave parents the option of “signing” an online consent form made available by the PI on Survey Monkey—the online survey program—or returning the initial permission form.

Student recruitment in the pilot study was conducted during site visits from the PI. The PI visited six high schools and had permission to recruit 803 students (697 of which were from one school). Across these high schools when absent students were not considered, only 20 (out of 702) declined to complete the survey, thus, producing a 97% survey response rate. Depending on the school and the number of students from each school who had been authorized to be recruited, the PI administered the survey in either individual or group formats. Before inviting the participants to complete the survey, the PI reviewed the student assent form with the students (some individually and some in group form), received assent from the students who chose to participate, and distributed the surveys. A small sample of the students completed a computerized version of the survey (N = 37), and the remainder completed a paper and pencil version. Students who took the paper and pencil version were instructed not to look back at previous pages of the measure to reduce the possibility that previous answers would influence upcoming responses.

Students in the main study were recruited via postcard. These students received an initial postcard inviting them to participate by completing an online (Survey Monkey) version of the survey. Students also received follow-up postcards reminding them to participate. In a final attempt to obtain an adequate sample from these schools, flyers reminding students to consider participating were distributed in study halls and announcements about the study were made during school hours. Only .05% of the high school students recruited (115/2468) completed the online survey.

Due to a substantially low survey completion rate, it is likely that the sample was not representative of the general population. The individuals who completed the survey may comprise a subsample of students who may have been motivated due to a personal interest in the survey or by the financial incentive. However, for the purposes of this project, it was important to have a group of students at schools with athletic trainers to compare to the athletes at schools without athletic trainers. Any differences should be interpreted with caution because of the unrepresentative sample. This issue will be addressed in more detail in the Discussion section below.

High school coaches were recruited in two different ways: 1) by receiving an invitation at a coaching workshop or 2) by receiving an email from the PI. In the former case, coaches were approached by the PI, and asked to complete a survey. Coaches who agreed to complete the survey were asked to avoid looking back at completed pages to reduce the influence of previous responses on future responses.

Coaches who were recruited to complete the computerized version of the survey were sent an email by the PI that was forwarded to them by their athletic director. The email included a web link that directed coaches to the consent form. The coaches were asked to review the consent form and then begin completing the survey. About 400 coaches from 57 high schools were recruited to participate in the survey, and 129 coaches completed the survey.

Athletic trainers were recruited by emails sent directly to them by the PI. As with the coaches, athletic trainers received a computerized version of the survey that was accessed via web link. They were instructed to review a consent form before completing the survey. It is unclear as to how many high school athletic trainers in NY and PA actually received the email. The mailing lists obtained from the National Athletic Trainers' Association member registry included all certified athletic trainers in NY and PA and did not specify the setting that they worked in (i.e., high school, college, clinic, etc.). Thus, invitation emails were sent to all athletic trainers in NY and PA regardless of work setting. In order to screen out athletic trainers who did not work in high schools, the subject line of the email indicated that the survey was for high school athletic trainers, and this message was reiterated at the start of the survey. A total 148 high school athletic trainers completed surveys.

Participation incentives. As an incentive to participate, students in the pilot study were provided an opportunity to place their name into a drawing for a cash reward of $100, and participants who completed the survey in the main study had their names entered into a drawing for two $50 rewards. Names of coaches and athletic trainers who completed the survey were placed into a $50 drawing for each respective group.

Measures

RoCKAS forms. The Rosenbaum Concussion Knowledge and Attitudes Scale (RoCKAS) is a newly formulated survey that was developed during the pilot study before being administered to the participants in the main study. Forms of the measure have been developed for students (RoCKAS-ST; showed in Appendix C), coaches (RoCKAS-CH; Appendix D), and athletic trainers (RoCKAS-AT; Appendix E; a list of these and other important acronyms that will be used in this section is in Appendix F).

The RoCKAS-ST consists of 39 items and a symptom checklist, whereas the RoCKAS-CH and AT each consist of 40 items. Each instrument is organized into five sections: 1) questions regarding knowledge about the causes and sequelae of concussion; 2) questions examining knowledge of concussion sequelae that pertain to sports scenarios; 3) questions relating to attitudes about concussion management and RTP decision making; 4) questions examining attitudes about concussion management and RTP decision making that pertain to sports scenarios; and 5) checklist containing eight postconcussive symptoms that are commonly reported after concussion and originally containing eight distractor symptoms (it should be noted that three of the distractor symptoms were removed because the incorrect response rates were about 14% or higher on each of the three symptoms; the criterion for removal of symptom checklist items was set at 15% ± 2% of participants incorrectly answering the items) that are very unlikely to be exhibited after concussion.

The questions presented in sections 1 and 2—the sections pertaining to knowledge about concussion—are in true/false response format. The response format for sections 3 and 4—the sections pertaining to attitudes about concussion management and RTP—is a five-point Likert scale ranging from strongly disagree to strongly agree. In Section 5, participants are instructed to place a check mark next to each of the symptoms that they believe an individual would experience after a concussion. The legitimate postconcussive symptoms are the most commonly reported symptoms by a sample of 73 concussed athletes. These symptoms are presented in the principal investigator's unpublished master's thesis (Rosenbaum, 2003).

The format of the RoCKAS is identical across all 3 forms (i.e., ST, CH, AT). There are minor differences among the forms in the content of the items. As was previously stated, the CH (i.e., coach version) and AT (i.e., athletic trainer version) versions include one additional item. This item was originally included on the ST (i.e., student version) but was removed because of feedback received during a qualitative analysis of the measure. Another difference between the ST and CH/AT versions is that some of the items require that participants estimate the attitudes of their colleagues/teammates, and because of this, the referent for these questions varies based on the form. For example, a question on the ST states that "Most athletes would say that Athlete M should return to play in the early season game," and the same question on the AT states that, "Most athletic trainers would say that Athlete M should return to play in the early season game."

Three of the 40 items on the RoCKAS forms are included to assess the validity of the individual's responses. These items are included because the face validity of the survey is quite high. This validity scale was placed in the measure to assess for indiscriminate responding which suggests poor/inconsistent effort and/or lack of thoughtfulness while completing the items.

Several of the items on the RoCKAS were selected from the KASCQ-52 (Simonds, 2005) and from the survey used in the Gouvier, et al. (1988) study. Many of these were altered to better facilitate participant understanding and, consequently, the facilitation of clear interpretation of the responses during data analysis.

RoCKAS-ST/AT/CH scoring system. Sections 1 and 2 include true/false items. Correct responses warrant 1 point and incorrect responses warrant no points. Additionally, Section 5 includes a list of legitimate postconcussive symptoms and distractor symptoms. Correctly identified symptoms result in 1 point being awarded and incorrectly identified items result in no points being awarded. The Concussion Knowledge Index (CKI) is derived by summing the scores across Sections 1, 2 and 5. Higher scores on this index indicate higher levels of knowledge.

Sections 3 and 4 include items rated on a Likert scale. Responses in the unsafe direction (the "unsafe" direction varies based on the item) warrant 2 points for a moderately unsafe response (i.e., agree or disagree) and 1 point for a very unsafe response (i.e., strongly agree or strongly disagree). A "neutral" response warrants 3 points. Safer responses warrant 4 points for a moderately safe response and 5 points for very safe responses. The scores from Sections 3 and 4 are tabulated and comprise the

Concussion Attitudes Index (CAI). Higher scores represent safer attitudes about concussion.

As indicated, the RoCKAS includes a validity scale (VS) that contains three questions with obvious answers. Thus, if participants are devoting adequate attention to the items, they will in all likelihood, answer these items correctly. Each of these questions is in True/False format. Correct responses warrant 1 point and incorrect responses result in no points. A score of 3 suggests that a participant is putting forth good effort. A score of 2 indicates that a participant's effort is not optimal, and a score of 0 or 1 suggests that participants are putting forth very little effort, and their data are likely to be invalid.

RoCKAS Supplements. The RoCKAS-Supplement forms have been designed to obtain detailed information about the demographic background and sport participation of the samples as well as obtaining additional information about concussion knowledge and attitudes. Separate forms were designed and tailored for students (RoCKAS-HSST Sup; 23 items; see Appendix G), athletic trainers (RoCKAS-HSATC Sup; 13 items; see Appendix H), and coaches (RoCKAS-HSCH Sup; 16 items; see Appendix I).

Each version of the RoCKAS-Supplement includes at least four sections: 1) "Demographic Information"; 2) "Occupational Information" for athletic trainers and coaches and "Academic Information" for students; 3) "School Information" for athletic trainers and coaches "Sports Participation and High School Information" for the students; and 4) "Concussion Questions". There is an additional section on the student form: "Concussion Ranking Lists". Each section will now be described.

The “Demographic Information” section is comprised of items about age, sex, and race/ethnicity. The “Occupational Information” section (for coaches and athletic trainers) includes information about coaches’ and athletic trainers’ experience level, the team(s) that they coach (for coaches only), and information about potential sources of concussion knowledge (for coaches) and outreach/educational activities (for athletic trainers).

The “High School Information” section includes questions about the individuals who make return to play decisions at school sporting events. Additionally, the student version also includes items about recent and current participation in sports.

Several items are included in the “Concussion Questions” section. All participants receive one common item from this section: an item that pertains to their perceptions about their personal concussion knowledge. Additionally, athletic trainers and coaches are presented three “concussion ranking lists” that include instructions directing the participants to rate the importance of the items presented in the following areas: type of injury (e.g., torn knee ligament vs. concussion), signs and symptoms of concussion (e.g., confusion vs. LOC), and return to play decision makers (e.g., coach vs. athletic trainer). These ranking lists are presented to the students in the “Concussion Ranking Lists” section.

Previous Concussion Questionnaire. The Previous Concussion Questionnaire (PCQ; shown in Appendix J) was administered to students only. The measure includes a definition of concussion indicating that a concussion can be induced by a jarring force to the brain and may lead to LOC, amnesia, with or without a small brain lesion as detected by brain imaging tools. This definition reflects the consensus opinion of the aforementioned Prague concussion conference (McCrory, et al., 2005). Additionally, the questionnaire contains a list of 20 symptoms that are commonly experienced after concussion. This list was derived from the PCSS (Lovell & Collins, 1998), a widely used self-report measure of cognitive, physical, and affective symptoms.

The instructions on the PCQ direct the participant to review the description of concussion and the list of symptoms, students are asked to report whether they have experienced any of the symptoms, and, if so, to estimate the number of concussions that they received during the last full academic year and throughout their lifetime.

Concussion Incidence Questionnaire. The Concussion Incidence Questionnaire (CIQ) is administered only to coaches and athletic trainers. There are two variations of the measure: CIQ-High School Athletic Trainer (CIQ-HSAT; see Appendix K) and CIQ-High School Coach (CIQ-HSCH; see Appendix L). Both variations include the same description of concussion as the PCQ. However, the coach version asks coaches to provide an estimate of the number of athletes on the team(s) that they coach that have had single or multiple concussions within the past full academic year. Coaches are also asked to estimate the percentage of high school coaches who make RTP decisions. The CIQ-HSAT includes questions about the estimated number of athletes in the *entire school* who sustained single or multiple concussions in sports within the past full academic year. Coaches and athletic trainers are also asked to rate their confidence in their estimates, and both versions include confidence ratings on a Likert scale of 1-5 (Low Confidence to High Confidence).

Marlowe-Crowne Social Desirability Scale (Marlowe-Crowne). This scale includes 33 items that are used to examine individuals' tendencies to present themselves in a favorable and socially-desirable manner (see Appendix M). The items included on the instrument are common experiences and reactions that may lead an individual to experience some discomfort or upset. Individuals who deny having many of these experiences are believed to be attempting to present themselves in an overly favorable manner.

The Marlowe-Crowne Scale includes such items as “I have never deliberately said something to hurt someone’s feelings” and “I never hesitate to go out of my way to help someone in trouble”. Crowne and Marlowe amassed significant evidence to demonstrate that their scale measured defensiveness and protection of self-esteem (1964, p. 206). Furthermore, they found that the scale correlates significantly (r (36) = .54, $p < .01$) with the L scale of the MMPI. High scorers on the L scale of the MMPI have been characterized as individuals who demonstrate defensiveness and denial in relation to negative characteristics, and who tend to repress signs of psychological distress (Graham, 2000). This measure was used to identify the participants in the pilot group who appear to be answering questions in a manner that suggests an overly socially desirable presentation that may obscure any important trends in unsafe attitudes.

Scoring procedure for the Marlowe-Crowne. As indicated, the Marlowe-Crowne items are in True/False format. Although there are no “correct” answers per se, most individuals who are answering honestly will answer display a certain pattern of reporting. Based on these commonly provided responses, each item will be scored 0 for an “honest” response and 1 for a “dishonest” response. The scores are summed and a total Marlowe-Crowne score is derived. Higher scores on this scale indicate a strong pattern of socially desirable responses.

Because the CAI and CKI indices are scored to derive an ascending order scoring system whereby higher scores indicate higher knowledge and safer attitudes, respectively, the PI chose to reverse code the Marlowe-Crowne (e.g., an initial score of 33 on the Marlowe-Crowne would be reverse coded to a transformed score of 1, and an initial score of 1 on the Marlowe-Crowne would be reverse coded to a transformed score of 33). Thus, instead of indicating high social desirability, the scores were transformed so that a high score would indicate low social desirability. By using this transformation system, the PI was able to examine all variables on the same metric (i.e., ascending order scoring system—a high attitude score would positively correlate with a high Marlowe-Crowne score indicating a safe attitude and low social desirability bias).

Procedure

With the exception of the confirmatory factor analysis and some of the power analysis, all analyses were conducting using the Statistical Package for the Social Sciences (SPSS) version 15 (SPSS, Inc., 2005). Amos 7.0 (Arbuckle, 1999) was used to conduct the confirmatory factor analysis, and GPower (Erdfelder, Faul, & Buchner, 1996) was used to conduct some of the power analyses.

Pilot study: Development of measures. As noted, the pilot study was conducted to examine the psychometric characteristics of the RoCKAS forms and the RoCKAS-Supplement forms.

RoCKAS-Preliminary forms. During the pilot study, potential differences were examined between two preliminary forms of the RoCKAS-ST that contained different wording on the attitude items in Section 3. The alternate preliminary forms of the RoCKAS-ST were the RoCKAS-Preliminary Direct question version (RoCKAS-PD) and the RoCKAS-Preliminary Indirect question version (RoCKAS-PI). These forms were used to identify which phrasing format was least affected by a socially desirable response bias and, thus, most likely to identify true concussion attitudes.

The lone difference between the RoCKAS-PD and PI was the wording of the items in Section 3. As noted, these items pertain to attitudes about concussion management and RTP decision making. The items in Section 3 of the RoCKAS-PD instruct participants to rate their level of agreement with questions that directly assess their attitudes (e.g., “I feel that it is usually best to play through the pain following concussion”). Section 3 of the RoCKAS-PI includes items that indirectly assess attitudes of participants by obtaining their perception of attitudes among their colleagues/fellow athletes (e.g., “Most athletes feel that it usually best to play through the pain following concussion”).

It should be emphasized that the RoCKAS-PD and PI were *preliminary* forms of the RoCKAS-ST and based on the correlations obtained when the attitudes reported were correlated with the Marlowe-Crowne. One form of the RoCKAS was selected for administration in the main study. The selection procedure will be described later.

RoCKAS-PD computerized and written versions. To increase the ease of administration and the portability of the survey, the computerized and written versions of the RoCKAS-PD were utilized and scrutinized. The content of both of the PD versions was identical, but the administration format varied. The computerized form was created because it is typically more difficult and costly to administer written forms. As will be indicated later, correlations were conducted comparing the two PD forms to identify the relationship between the forms of administration.

Validation procedure for RoCKAS-ST and Supplements. The validation procedure for the RoCKAS-ST in the pilot study was conducted in three phases.

Phase I: Qualitative validation from experts. The initial phase was conducted to obtain information about the content validity of the written forms of the RoCKAS-PD and PI; RoCKAS-HSST, HSAT, and HSCH Supplements; and the PCQ, CIQ-HSST, and CIQ-HSCH. To expedite the completion of phase I, the RoCKAS-PD and PI were combined. Because the only difference between the two versions was the wording of Section 3, this section from the RoCKAS-PI was appended to the end of the RoCKAS-PD. Thus, the experts received the RoCKAS-PD with Section 3 from the RoCKAS-PI (i.e., RoCKAS Combined form [i.e., RoCKAS-PD+]). A bulleted outline of the order in which the measures were administered to the students (i.e., RoCKAS-ST, RoCKAS-HSST Sup, PCQ, and Marlowe-Crowne) was also submitted to the expert panel to obtain their input on optimal sequencing of measures and to avoid any priming effects (i.e., a previous item providing information that can assist in answering later items).

The RoCKAS-PD+, each RoCKAS Supplement, PCQ, and CIQ were reviewed by several professionals: three neuropsychologists, one psychophysiologist, and one industrial/organizational psychologist. Additionally, the RoCKAS-AT, RoCKAS-HSAT Sup and CIQ-HSAT were reviewed by two certified athletic trainers, and the RoCKAS-CH, RoCKAS-HSCH Sup, and CIQ-HSCH were reviewed by two high school coaches. This panel of experts was used to identify any potentially confusing, unnecessary, or problematic content within the measures. Much of the feedback obtained resulted in minor wording changes. However, there were some suggestions made about potential new items and excessive and superfluous items. Based on these suggestions, a handful of items on each of the above items combined were removed. Moreover, the experts approved the proposed order of administration of the measures, and this ordering was used throughout the subsequent phases and into the main study (with the exception of the Marlowe-Crowne, which was not administered to participants in the main study).

Phase II: Qualitative validation from students. This phase involved obtaining further information about the content validity of the measures from small groups of students. Seven students (5 athletes and 2 non-athletes; 3 males, 4 females) were placed into two groups. One group (N = 3) received the computerized RoCKAS-PD+, and the other group (N = 4) received the written version. Additionally, due to the time constraints of the participants, they each only received 2 of the 3 accompanying measures (i.e., the RoCKAS-HSST Sup, PCQ, and the Marlowe-Crowne).

In order to assess the clarity of the items, the PI sat with each participant individually as they completed the measures. Before completing the survey, the PI instructed the participants to ask any questions that arose while they completed the survey. Additionally, the PI pre-selected several items on each measure and queried participants about their interpretation of the meaning of the items and their rationale for the answers that they provided.

Analysis and alteration of measures after Phase II. It was determined before this phase of the study that the appended questions from Section 3 of the RoCKAS-PI would be removed, and this was done accordingly. Based on the student feedback, one item was removed from the RoCKAS-PD/PI, and this was due to lack of understanding about the terminology used in the question. Three items were removed from the RoCKAS-HSST Supplement all having to do with concussion grading and RTP criteria because the students' responses suggested that the items were beyond the scope of a typical student's knowledge.

Phase III: Quantitative validation of RoCKAS-PD. Among other objectives for Phase III, the computerized and written versions of the RoCKAS-ST were examined to establish content and construct validity. One hundred twenty-seven participants adequately completed the measures in Phase III. Three forms of the RoCKAS were administered to three subgroups: written RoCKAS-PD (*N* = 43), computerized RoCKAS-PD (*N* = 37), and written RoCKAS PI (*N* = 47). Table 2 shows the distribution of participants by athletic status and sex. The distribution of the participants into these groups is appropriate and roughly equivalent to the distribution of remaining pilot sample which will be described in the next section.

Table 2

Demographic Information for Participants Completing RoCKAS-PD Forms or RoCKAS-PI Form

RoCKAS Form	*N*	Athletes	Non-Athletes	Males	Females
Written RoCKAS-PD	43	28 (65.1 %)	15 (34.9%)	19(44.2%)	24(55.8%)
Computerized RoCKAS-PD	37	21 (56.8%)	16 (43.2%)	20(54.1%)	17(45.9%)
Written RoCKAS-PI	47	33 (70.2%)	14 (29.8%)	18(38.3%)	29(61.7%)

Analysis and alteration of measures after Phase III. Although the exact details of the data analysis will be elaborated upon later, it is important to note how the data were used to shape the RoCKAS-ST. Independent sample t-tests were conducted to establish equivalency between the critical indices (i.e., CKI, CAI, and Marlowe-Crowne) on the different forms of administration (i.e., RoCKAS-PD computerized and RoCKAS-PD written).

In order to identify the relationship between the content of the questions (i.e., either direct or indirect questions) pertaining to participants' attitudes (i.e., Section 3 on the RoCKAS) and the results of the Marlowe-Crowne, a correlational analysis was conducted. As will be discussed in more detail later, the RoCKAS-PD and the RoCKAS-PI exhibited similar non-significant correlations to the Marlowe-Crowne (i.e., neither version appeared to be especially vulnerable to social desirability). Thus, because the RoCKAS-PD items ask directly about personal attitudes (i.e., the primary construct being measured), that version was retained.

Equivalence between the written and computerized forms of the RoCKAS-PD on the critical indices (i.e., CKI and CAI) was established using independent samples t-tests. This finding provided validation for the use of both forms to assess concussion knowledge and attitudes.

After equivalency between the versions was established, test-retest reliability analyses were conducted on the RoCKAS-ST. Students who completed this version of the survey (N = 54; see Table 3). The proportion of participants completing the test-retest study appeared to be different from that of the remaining pilot sample. Thus, various statistical analyses were conducted to examine this discrepancy. These analyses are reported in the next section.

Table 3

Demographic Information for Participants in Test-Retest Sample

RoCKAS Form	*N*	Athletes	Non-Athletes	Males	Females
RoCKAS-ST—Test-Retest Analysis	54	43 (73.6%)	11 (20.4%)	21 (38.9%)	33 (61.1%)

The participants were administered the measures on two occasions with two days separating the administrations. Although this test-retest interval was not ideal, it was chosen to accommodate the needs of the high school students, teachers, and administration.

Correlational analyses were conducted comparing the day 1 and day 2 performances on the RoCKAS-ST and RoCKAS-HSST Sup.

Phase IV: Development of construct validity and reliability. To identify the factor structure of the RoCKAS-ST CAI, an exploratory factor analysis (EFA) was conducted. Specific information pertaining to the EFA will be discussed later, but upon choosing an appropriate EFA model, a confirmatory factor analysis (CFA) was conducted to establish the goodness of fit of the model to the data. Due to the binary nature of the CKI items, a cluster analysis was conducted to examine the construct validity of the index.

Internal consistency (Cronbach's Alpha) analyses were conducted on the CAI after the initial quantitative analysis stage. These analyses were used to establish the reliability of the scales derived from the EFA and CFA. The results of the analyses will be discussed later.

Procedure for main study. After undergoing the validation procedures, the revised RoCKAS-ST/AT/CH were administered to the respective samples. After consenting to participate in the study, students completed the measures via computer.

Athletic trainers, after consenting to participate, were asked via email to complete the online computerized versions of the measures.

Coaches received the measures after consenting to participate. About 1/3 of the coaches' sample completed written copies of the measures before participating in a sports injury safety workshop, and the majority of coaches completed the measures in computerized form after receiving an email from the PI that was forwarded to them by their athletic director.

Chapter 3

Results

Pilot Study

As was indicated above, phases I and II were qualitatively based, and, thus, no statistical analyses were conducted on the data collected during those phases.

Phase III: Part 1—Comparison of RoCKAS-PD to RoCKAS-PI. This portion of the pilot study involved the comparison of the phrasing of the attitude questions in Section 3 on the RoCKAS-PD and RoCKAS-PI, respectively (as indicated, the only difference between these measures was the phrasing of the items pertaining to attitudes; in the PD version, participants were asked to make selections based on their own personal feelings, and in the PI version, participants are asked to make selections based on their views of the feelings of most other athletes). However, because the samples of participants completing either version of the RoCKAS contained students from multiple high schools, a non-parametric analysis was conducted to establish homogeneity of the sample of participants who completed each version.

Students from three high schools completed each form of the RoCKAS-PD. Thus, to assure homogeneity among the participants within each group on the critical indices, preliminary non-parametric statistical analyses were conducted. Non-parametric analyses were selected due to the relatively small number of participants from each school who completed each version.

Participants from three high schools completed the written version of the RoCKAS-PD and were compared using Kruskal-Wallis analyses which revealed no significant between-group differences on CKI scores χ^2 (2, N = 36) = 1.24, $p > .05$ or CAI scores χ^2 (2, N = 36) = .45, $p > .05$.

The written version of the RoCKAS-PI was completed by participants from two high schools (N = 46). Mann-Whitney U tests were conducted comparing participants from each high school on the CAI and CKI scores. There were no statistically significant differences among the participants from different high schools on the CKI (U = 193.00, N_1 = 29, N_2 = 17, $p > .05$, two-tailed) or on the CAI (U = 237.50, N_1 = 29, N_2 = 17, $p > .05$, two-tailed). These findings suggest that, because there were no significant differences on the basis of the school that the participant attended on the written RoCKAS-PD or on the written RoCKAS-PI, the homogeneity of participants who completed either version was established.

After the group homogeneity was established, the CAI scores on the RoCKAS-PD and RoCKAS-PI were correlated with the total score on the Marlowe-Crowne Social Desirability Scale. These analyses were conducted to identify which version of the RoCKAS was less susceptible to socially desirable responding and, thus, more indicative of genuine concussion attitudes. Bivariate Pearson Product Moment correlation coefficients were conducted to identify these relationships.

There was no statistically significant correlation between the RoCKAS-PI CAI and the Marlowe-Crowne (r = -.08, N = 46, $p > .05$, d = .006). However, a significant difference was identified between the RoCKAS-PD CAI and the Marlowe-Crowne (r = -.36, N = 36, $p < .05$, d = .13).

Because the correlation was statistically significant, an additional 331 participants (i.e., the Large Sample), who were initially reserved for analyses to be conducted in another phase of the study but who also completed the RoCKAS-PD, were combined with the original 36-participant RoCKAS-PD sample (i.e., the Small Sample). The addition of these participants resulted in the relationship between the CAI and Marlowe-Crowne scores becoming statistically non-significant (r = -.09, N = 367, p > .05, d = .008).

Thus, based on an analysis conducted using only the Small Sample, the RoCKAS-PD appeared to be vulnerable to social desirability, but when a more statistically powerful sample was examined, this apparent vulnerability all but disappeared. The latter finding suggests that the RoCKAS-PD is likely to be an adequate indicator of attitudes about concussion that is not significantly contaminated by social desirability bias.

It should be noted that the Large Sample consisted of students from an additional high school. Thus, in order to establish the homogeneity of the Small and Large Samples, independent samples t-tests were conducted to compare CAI scores and CKI scores across the samples. The results of these analyses showed that the samples were not significantly different on the CAI score (t = 1.34, df = 365, p > .05, two-tailed) or on the CKI score (t = .25, df = 365, p > .05, two-tailed), and suggest homogeneity across the Small and Large Samples on these two indices.

Phase III: Part 2—Comparison of Written & Computerized Versions. In order to establish the equivalence of the written RoCKAS-PD and the CPU RoCKAS-PD, a separate sample of participants from three high schools (*N* = 33) was obtained to complete the RoCKAS-PD computerized version.

The homogeneity of CAI and CKI scores across participants from the three schools was established using Kruskal-Wallis analyses. The results indicated that both the CKI (χ^2 (2, *N* = 33) = .08, *p* > .05) and CAI (χ^2 (2, *N* = 33) = 3.42, p > .05) scores were not significantly different and suggest homogeneity of participants who completed the computerized version of the RoCKAS-PD.

After establishing group homogeneity, t-tests were conducted to identify whether the written and computerized versions of the RoCKAS-PD displayed relative equivalence on the CKI and CAI scores. Independent samples t-tests revealed no significant difference between the scores obtained on either version of the CKI (*t* = .64, df = 67, *p* > .05, two-tailed) or the CAI (*t* = -.03, df = 67, *p* > .05, two-tailed). These results suggested that that written and computerized versions of the RoCKAS-PD were equivalent.

Phase III-Part 3: Test-retest reliability. As noted in the previous section, there were a significantly higher proportion of athletes in the test-retest sample relative to the proportion of athletes in the remaining pilot sample. Chi square analyses established the statistical significance of this difference (χ^2 (1, *N* = 504) = 4.20, *p* < .05).

Thus, a two-way MANOVA (2*2—Athletic status*Group membership [test-retest sample or sample from previous phases of pilot study]) was conducted to determine whether the numbers of athletes and non-athletes participating in the test-retest (TR) phase were significantly different from the numbers of athletes and non-athletes participating in the previous phases (PP) of the pilot study (excluding those who completed the RoCKAS-PI). It should be noted that CAI and CKI scores from the first survey completed by the TR sample were used in the analysis. The results of the MANOVA are displayed in Table 4.

Table 4

Results of MANOVA Examining Differences Between Test-Retest Sample and Sample from Previous Phases

MANOVA	F-statistic (2,499)	p-value	Wilks' Lambda	partial η^2
Main Effect of Group (Test-retest Group or Pilot Group)	.27	>.05	.99	.001
Main Effect of Athletic Status (Athlete or Non-Athlete)	1.56	>.05	.99	.006
Interaction between Group & Athletic Status	.97	>.05	.99	.004

The results suggest that the TR and PP groups did not significantly differ on CAI or CKI scores. Additionally, athletes and non-athletes do not appear to exhibit any statistically significant between-group differences on CAI or CKI scores. Finally, the interaction between group and athletic status failed to achieve statistical significance, suggesting the absence of any substantial CAI or CKI score differences between students on the basis of their athletic status as a function of group membership. This finding established the relative equivalency of the CAI and CKI scores across groups, and, thus, justified the use of the data collected from the TR sample to estimate the test-retest reliability of the CKI and CAI.

Two bivariate Pearson Product Moment correlational analyses were conducted to establish the test-retest reliability of the CKI and CAI. The first analysis compared CKI scores at survey times 1 and 2 and the second analysis compared CAI score at survey times 1 and 2. A significant positive correlation between CAI scores (r = .79, N = 54, p < .001, two-tailed) was identified which suggests that the test-retest reliability of the CAI was adequate.

Although a statistically significant positive correlation between CKI scores was identified (r = .67, N = 54, p < .001, two-tailed), the failure of the coefficient to reach at least .70 places the stability of the CKI into question. This result may be explained by several factors which will be discussed in the next section.

Phase IV: Data Reduction and Scale Development—Part 1-Exploratory factor analysis. Before conducting the exploratory factor analysis (EFA) on the 15 items believed to comprise the Concussion Attitudes Index (CAI), a missing values analysis was conducted to identify the rates of missing responses for each item. Tabachnick and Fiddell (2001) indicated that items with no greater than 5% of the data missing can be retained for analysis. None of the 15 CAI items surpassed 3.7%, and a large majority were missing 2% of the data or less. The missing data was replaced using a group mean replacement procedure (Tabachnick & Fiddell, 2001) whereby the mean score of the pilot sample was calculated and used to fill in the missing data cells. As was indicated earlier, the researcher removed participants' data from the analysis in the case that they were missing more than two CAI items.

EFA of the 15 items on the CAI produced a four-factor solution containing 13 items that explained about 59% of the total variance. A principal components analysis with varimax rotation produced the final solution, but three EFAs were conducted before reaching this solution.

EFA 1 was an unconstrained principal components analysis that was rotated using promax rotation because it was initially believed that the factors would be moderately to highly correlated. This EFA produced a five-factor solution and contained several items that displayed multicollinearity among factors. As was the case with this and each of the additional EFAs, factors were selected based on examination of the scree plot and eigenvalues greater than or equal to 1. Additionally, the median intercorrelation among the factors was .16 (range = .03-.37; includes 10 intercorrelations among factors). The complete correlation matrix can be found in Appendix N.

Thus, due to the relatively low correlations among the factors, the decision was made to conduct a second EFA using varimax rotation. EFA 2 was also unconstrained, but used an orthogonal factor rotation method (i.e., varimax rotation) to extract the factors. As with EFA 1, a five-factor model was generated, and again some of the items showed substantial multicollinearity among factors. Factor 5 contained two items, but due to multicollinearity, one of the items was uninterpretable.

Based on these findings, data were placed into a constrained four-factor EFA with varimax rotation and included all 15 CAI items in the model. Relative to EFA 3, loadings improved for most of the items with the exception of two items that were multicollinear. These items were removed and the final EFA was conducted using the 13 remaining items which were placed into a constrained four-factor solution with varimax rotation.

The final solution approached simple structure. Factor 1 (Eigenvalue = 3.31) consisted of four items pertaining to personal attitudes about concussion (e.g. "I would continue playing a sport while also having a headache that resulted from a minor concussion.") and was labeled Personal RTP Attitudes. The second factor (Eigenvalue = 1.78) contained four items that were related to others' attitudes towards concussion (e.g. after being presented with a scenario, participants are asked to indicate whether they thought that "Most athletes would feel that Athlete H should tell his coach about the symptoms.") and was labeled Views about Others' RTP Attitudes. Participants' views about coaches' concussion management were addressed in Factor 3 (Eigenvalue = 1.51). This factor contained three items (e.g. I feel that coaches need to be extremely cautious when determining whether an athlete should return to play) and was labeled Views about Coaches' Concussion Management and Precautions. Factor 4 (Eigenvalue = 1.10) contained only two items that were focused on views about the role of the athletic trainer (e.g., the participant read a scenario about an athlete who sustained a concussion in the presence of an athletic trainer and the participant was asked to indicate the extent to which "I feel that the athletic trainer, rather than athlete R, should make the decision about returning Athlete R to play"). This factor was labeled Views about Athletic Trainers' Concussion Management.

Phase IV: Data Reduction and Scale Development—Part 2: Internal consistency of extracted CAI factors. Internal consistency analyses using Cronbach's Alpha scores were conducted on the entire 13 item index as well as on each of the subscales. The internal consistency of the 13 item index was acceptable (coefficient alpha = .74). According to the coefficient alpha, and the change in Cronbach's Alpha if Item Deleted, there did not appear to be any items that should have been removed from the index. Subscales 1 and 2 (Personal RTP Attitudes and Views about Others' RTP Attitudes, respectively) displayed acceptable coefficient alpha values of .71 and .70, respectively. However, the coefficient alpha estimates for Subscales 3 & 4 (Views about Coaches' Concussion Management & Precautions and Views about Athletic Trainers' Concussion Management, respectively) were marginal as they displayed alphas of .60 and .61. These low estimates are likely due to the relative lack of items within each subscale (two items and three items, respectively), but a more detailed discussion of this of this issue will be included in the next section.

Phase IV: Data Reduction and Scale Development—Part 3-Confirmatory factor analysis. Confirmatory factor analyses (CFA) were conducted to establish the goodness of fit of the four-factor model identified by the EFA. Amos 7.0 was used to conduct all CFA analyses and maximum likelihood estimation was utilized. Four models were examined to establish the goodness of fit of the primary model (i.e., the model identified by the EFA) relative to alternative models. The four models are shown in Table 5.

Table 5

Four models establishing the goodness of fit of the primary model (i.e., the model identified by the EFA) relative to alternative models

Model	df	χ^2	*GFI*	*CAIC*	*RMSEA*	χ^2 difference between previous model

Model 1 (1 factor)	65	643.78	.81	829.19	.14	N/A
Model 2 (Hierarchical Model)	61	277.44	.92	491.38	.09	χ^2 difference (4, N = 460) = 366.34, $p < .001$
Model 3 (4 factor intercorrelated/primary model)	60	255.12	.92	476.19	.08	χ^2 difference (1, N = 460) = 22.32, $p < .001$
Model 4 (modification indices)	59	179.17	.94	407.37	.07	χ^2 difference (1, N = 460) = 75.95, $p < .001$

Model 1 included all 13 CAI items which were loaded onto a single general attitude factor. This one-factor model was analyzed because it was the most parsimonious (i.e., greatest degrees of freedom and least number of statistical constraints) and to provide a comparison for other multifactorial models including the primary model.

Model 2 was a second-order model that included the four factors identified by the EFA and a general attitude factor. This model was hierarchical in that it suggested that each of the CAI items loaded onto both a general attitude factor and onto one of the four EFA factors.

The third model (Model 3) was the first iteration of the primary (four-factor) model. In this model, CAI items were distributed among the factors according to their EFA factor loading. The model also included correlations among the factors. Initial analysis of this model revealed a negative variance estimate for one variable and, consequently, goodness of fit analyses could not be conducted. The variance for this variable was set at 0 and reanalysis of the model produced the Model 3 data shown above.

Modification indices were included in Model 4. This model was similar to the third model, but adjusted for high covariance estimates among error variables according to modification indices.

Goodness of fit indices were calculated for each model. These indices were selected to provide a variety of model fit estimates that each examined different elements of goodness of fit. Three indices were used to establish goodness of fit: 1) the goodness of fit index (GFI) is a measure of the amount of variance and covariance in the data accounted for by the model and is not adjusted for model parsimony, 2) the Consistent Akaike Information Criterion (CAIC) is a test that accounts for parsimony and sample size to establish goodness of fit, and 3) root mean square error of approximation (RMSEA) is based on the degrees of freedom in the model and does not account for the size of the model. For the GFI, values closer to 1.00 suggest good fit; although cutoff values do not exist for the test, smaller values on the CAIC suggest good fit; and values below .05 on the RMSEA indicate good model fit (Byrne, 2001).

Additionally, chi square goodness of fit tests were conducted, and the chi square values were used to conduct chi square difference tests. The chi square difference is calculated by subtracting chi square scores and the degrees of freedom of two CFA models. Statistical significance of the chi square difference is determined by comparing the difference between chi square values and the difference between the degrees of freedom of each model to a chi square significance table. For example, the chi square value and the degrees of freedom from model 2 are subtracted from the corresponding values in model 1. If the difference is positive and statistically significant, then it can be concluded that the latter model fits the data better than the former.

The results of the CFA suggested that the four-factor primary model with modification indices included produced the best fit. Relative to Model 1, each of the other models showed substantially better fit, thus suggesting that the data are best explained by a multifactorial model. The failure of Model 2 to produce the best fit, when considered in combination with the poor fit of Model 1, indicated that a general factor is likely not accounting for a substantial amount of variance within the sample. Thus, Model 3 and Model 4, which both include orthogonal four-factor models, appear to best fit the data. However, due to a moderately strong correlation between the error variance of two variables, which was accounted for in Model 4, it was apparent that Model 4 produced the best fit.

Phase IV: Data Reduction and Scale Development—Part 4-Cluster Analysis. This analysis was chosen instead of a factor analysis due to the binary nature of the responses on the 25 CKI items. A hierarchical cluster analysis using binary measurement (i.e., correct responses set to 1 and incorrect responses set to 0) of squared Euclidean distances was conducted.

Cluster analysis is a procedure whereby a group of heterogeneous items are organized into pairs and/or groups to produce homogenous latent constructs. The groups, or clusters, are formed after distances are calculated between a score on a particular item and scores on every other item. The two items with the lowest proximity scores (i.e., small distance between items) comprise the first cluster. The next cluster is formed by finding the next variable that has the next lowest proximity score relative to either another item or to the first cluster. This process continues until all items comprise one cluster (George & Mallery, 2001).

The agglomeration schedule is commonly used to visually estimate the number of clusters. The schedule includes hierarchically arranged clusters and displays proximity coefficients. These coefficients are used to determine the number of clusters. Although, there is no particular coefficient cutoff, the agglomeration schedule is similar to the scree plot used in the factor analysis procedure. Specifically, when the coefficient scores begin to drop substantially from one cluster to the next, a range of clusters is determined by the researcher and a subsequent cluster analysis is conducted within the range of clusters set by the researcher.

An unconstrained cluster analysis was conducted using all 25 CKI items, and examination of the agglomeration schedule suggested a 2-5 cluster solution. Next, a second cluster analysis was conducted that constrained the data to 2-5 clusters. The item composition of each of the cluster solutions was examined and evaluated on the basis of theoretical and practical relevance and applicability. The three-cluster solution was selected because it portrayed the relationships among the data in the most comprehensible and seemingly parsimonious manner. Table 6 displays this solution, and the percentage of participants who correctly answered each item.

Table 6

Cluster Structure of Concussion Knowledge Index

	Cluster		
Item	1	2	3
# of items	20 items	2 items	3 items
Cluster Item 1 (% of participants correctly answering items)	There is a possible risk of death if a second concussion occurs before the first one has healed. (90.0%)	People who have had one concussion are more likely to have another concussion. (48.0%)	After a concussion occurs, brain imaging (e.g., CAT scan, MRI, X-Ray, etc.) typically shows visible physical damage (e.g., bruise, blood clot) to the brain. (16.5%)
Cluster Item 2	In order to be diagnosed with a concussion, you have to be knocked out. (90.9%).	A concussion can only occur if there is a direct hit to the head. (50.7%)	After a concussion people can forget who they are and not recognize others but be perfect in every other way. (25.2%)

Cluster Item 3	Being knocked unconscious always causes permanent damage to the brain. (75.9%)	An athlete who gets knocked out after getting a concussion is experiencing a coma. (34.6%)
Cluster Item 4	Symptoms of a concussion can last for several weeks. (92.6%)	
Cluster Item 5	Sometimes a second concussion can help a person remember things that were forgotten after the first concussion. (75.9%)	
Cluster Item 6	If you receive one concussion and you have never had a concussion before, you will become less intelligent. (95.7%)	
Cluster Item 7	After 10 days, symptoms of a concussion are usually completely gone. (52.4%)	
Cluster Item 8	Concussions can sometimes	

	lead to emotional disruptions. (85.0%)
Cluster Item 9	There is rarely a risk to long-term health and well-being from multiple concussions. (75.4%)
Cluster Item 10	It is likely that Player Q’s concussion will affect his long-term health and well-being. (80.2%)
Cluster Item 11	It is likely that Player X’s concussion will affect his long-term health and well-being. (87.2%)
Cluster Item 12	Even though Player F is still experiencing the effects of the concussion, her performance will be the same as it would be had she not suffered a concussion. (87.6%)
Cluster Item 13	Headache (96.5%)
Cluster Item 14	Sensitivity to Light (81.1%)

Cluster Item 15	Difficulty Remembering (84.3%)
Cluster Item 16	Feeling in a Fog (79.6%)
Cluster Item 17	Feeling Slowed Down (78.5%)
Cluster Item 18	Difficulty Concentrating (84.6%)
Cluster Item 19	Dizziness (95.0%)
Cluster Item 20	Drowsiness (71.5%)

Note: *N* = 460. Cluster 1 = Low Degree of Difficulty; Cluster 2 = Moderate Degree of Difficulty; Cluster 3 = High Degree of Difficulty.

The table displays the diversity of items within each cluster. There do not appear to be any consistent theoretical constructs underlying the clusters, but rather, items seem to be distributed on the basis of percentage of participants who answered the items correctly. Thus, it appears that the items on the CKI comprise discrete groups based on their level of difficulty. Cluster 1 contained items that had the lowest level of difficulty. This is evidenced by the fact that only two of the 20 items were answered incorrectly by more than 25% of the sample. Cluster 2 was comprised of two items that were answered correctly by at least half of the participants, and the response patterns suggest that this cluster of items was moderately difficult. Cluster 3 contained three items that resulted in *incorrect* responses in at least 65% of the participants, thus suggesting that these had a high degree of difficulty. Due to the categorical nature of the variables and the relative lack of variability among the items included in the CKI, internal consistency analyses could not be conducted.

Phase IV: Data Reduction and Scale Development—Part 5—Validity scale. As indicated, the validity scale contained three items. The scale initially included seven items, but an analysis of the frequency of incorrectly answered items revealed that four items were answered incorrectly by between 17.4 - 36.3% of the participants. These items were deemed inadequate and removed from the validity scale due to high rates of incorrect responding, which indicated that the items likely lack the specificity required to identify participants who are providing adequate effort.

The response rates on the remaining three items ranged from 2.2 - 4.8%, and these items were retained in the Validity Scale.

Main study: Examination of knowledge about concussion. Because several groups were being compared on basis of their performance on the CKI, a univariate analyses of variance (ANOVA) was planned and was intended to serve as an omnibus examination of between-group differences in concussion knowledge. The groups that were to be included in these analyses were athletes with and without athletic trainers, non-athletes, athletic trainers, and coaches. However, the scores of the athletes who did not have athletic trainers were not normally distributed. Thus, a data transformation was conducted to reduce the skewness and kurtosis of the distribution (Tabachnick & Fiddell, 2001; formula: √([number of items on the measure + 1] - participant's observed score) and normality was established.

ANOVA was conducted using the transformed CKI, and a Levene's test revealed inequality of variances among the groups. Studentized residuals (Tabachnick & Fiddell, 2001) were calculated using the entire sample of participants across groups to identify and remove outliers. An additional ANOVA was conducted with outliers removed and variances remained unequal across groups. Thus, the decision was made to conduct a Kruskal-Wallis test and follow-up the "omnibus" test with t-tests adjusted for unequal variances, when necessary, to identify specific between-group differences in concussion knowledge. Because five t-tests were used, a Bonferroni correction for multiple comparisons was conducted (Miller, 1991). It was determined that type I error due to multiple comparisons could be avoided if the significance values of the t-tests fell below .01.

Two Kruskal-Wallis tests were conducted, and both included the transformed CKI scores as the dependent variable. However, the analyses differed in the number of levels of the independent variable: group membership. In the first Kruskal-Wallis analysis (K-W 1), athletes were split into groups based on the presence or absence of an athletic trainer at their respective schools. The athlete sample was divided in order to assess the potential influence of ATC availability on the concussion knowledge of athletes.

K-W 1 displayed statistical significance which indicated the presence of one or more between-group differences (χ^2 (4, N = 755) = 244.39, $p < .001$). This analysis and the follow-up t-tests described later were conducted to test Hypothesis 1 which stated that experience with and education about concussion would be closely associated with concussion knowledge. Five predictions were made and tested to establish the plausibility of the hypothesis, and they will be described in turn.

Hypothesis 1—Prediction 1. Prediction 1 stated that, relative to athletes at schools without ATCs, athletes at schools employing ATCs would be more knowledgeable about concussion. An independent samples t-test with presence/absence of an athletic trainer as the independent variable and transformed CKI score as the dependent variable was conducted. The results showed that the between-group difference did not achieve statistical significance (t = -1.48, df = 335, p > .05, d = .25, power = .53). Indeed, inspection of the non-transformed mean CKI scores for athletes with and without an ATC (see Table 7) shows that a small difference of less than one point separates the groups.

Table 7

Non-transformed CKI Descriptive Information Listed according to Group

Index	Group	Mean	*SD*	*N*
CKI				
	Athletic Trainers	21.63	1.24	148
	Coaches	20.67	1.79	129
	Athletes			
	-All athletes	18.70	2.52	337
	-Athletes with ATC	19.22	2.07	45
	-Athletes without ATC	18.62	2.58	292
	Non-Athletes	18.06	2.69	141

Note: Highest possible score on CKI is 25. A higher score indicates greater knowledge about concussion.
Transformed values rather than the non-transformed values listed in this table were used in the ANOVAs, but these values are reported to aid with interpretation.

Although a series of additional t-tests to identify specific between-group differences were planned, the initial t-test described above suggested equivalence within the total sample of athletes. Thus, the athlete groups were combined and a second Kruskal-Wallis test (K-W 2) was conducted. Transformed CKI score was again designated as the dependent variable and group membership was entered into the analysis as the independent variable.

Table 8 shows the results of the second Kruskal-Wallis test (K-W 2) and the follow-up t-tests.

Table 8

Kruskal-Wallis 2—Comparing CKI Scores across 4 Groups of Participants (Athlete Groups Combined)

Analysis	χ^2	*t*	df	*p*	*d*	Power
Kruskal-Wallis						
	χ^2 (3, *N* = 755) = 243.51, *p* < .001					
Follow-up t-tests						
	Coach vs. Ath	.62	464	< .001, two-tailed	88	N/A[c]
	ATC vs. Ath	6.99	403.22[a]	< .001, two-tailed	[b]	N/A[c]
	Coach vs. ATC	.99	243.64[a]	< .001, two-tailed	[b]	N/A[c]
	Ath vs. Non-Ath	2.55	476	.011[d], two-tailed	26	.52

Note: IV = Group membership (Levels = Athletes with ATC, Athletes without ATC, Non-athlete, Coaches, ATCs)
DV = Scores on Transformed CKI
df values that include decimals are indicative of *t* values obtained when equal variances were not assumed.

Bonferroni correction for multiple comparisons resulted in an adjusted *p* value of .01.
[a] Denotes that variances were unequal; df adjusted for unequal variances.
[b] Denotes that effect size could not be calculated due to unequal variances.
[c] Power is not reported because *p* value is statistically significant.
[d] *p* value is not significant at the Bonferroni adjusted level of .01.

Hypothesis 1—Prediction 2. The researcher predicted that a relationship would be identified between an athletes' primary knowledge source and their level of concussion knowledge. Table 9 shows the distribution of athletes by primary knowledge source. This table is a revision of Appendix O.

Initially, the sample was distributed into one of 11 groups based on the primary source that the athlete reported (see Appendix O). However, due to commonalities between some the sources (i.e., athletic trainers and physicians are both medical personnel), the fact that relatively few athletes endorsed certain sources, and for ease of interpretation, the initial groups were consolidated into 7 sources. Three sources—courses/workshops, neurologists/neuropsychologists, and "other"—were combined to form the "Other" group due to low endorsement rates, heterogeneity with other sources (i.e., neurologists/neuropsychologists likely possess greater knowledge about concussion than physicians and athletic trainers), and heterogeneity within the group (i.e., the initial "other" group contains a variety of unrelated sources). Additionally, a "Media" source was created and combined the athletes who reported either television or newspapers/periodicals as their primary source. A "Medical Personnel" source was also created and combined athletes who reported athletic trainers or physicians as their primary knowledge source.

It was expected that most athletes would list their coach as their primary knowledge source, but as Table 9 shows, only about 9% of athletes in the pilot and main studies (313 athletes responded to the question) listed their coach, whereas about 18% listed their parents. Other notable sources selected by both athletes with and without ATCs were family physician (14.7%), personal/teammate/opponent concussion (13.1%), and, in the sample of athletes with an athletic trainer (44 athletes with athletic trainers responded to the question), 25% reported that their athletic trainer was their primary source of knowledge. (It should be noted that many of the athletes with ATCs attended high schools where the ATCs were extremely active in promoting concussion safety. Therefore, it is possible that these athletes may have reported their ATC as their primary knowledge source more often than other athletes at schools with ATCs, and, consequently, may not be representative of the general population of athletes with ATCs).

Table 9

Percentage of Athletes in the Pilot and Main Studies Reporting Source as Most Important Source of Concussion Knowledge

Source	Athletes w/out ATC % athletes (# athletes)	Athletes w/ ATC % athletes (# athletes)	Average % across groups
Parents	18.2 (49)	13.6 (6)	17.6
Coach	9.7 (26)	4.5 (2)	8.9
Medical professionals	17.8 (48)	34.1 (15)	20.1
--Athletic trainer	--2.2 (6)	--25.0 (11)	--5.4
--Family physician	--15.6 (42)	--9.1 (4)	--14.7
Personal/teammate/opponent concussion	12.3 (33)	18.2 (8)	13.1
Friend	17.1 (46)	6.8 (3)	15.7
Media	10.8 (29)	11.3 (5)	10.9
Other[a]	12.3 (33)	11.4 (5)	12.1

[a]Sources of knowledge excluded—courses/workshops, neurologist/neuropsychologist, “other”—because of low representation, heterogeneity with other combined categories, and heterogeneity within category (i.e., “other”).

Thus, there appear to be a variety of sources that influence athletes’ concussion knowledge. Although, it is not listed on Table 9 it should be noted that courses/workshops about concussion were endorsed by only about 3% of the combined pilot and main samples. Additionally, a separate question was asked of the athletes about whether they had ever attended a presentation or received materials about concussion, and only about 6% of the athletes without ATCs and about 20% of the athletes with ATCs indicated that they had. Unfortunately, due to the small sample of athletes who reported receiving some educational information, analyses could not be conducted to compare knowledge differences between athletes who had and had not received concussion information.

Although coaches and athletic trainers were included in the study, one-to-one relationships between coaches' and athletes' or athletic trainers' and athletes' concussion knowledge could not be examined due to the lack of adequate sample sizes in the groups. The sample used in the survey included athletes from four schools with athletic trainers, and only three of the athletic trainers from these schools completed surveys.

Additionally, the sample sizes of athletes from these schools were quite small, and, as a result, statistical comparisons were not made between athletes and their athletic trainers on the basis of concussion knowledge (or concussion attitudes). Similar difficulties were encountered when comparisons between athletes and their coaches were considered. Hence, one-to-one comparisons on the basis of concussion knowledge (and concussion attitudes) could not be made.

In lieu of the one-to-one comparisons that were planned, differences in knowledge about concussion in coaches/athletic trainers (i.e., two sources that have been identified in the literature as influential to athletes; Sefton, 2003) and athletes were examined. These analyses do not directly address any potential influence that these individuals have on athletes, nor do they focus on the magnitude of the relationship between coach/ATC knowledge and athlete knowledge. However, they do shed light on general similarities/differences in concussion knowledge among the groups. Convergence (i.e., similar mean CKI scores, non-significant between-group differences, etc.) between the samples of athletes and one or both of the influencing groups may suggest similar levels of knowledge proficiency/deficiency and may serve as a *preliminary* indicator of a relationship between knowledge and attitudes between these groups.

In order to examine between-group similarities/differences in general concussion knowledge, the aforementioned K-W test was conducted and t-tests were run as follow-up analyses. Table 8 shows the results of the independent samples t-tests comparing athletes' transformed CKI scores to the scores of coaches and athletic trainers. Both analyses revealed substantial between-group differences. It is apparent from the mean values shown in Table 7 that the differences between both coaches and athletes and ATCs and athletes were somewhat marked.

On average, athletes scored two points lower than coaches and three points lower than athletic trainers. The effect size estimate for the difference between coaches' and athletes' scores was high (d = .88). Unfortunately, differences in the variability of the ATC and athlete scores were too large to calculate a reliable effect size value. Despite these statistical problems, meaningful and interpretable differences were identified. Contrary to the prediction, these data appear to suggest that there is little convergence among the concussion knowledge levels of athletes and coaches/athletic trainers.

An additional analysis was conducted which involved the assignment of athletes to identify any differences across athletes on the basis of their most important knowledge source. A single factor between-groups ANOVA was conducted. The dependent variable was concussion knowledge (transformed CKI scores were used due to non-normality of the data), and the independent variable was primary source of concussion knowledge. The results of the univariate ANOVA were not statistically significant ($F(5, 365) = 1.18$, $p > .05$, partial $\eta^2 = .02$, power = .42) suggesting that, regardless of primary knowledge source, substantial differences in concussion knowledge were not apparent across athletes.

Hypothesis 1—Prediction 3. The researcher predicted that coaches would have less knowledge about concussion than athletic trainers, and, indeed, the data supported this prediction. As shown in Table 8, the independent samples t-test comparing the transformed CKI scores of coaches' and ATCs' transformed CKI scores was statistically significant.

One of the factors that may contribute to the discrepancy between coaches' and athletic trainers' knowledge may be due to differences in academic and practical training in concussion definition, detection, and management. Athletic trainers typically receive training in many domains of athletic injury and may be more likely to be prepared to appropriately manage concussions (W. Buckley[1], personal communication, 8/2/07). However, it was unclear as to what type of training high school coaches typically receive. To address this issue, coaches in the current study were asked to list their college major.

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[1] Dr. Buckley is a certified athletic trainer and a faculty member in the Department of Kinesiology at Penn State who is involved in the development of the athletic training curriculum and in the instruction of undergraduate and graduate athletic training students.

About two-thirds of the coaches surveyed reported possessing a degree in physical education, health education, or other education specialties, whereas only about 4% reported receiving degrees in athletic training or other allied health fields. Thus, the coaches in the study who obtained college degrees in allied health fields are far outnumbered by those who obtained educational degrees.

Hypothesis 1—Prediction 4. It was predicted that athletes would have greater knowledge about concussion than non-athletes. The results of the independent samples t-test shown in Table 8 indicated the presence of a statistically significant difference by conventional standards (i.e., $p < .05$), but did not reach statistical significance at the .01 level—the criterion that was established by the Bonferroni correction for multiple comparisons. Additionally, the discrepancy between the mean values is less than one point, suggesting that the difference may have little practical significance.

Hypothesis 1—Prediction 5. It was predicted that concussion knowledge would differ based on the sport that the athlete played. Appendix P displays all of the sports that athletes in the project reported playing within their current academic year. Note that many athletes participated in multiple sports and are thus represented more than once in Appendix P.

The table shows wide distribution among sports on the basis of participation. However, due to limitations in sample size within each sport and overlap of students playing multiple sports, it was not possible to conduct between-sport comparisons on the basis of knowledge (i.e., compare football players' knowledge to ice hockey players' knowledge, etc.). Thus, athletes were classified into high, moderate, and low injury risk categories.

Injury risk level was defined according to the categories proposed by the American Academy of Pediatrics (1988): Contact/Collision, Limited Contact/Impact, Strenuous Noncontact, and Nonstrenuous Noncontact. Athletes were originally distributed into one of the four categories, but due to low sample sizes in the Strenuous Noncontact and Nonstrenuous Noncontact groups and due to the small relative differences in the concussion risk of the sports within each group, these groups were combined. For ease of interpretation, the American Academy of Pediatrics category names were changed. Specifically, Contact/Collision was changed to High Risk, Limited Contact/Impact was changed to Moderate Risk, and Strenuous Noncontact and Nonstrenuous Noncontact both were changed to Low Risk.

As is the case in most high school settings, few athletes participate in a single interscholastic sport. In the case that an athlete participated in multiple sports, the athlete was placed into the category of the sport that put the athlete at highest risk for injury. For example, if an athlete played football (high risk), basketball (moderate risk), and golf (low risk), they would be placed into the high risk category because football put that athlete at high risk for concussion.

Using this classification system, it was determined that only 15 of 336 athletes participated in one or more low risk sports, but *did not* participate in moderate or high risk sports. The remaining athletes were split among the moderate risk (N = 197) and high risk (N = 124) sports. These figures indicated that 197 athletes participated in at least one moderate risk sport, *may* have participated in one or more low risk sports, but *did not* participate in a high risk sport. The remaining group of 124 athletes competed in at least one high risk sport and *may* have participated in moderate risk or low risk sports

Due to the relatively small sample size of the low risk group and the substantially larger sample size of the high risk and moderate risk groups, a non-parametric Kruskal-Wallis test was used to examine the between-group differences on the CKI scores. The analysis showed no significant between-group differences, $\chi^2(2, N = 336) = 1.34, p > .05$. Table 10 shows the mean CKI scores for each group.

Table 10

Mean CKI scores by Level of Concussion Risk of Sports

Group	Mean	*SD*	*N*
High Risk	18.56	2.42	124
Moderate Risk	18.73	2.62	197
Low Risk	18.20	3.14	15

The table shows that the greatest difference between groups on the CKI was about one-half of a point. Due the relatively small differences among the groups, individual between-group statistical comparisons were not conducted.

Main study: Examination of concussion attitudes. The procedure that was used to establish an omnibus measurement of concussion knowledge was again used in the analysis of concussion attitudes. Specifically, before data were analyzed, tests of normality were conducted. The results showed that athletic trainers' CAI scores were not normally distributed. Thus, a data transformation was conducted to reduce the skewness and kurtosis of the distribution (Tabachnick & Fiddell, 2001; formula: √([number of items on the measure + 1] - participant's observed score) and normality was established.

ANOVA was then conducted using the transformed CAI score as the dependent variable and group membership as the independent variable. The groups included in the analysis were athletes with ATCs, athletes without ATCs, coaches, ATCs, and non-athletes. The univariate test was statistically significant, $F(4, 750) = 245.20$, $p < .001$, partial $\eta^2 = .57$. Bonferroni post-hoc analyses were performed to identify between-group differences among the levels of the independent variable (i.e., group). The difference between athletes with ATCs and those without did not achieve statistical significance ($p > .05$). This finding indicated that the division of athletes into groups based on the availability of an athletic trainer was not necessary, and the groups were combined.

A second ANOVA was conducted that included four levels of the independent variable: combined group of athletes, coaches, athletic trainers, and non-athletes. Table 11 shows that the univariate F test was significant, and most of the post-hoc analyses reached statistical significance as well. These post-hoc tests will be described in the upcoming paragraphs.

Table 11

ANOVA Comparing CAI Scores across 3 Groups of Participants (*Athlete Groups Combined*)

Analysis	*F*	*p*
ANOVA		

$F(3, 751) = 324.82$, $p < .001$, partial $\eta^2 = .57$

Bonferroni Post-Hoc

Athletes vs. Non-Athletes	> .05
Coaches vs. ATCs	< .001
Ath vs. Coaches	< .001
Ath vs. ATC	< .001

Note: IV = Group membership (Levels = All Athletes [Athletes with & without ATCs], Non-athlete, Coaches, ATCs)
DV = Scores on Transformed CAI

Hypothesis 2. Hypothesis 2 stated that experience with and education about concussion will be closely associated with attitudes toward concussion. Several predictions were posited to test the hypothesis.

Hypothesis 2—Prediction 1. This hypothesis stated that athletes at schools employing an athletic trainer would possess safer attitudes about concussion than athletes at schools not employing an athletic trainer. As indicated above, a Bonferroni post-hoc test revealed that a statistically significant difference was not present when concussion attitudes of athletes from schools with ATCs were compared to concussion attitudes of athletes from schools without ATCs. Further examination of Table 12—which shows descriptive data for each group based on their performance on the CAI—shows a relatively small difference between the groups.

Table 12

Non-transformed CAI Descriptive Information Listed according to Group

Index	Group	Mean	*SD*	*N*
CAI				
	Athletic Trainers	71.26	4.46	148
	Coaches	67.37	5.72	129
	Athletes			
	-All Athletes	55.08	7.76	337
	-Athletes with ATC	57.32	6.45	45
	-Athletes without ATC	54.73	7.90	292
	Non-Athletes	56.21	7.27	141

Note: The highest possible score on CAI is 75. A higher score indicates suggests safer concussion attitudes.
Transformed values rather than the non-transformed values listed in this table were used in the ANOVAs, but these values are reported to aid with interpretation.

It appears that these groups of athletes do not differ significantly in the safety of their views about concussion. Although coaches and athletic trainers were included in the study, one-to-one relationships between coaches' and athletes' or athletic trainers' and athletes' concussion could not be examined due to the lack of adequate sample sizes in the groups. The sample used in the survey included athletes from four schools with athletic trainers, and only three of the athletic trainers from these schools completed surveys. Additionally, the sample sizes of athletes from these schools were quite small, and, as a result, statistical comparisons were not made between athletes and their athletic trainers on the basis of concussion knowledge (or concussion attitudes). Similar difficulties were encountered when comparisons between athletes and their coaches were considered. Hence, one-to-one comparisons on the basis of concussion knowledge (and concussion attitudes) could not be made.

Hypothesis 2—Prediction 2. It was predicted that a relationship would be identified between athletes' primary knowledge source and their attitudes toward concussion. As indicated in the summary of group differences according to concussion knowledge, it was not possible to conduct an analysis examining the one-to-one relationships between coaches'/athletic trainers' knowledge and that of the athletes with whom they work. However, the analysis could not be conducted due to same issues described in Hypothesis 1—Prediction 2 (see above for more details). Therefore, the analysis was not conducted.

As was the case with concussion knowledge, the researcher considered the comparison between athletes' attitudes and coaches'/athletic trainers' attitudes important despite the relatively low rate of athletes reporting coaches as their most influential knowledge source (see Table 9). An analysis was conducted to identify any general differences or trends which might suggest some convergence in the knowledge levels of athletes to coaches/ATCs.

Bonferroni post-hoc tests conducted after the univariate ANOVA described above revealed statistically significant attitudinal differences between ATCs and athletes ($p < .001$) and between coaches and athletes ($p < .001$). Examination of Table 12 shows that, on average, coaches scored over 1.5 standard deviations higher than athletes' mean CAI score and athletic trainers scored over 2 standard deviations higher.

Based on these results, it seems likely that coaches and ATCs possess safer attitudes about concussion. As with concussion knowledge, there is virtually no convergence between the attitudes of athletes and individuals who may influence them. In order to determine whether there were any differences in athletes' attitudes on the basis of their primary knowledge source, a single factor between-groups ANOVA was utilized. The analysis included knowledge source as the independent variable and non-transformed CAI scores as the dependent variable (due to lack of normality of data within particular levels of the independent variable). The results of the ANOVA revealed no statistically significant differences in concussion attitudes on the basis of knowledge source ($F(5, 262) = .58$, $p > .05$, partial $\eta^2 = .01$, power = .21). It appears that there are no substantial attitude differences among athletes according to their primary knowledge sources.

Hypothesis 2—Prediction 3. Prediction 3 stated that coaches' concussion attitudes would be less safe than the attitudes of the athletic trainers. The Bonferroni post-hoc test result comparing these groups is shown on Table 11. The between-groups transformed CAI score difference was statistically significant ($p < .001$), and the mean non-transformed CAI difference favored ATCs by about 4 points. This result suggests that, relative to coaches, athletic trainers have safer concussion attitudes.

It should be noted that non-athletes were included in the univariate ANOVA examining attitude differences, but this group has not yet been discussed. Because previous studies have not adequately addressed the nature of concussion attitudes in non-athlete samples, the relationship between of non-athletes' and athletes' attitudes is unclear. Thus, the post-hoc analysis comparing non-athletes to athletes will be addressed later in the exploratory question segment of this section.

Hypothesis 3. It was hypothesized that concussion knowledge and attitudes would be related to the rate of concussion and to concussion management practices.

Hypothesis 3—Prediction 1. As indicated earlier, it was predicted that, relative to high schools without ATCs, high schools with ATCs would have lower rates of athletes per year who sustained concussions. This prediction pertained to concussion management practices in high schools. Athletic directors (ADs) were sought to provide information about concussion incidence rates in high school athletes.

At the high school level, the AD is likely to be aware of most, if not all, of the concussions that are reported to medical personnel. It should also be noted that, due to anticipated time constraints among athletic directors and concerns about inadequate response rates, athletic directors, unlike other groups examined in the study, were not presented with a definition of concussion. Additionally, ADs were only presented with a question about number of athletes who sustained concussion rather than separate questions about number of athletes with a single concussion and number with multiple concussions.

Because the sample of ADs was distributed among high, medium, and large school enrollments, the estimated number of athletes in each school varied significantly (M = 360 athletes, SD = 315 athletes). To account for differences in absolute numbers of concussions reported by ADs, percentages were calculated. The estimated total number of concussed athletes as reported by ADs was divided by the estimated total number of athletes at their high school. The quotient was then multiplied by 100 to create a percentage.

Table 13 shows the incidence rates of concussion in a sample of 86 high schools as reported by athletic directors.

Table 13

Athletic Directors Reporting Specified Rates of Concussion

Percentage range of athletes sustaining concussion	# of ADs reporting rate of concussions (% of ADs)[a]
0%	14 (15.9%)
0.01-0.5%	24 (27.2)
0.51-1.0%	20 (22.7)
1.01-1.5%	13 (14.8)
1.51-2.0%	11 (12.5)
> 2.0%	6 (6.8)

Note: Highest rate reported was 5.71%
[a]*N* = 88

The table shows that the incidence of concussions according to ADs is relatively low. Over 90% of the ADs reported that concussion incidence rates among athletes were 2% or less.

The median percentage of athletes sustaining concussion in schools with ATCs was about 0.67% (range = 0 - 5.71%) and in schools without ATCs, the median percentage was 0.83% (range = 0 - 4.29%). Due to lack of normality in the data, a non-parametric Mann-Whitney U test was conducted to examine differences in concussion incidence across schools with and without an athletic trainer. The analysis revealed no significant difference between these groups (U = 903.50, N_1 = 43, N_2 = 43, $p > .05$, two-tailed).

Hypothesis 3—Prediction 2. It was predicted that presence and number of concussions would influence concussion knowledge in athletes. In order to test this prediction, athletes were classified into three groups: those reporting no previous concussions (NC), those reporting one previous concussion (OC), and those reporting two or more previous concussions (TC). Single factor between-groups analysis of variance (ANOVA) was conducted using number of concussions reported as the independent variable and CKI score as the dependent variable. No significant differences were identified, $F(2, 280) = 2.68$, $p > .05$, partial $\eta^2 = .02$, power = .53. This finding suggests that there is little relationship between number of concussions and knowledge about concussion.

Hypothesis 3—Prediction 3. Prediction 3 stated that presence and number of concussions would influence attitudes about concussion in athletes. Participants were again categorized according to number of concussions reported (i.e., 0, 1, and ≥ 2 concussions), and the dependent variable was CAI score. Single factor between-groups ANOVA was conducted with CAI score as the dependent variable and number of concussions as the independent variable (3 levels: no previous concussion [N = 185], one previous concussion [N = 68], and two or more previous concussions [N = 141]).

The univariate test was statistically significant ($F(2, 391) = 4.86$, $p < .01$, partial $\eta^2 = .02$), and the Bonferroni post-hoc tests indicated the presence of a significant difference ($p < .01$) between NC and TC athletes that favored the NC athletes by about 2.5 points on the CAI. However, the NC-OC and OC-TC comparisons did not yield statistically significant results. It is apparent that a significant difference does exist between the NC and TC groups, but the effect size measure suggests that the magnitude of the difference is relatively low. Additionally, Table 14 shows a relatively small difference of about 2.5 points between the NC and TC groups. Therefore the difference, though statistically significant, should be interpreted with caution.

Table 14

Mean Attitude Scores of Athletes According to # of Concussions Reported

Number of Concussions Reported	*N*	Mean	*SD*
No Concussion	185	56.74	7.00
One Concussion	68	56.24	7.23
2+ Concussions	141	54.18	8.17

Hypothesis 4. The fourth hypothesis stated that financial resources would be associated with the presence of medical staff at sporting events (i.e., practices and games). Three analyses were conducted to test this hypothesis: 1) comparison of schools by enrollment category on the basis of whether they employ an athletic trainer, 2) comparison of the relative numbers of RTP decision makers (i.e., athletic trainers/physicians vs. coaches) across enrollment categories, and 3) comparison of the relative numbers of coaches making RTP decisions across enrollment categories.

Hypothesis 4—Prediction 1. The researcher predicted that HE schools would be more likely than ME or LE schools to employ an athletic trainer. The information that was collected from the sample of athletic directors was used to test this prediction. A 2x3 chi square analysis was conducted using presence/absence of ATC and enrollment classification as the variables. The results supported the prediction ($\chi^2(2, N = 141) = 37.46, p < .001$) as about 80% (45/55) of HE schools employed ATCs on either a part-time or full-time basis; about 50% (21/45) of ME schools; and about 20% (8/41) of LE schools employed ATCs.

In order to identify the factors that may prevent schools from employing ATCs, the athletic directors were presented with an open-ended question asking them to provide the primary reasons that an athletic trainer was not on staff. About 80% indicated that finances prevented them from employing an ATC. These results suggest that athletic trainers (i.e., an individual trained to identify and safely manage concussion) are staffed primarily by schools that can afford to do so.

Hypothesis 4—Prediction 2. The researcher predicted that high enrollment (HE) schools would be more likely than schools with medium enrollment (ME) or low enrollment (LE) to have medical staff, rather than coaches, making RTP decisions. The data used to test this prediction were based on the responses coaches provided for two questions: 1) "Who typically makes RTP decisions for athletes who sustain concussions during practices?" and 2) "Who typically makes RTP decisions for athletes who sustain concussions during games?" These questions were presented in multiple choice format, and coaches were asked to choose only one source. The choices were as follows: coach, athletic trainers, physician, the athlete, or "other".

The coaches' responses are displayed in Table 15 below.

Table 15

Coaches' Reports of Primary RTP Decision Maker

	RTP Decision Maker during Practice		RTP Decision Maker during Game	
	# Coaches Reporting	% Coaches Reporting	# Coaches Reporting	% Coaches Reporting
Coach	86	70.5	81	65.3
Athletic Trainer	12	9.8	20	16.1
Physician	22	18.0	18	14.5
Athlete	2	1.6	2	1.6
Other	0	0	3	2.4

It appears that the majority of coaches across the total sample—regardless of enrollment classification—report being the primary decision maker and that significantly fewer coaches rely on medical professionals (i.e., athletic trainers and physicians) to make RTP decisions .

In order to identify whether there were statistically significant differences between the numbers of medical personnel versus the numbers of coaches making RTP decisions across the enrollment classifications, a 2x3 chi square analysis was conducted.

The variables examined in the analysis were enrollment classification and RTP decision maker (i.e., coach or athletic trainer/physician).

Although there were some small differences between the observed and expected rates of coaches and ATCs/physicians making RTP decisions during practices, these differences did not reach statistical significance, χ^2 (2, N = 120) = 2.28, $p > .05$.

An additional 2x3 chi square analysis was conducted to compare RTP decision makers during games across enrollment categories, and statistically significant differences were again not identified, χ^2 (2, N = 119) = 5.36, $p > .05$. These results indicate that primary RTP decision maker at practices or games is not statistically significantly related to size of the high school.

Despite providing some important information about the availability of medical staff, these analyses did not provide specific information about differences in the rates of coaches making RTP decisions. That issue was addressed in the Prediction 3 analyses.

Hypothesis 4—Prediction 3. It was predicted that LE coaches would be more likely to be the primary RTP decision maker relative to ME and HE coaches. When the entire sample of HE, ME, and LE high schools were examined, the results showed that about 7 out of 10 coaches (86/122) reported being the primary RTP decision maker during practices and about 65% (81/122) of coaches reported being the primary RTP decision maker during games. Analysis of the RTP trends across enrollment classifications revealed that about 60% of HE coaches, about 70% of ME coaches, and about 80% of LE coaches make RTP decisions during practices.

The statistical significance of these differences was evaluated using a 2x3 chi square analysis. The analysis examined the relationship between enrollment classification (HE, ME, LE) and coach as RTP decision maker (coach is decision maker vs. coach is not decision maker). The analysis showed a statistically non-significant difference among the groups (χ^2 (2, N = 122) = 2.85, $p > .05$). A follow-up analysis using only HE and LE groups was conducted to directly assess for between-group differences without the influence of the ME group. Again, a statistically significant difference was not found, χ^2 (1, N = 61) = 2.78, $p > .05$.

When the question of RTP decision maker during games was considered, the results showed that about 50% of HE coaches and 60% of ME coaches reported being the primary decision maker. The rate of coaches from LE high schools who reported making RTP decisions during games was identical to the rate reported for practices (81.3%). A 2x3 chi square test examining these differences approached statistical significance (χ^2 (2, N = 124) = 5.65, $p = .06$). A second chi square analysis including only the HE and LE coaches was conducted, and a significant between-group difference was found (χ^2 (1, N = 62) = 5.52, $p < .05$). A risk ratio analysis was conducted as a follow up to this second chi square and revealed that coaches at LE schools were found to be 1.5 times more likely to be the primary RTP decision maker at practices than coaches at HE schools.

These results suggest that at least half of the coaches, regardless of enrollment classification, are making RTP decisions during practices or games. There also appears to be an inverse relationship between the rates of coaches making RTP decisions at practices and games and school enrollment: as school enrollment decreases, the rate of coaches making RTP decisions increases.

Exploratory question 1: The question initially posed pertained to the relationship between concussion knowledge and attitudes in athletes, non-athletes, coaches, and athletic trainers. Pearson Product Moment correlational analyses were conducted comparing the CKI and CAI scores within coaches, athletic trainers, non-athletes, and athletes. Table 16 shows the results of those analyses.

Table 16

Correlation between CKI (concussion knowledge) and CAI (concussion attitudes)

Group	Correlational Analysis Results
All groups combined	r = .44, N = 772, p < .001, two tailed, d = .19
Athletic Trainers	r = .14, N = 148, p > .05, two tailed, d = .02
Coaches	r = -0.07, N = 129, p > .05, two tailed, d = .005
Non-Athletes	r = .03, N = 141, p > .05, two tailed, d = .0009
Athletes	r = .20, N = 337, p < .001, two tailed, d = .04

These results of these analyses are mixed. There appears to be a moderate relationship between concussion knowledge and attitudes when all participants (i.e., athletic trainers, coaches, non-athletes, and athletes) are included in the analysis. However, when the relationship between knowledge and attitudes is examined separately within each group, the strength of the correlations diminish substantially, and for three of the four groups, the correlations did not reach statistical significance. The only statistically significant correlation was within the athlete group, and, despite the statistical significance, the magnitude of the relationship was relatively small. The reasons for these seemingly paradoxical findings will be discussed in the following section. To summarize, the correlation between concussion knowledge and attitudes is moderate when all participants are analyzed together, but this relationship is significantly reduced when each group is analyzed separately.

Exploratory question 2: This question pertained to the general nature of non-athletes' concussion attitudes. This issue was addressed by comparing the non-athletes' attitudes to the attitudes of athletes. Table 11 shows that there was no significant difference between the attitudes of athletes and non-athletes. Additionally, the mean non-transformed CAI scores showed a negligible difference between groups. These results suggest that non-athletes possess concussion attitudes that are similar to the attitudes of athletes, and may point to the presence of a "general high school student view" of concussions that appears to be significantly less safe than that of coaches or athletic trainers.

Chapter 4

Discussion

The primary goals of the study were as follows: 1) develop psychometrically-sound and comprehensive measures of concussion knowledge and concussion attitudes; 2) identify the relationship between concussion knowledge and attitudes within athletic samples (i.e., athletes, coaches, and athletic trainers) and within the general population (i.e., high school non-athletes); 3) identify the level of influence that different sources of information (i.e., coaches and athletic trainers) have on concussion knowledge and attitudes; and 4) identify the relationship between the availability of an athletic trainer and the rates of concussions sustained by athletes at schools with and without an athletic trainer on staff.

As noted, the study was divided into a pilot portion and main portion. The pilot portion was conducted to establish the reliability and validity of the RoCKAS-ST and the accompanying measures (i.e., RoCKAS-HSST and PCQ). The main study addressed several hypotheses pertaining to concussion knowledge and attitudes, incidence of concussion, and presence of medical staff in high school.

Summary of Pilot Study findings. A qualitative analysis of the measures was conducted by presenting them to a panel of neuropsychologists, athletic trainers, coaches, and concussion experts. This initial analysis provided vital information, and recommendations were integrated into revisions of the measures. After expert analysis and revision of the measures, high school student feedback was obtained, and, again items were altered and/or removed based on the feedback. The qualitative analysis of the measures resulted in the establishment of content validity and in the development of measures that included understandable items and a user-friendly design.

The RoCKAS-ST—which contains items that comprise the Concussion Knowledge Index (CKI) and the Concussion Attitudes Index (CAI)—underwent intense psychometric scrutiny. The CKI consists of 25 items that examine various domains: post-concussive symptoms, acute effects of concussion, long-term effects of concussion, effects of multiple concussions, and recognition/definition of concussion. A cluster analysis was conducted to identify the construct(s) underlying the knowledge items. Three subscales were identified, but they did not point to the presence of any underlying constructs. Instead, subscale 1 consisted of 20 items of relatively low difficulty, subscale 2 contained two items of moderate difficulty, and subscale 3 was comprised of three items of high difficulty. Due to the binary nature of the items, reliability analyses could not be conducted. In sum, the CKI appears to contain three subscales that include items of varying levels of difficulty rather than underlying concussion knowledge constructs.

The 15-item CAI was examined using exploratory and confirmatory factor analytic procedures. The EFA revealed four discrete factors that displayed mostly low intercorrelations suggesting orthogonality of the factors. The derived factors were as follows: personal concussion attitudes, views about others’ concussion attitudes, views about coaches’ concussion management and precautions, and views about athletic trainers’ concussion management. The CFA indicated that the four-factor model—with limited statistical adjustment—displayed adequate fit with the data and provided additional evidence for four discrete attitudinal constructs.

The test-retest reliability of the RoCKAS-ST CAI and CKI indices was examined, and the results showed that the CAI displayed adequate reliability, but the items on the CKI showed slightly less than optimal reliability (i.e., < .70). However, the reliability of the CKI did closely approach the .70 threshold with a value of .67. Although these findings suggest that the CKI in the current form is not an excellent measure of concussion knowledge, it can still provide some important and useful information about the knowledge of the samples examined. Also, further modification could improve the reliability of the measure.

Summary of Main Study Findings.

Hypothesis 1: Experience with and education about concussion will be closely associated with knowledge about concussion.

Hypothesis 2: Experience with and education about concussion will be closely associated with attitudes toward concussion.

Both hypotheses were partially supported by the data. Several between-group analyses were conducted to identify differences among athletes (both with and without athletic trainers at their schools), coaches, athletic trainers, and non-athletes. The results of the analyses showed that both athletic trainers and coaches were more knowledgeable than athletes, and that athletic trainers were more knowledgeable than coaches. Among athletes and non-athletes, no knowledge differences were found, and this suggests that the general population of non-athlete high school students may possess knowledge similar to that of their athlete counterparts. Within the sample of athletes, the comparison between athletes with and without athletic trainers indicated that the presence of an athletic trainer did not appear to be related to concussion knowledge. Finally, athletes who competed in a high risk sport were compared to athletes competing in moderate risk and low risk sports. There were no significant differences found among the athletes on the basis of risk level. Thus, it appeared that there was no relationship between an athletes' knowledge and the level of injury risk of a sport.

The between-group comparisons made on the basis of concussion attitudes revealed that there were no significant differences between athletes and non-athletes, and points to relative equivalence of attitudes about concussion among the general population of students in high school and interscholastic athletes (this finding addresses Exploratory Question 2). Also, no differences were found when athletes with athletic trainers were compared to athletes without athletic trainers at their schools. However, the athletes displayed significantly less safe attitudes relative to both athletic trainers and coaches. These results suggest that high school students, regardless of athletic status or the availability of a knowledgeable resource (i.e., athletic trainer) seem to possess similar attitudes about concussion, and these attitudes are significantly less safe than the attitudes of the individuals responsible for their care. Additionally, when coaches were compared to athletic trainers, the results showed that the latter group possessed safer attitudes.

Unfortunately, due to recruitment difficulties, one-to-one comparisons could not be made between the athletes' knowledge and attitude levels and potentially important sources of athletes' knowledge and attitudes (i.e., coaches and ATCs). However, some important information was obtained about high school students' primary knowledge sources. Differences were found between the athletes with ATCs and those without

ATCs. Specifically, athletes without ATCs most commonly reported parents (18.2%), friends (17.1%), physicians (15.6%), personal concussions/concussions of teammates or opponents (12.3%), and coaches (9.7%) as their primary knowledge source. Whereas, the most commonly reported primary knowledge sources in athletes with ATCs were ATCs (25%), personal concussions/concussions of teammates or opponents (18.2%), parents (13.6%), physicians (9.1%), friends (6.8%), and coaches (4.5).

These findings indicate that relatively few athletes are highly influenced by coaches, but many have drawn their knowledge from their parents and friends. ATCs were the most commonly reported concussion knowledge source in athletes with ATCs, and physicians were often reported as a primary source in athletes without ATCs. Thus, it appears that these medical professionals serve as important resources for athletes about concussion. Despite that finding, neither the knowledge nor the attitudes of the athletes significantly differed on the basis of their primary knowledge sources.

Hypothesis 3: Concussion knowledge and attitudes will be related to the rate of concussion and to concussion management practices.

This hypothesis was not supported. Athletic directors' reports were used to identify differences in the rates of concussions sustained by athletes at schools with and without athletic trainers. Concussion rates were similar across high schools regardless of the availability of an athletic trainer, thus raising the possibility that there may be no relationship between the presence of an athletic trainer and concussion incidence. However, as will be discussed below, there were some confounding factors that diminished the likelihood of this possibility. An additional finding showed that, according to athletic directors' reports, the incidence rates of concussion in a sample of 142 high schools typically did not exceed 2% of athletes.

Number of concussions sustained during the previous school year as reported by athletes was compared to the athletes' concussion knowledge and attitudes. Athletes were placed into groups based on the number of concussions sustained: no concussions (NC), one concussion, and two or more concussions (TC). When knowledge levels were compared across groups, no significant differences were found. This indicates that concussion knowledge may not be affected by the number of concussions a student has sustained. However, a significant difference in attitudes was found between NC athletes and TC athletes. The results showed that NC athletes possessed safer attitudes than TC athletes. Differences between NC and OC athletes and between OC and TC athletes were not statistically significant.

Hypothesis 4: Financial resources will be associated with the presence of medical staff at sporting events (i.e., practices and games).

This hypothesis was partially supported. Athletic directors' survey responses were again used to determine whether there was a relationship between enrollment category (HE, ME, LE) and the presence of an athletic trainer on the school medical staff. Statistically significant differences among the enrollment categories were found as about 80% of HE schools employed ATCs, whereas about 50% of ME schools and about 20% of LE schools employed an ATC. About 80% of the ADs who reported not having an ATC on staff indicated that they did not employ an ATC due to financial constraints.

Despite the increased availability of an athletic trainer at schools with larger enrollments, they are clearly not the only individuals making RTP decisions. This is apparent in the finding showing that there was no statistically significant relationship between the size of a high school (i.e., enrollment group) and the primary RTP decision maker (i.e., coaches or athletic trainers/physicians) after concussions occurring at practices or games.

When the relationship between coaches as primary RTP decision maker at games (i.e., coach is primary RTP decision maker vs. coach is not primary RTP decision maker) and enrollment category was examined, a statistically significant relationship was not found. However, there was statistically significant relationship when coaches who did or did not report being primary RTP decision maker after concussions occurring during practices were compared across enrollment categories. Specifically, coaches from LE schools were 1.5 times more likely to be the primary RTP decision maker than coaches at HE schools.

Finally, the mean rate of coaches as primary RTP decision maker across enrollment groups was calculated, and the results showed that 65% of coaches make RTP decisions during games and 70% make RTP decisions during practice. An examination of the self-reported college majors of the sample of coaches in the study revealed that only about 4% majored in a medical or allied health field. This finding suggests that a large majority of coaches who may also be the primary decision makers for RTP may not possess the requisite skills and/or have the necessary time to adequately address concussions.

Exploratory Question 1. What is the nature of the relationship between concussion knowledge and attitudes in athletes, non-athletes, coaches, and athletic trainers?

A statistically significant relationship between concussion knowledge and attitudes was identified when all participants from each group (i.e., athletes, non-athletes, coaches, and athletic trainers) were included in the correlational analysis. The strength of the correlation was moderate. However, when the correlations between knowledge and attitudes were conducted within each group, only the correlation for the group of athletes was statistically significant, although the correlation was relatively weak in strength and small in magnitude. Thus, it appears that, when all groups are analyzed together, knowledge and attitudes seem to be related in a meaningful way, but when the groups are analyzed separately, the relationship tends to diminish substantially. .

Interpretation of findings. The moderate correlation that was identified between concussion knowledge and attitudes was perhaps the most important finding in this study. Although the directionality of the relationship cannot be established on the basis of these findings, is important to consider a possible implication of this finding: by improving knowledge, it may be possible to improve the safety of concussion attitudes, and vice versa.

As was previously mentioned, the sex and HIV education literature has established connections between improved knowledge, safer attitudes, and increased efforts on the part of adolescents to prevent pregnancy and protect themselves from the transmission of HIV and other sexually transmitted infections (STIs). These changes are believed to be due to increases in initial increases in awareness and knowledge. If these findings are extended to concussion knowledge, attitudes, and concussion reporting and management, it is possible that information obtained from an educational program pertaining to concussion could change concussion knowledge and attitudes and contribute to changes in behavior after a concussion is sustained. However, future research will be necessary to establish these proposed relationships and to influence the proposed behavioral changes.

Despite the finding suggesting a moderately strong relationship between knowledge and attitudes, within-group relationships between knowledge and attitudes were relatively weak. This may be due to the relative lack of within-group variability in knowledge and attitudes. Examination of Tables 7 and 12 reveals that the standard deviations of the within-group knowledge and attitude scores are relatively small. These findings suggest relative homogeneity of scores and a lack of variability in performance.

Sufficient variability is necessary for a correlational analysis to successfully explain the phenomena being examined; however, the within-group variability was apparently insufficient, thus potentially contributing to the low correlations. Although it is possible that there are, in fact, poor relationships between knowledge and attitudes within each group, this explanation is unlikely to explain the findings as evidenced by the moderate strength of the correlation between knowledge and attitudes of the entire sample. In this sample, the variability in scores across participants in different groups is sufficient enough to detect a relationship between knowledge and attitudes.

Finally, the lack of within-group variability may be an artifact of the structure of the items on the test. Indeed, the binary nature of many of the knowledge items on the survey likely produced a restricted range of responses in already homogenous groups, and, hence, likely led to reduction in the variability in responding. Therefore, it is possible that if items are altered to allow for more variability in responding, stronger within-group correlations may be identified in future research.

Concussion knowledge. The concussion knowledge differences may be explained by the amount of training in the recognition and management of concussions that an individual has received. It is quite possible that the difference between knowledge levels found when coaches and athletic trainers were compared may be at least partially accounted for by their respective college curricula. The curriculum for college athletic trainers is typically centered around the development of specific proficiencies. These proficiencies pertain to different aspects of sports injury (i.e., prevention, detection, treatment, management, and rehabilitation). Athletic trainers are trained to work in clinical settings where practical application of knowledge through intervention is routine (W. Buckley, personal communication, 8/2/07). Conversely, physical education and health education college curricula focus more on preparing students to instruct children and adolescents in a variety of physical fitness and health domains (i.e., teaching about diseases, dangers of substance use, promotion of physical activity, introduction to a variety of sports, etc) and guide activities that are physically and/or mentally stimulating. If injuries arise during the course of physical activities that they are supervising, these educators are taught to "recognize and refer, not intervene" (W. Buckley, personal communication, 8/2/07).

Many of the coaches in the study had backgrounds in physical/health education which suggests that they may have learned only about the basics of sports injury recognition and management during their college careers. Moreover, coaches' primary responsibilities are to manage athletes and place these athletes in a position to win. Conversely, athletic trainers are trained in and responsible for recognizing and managing injuries. The differences between the primary duties and backgrounds of coaches and athletic trainers are quite substantial, and it is quite possible that these differences contributed to the knowledge differences that were identified.

The knowledge differences that were found when comparisons were made between coaches and athletes and between athletic trainers and athletes may be explained by the apparent lack of athlete exposure to information about concussion. This is evidenced by the finding showing that only about 6% of athletes without athletic trainers and about 20% of athletes with athletic trainers reported that they had attended a presentation or received materials related to concussion. This finding is particularly important in light of the results of the McCrea et al (2004) study showing that about one-third of their sample of high school athletes, who had sustained but did not report a past concussion, indicated that they did not do so because they were not aware that they had sustained a concussion.

Another factor that may both impact and result from knowledge about concussion is that a substantial proportion of athletes simply do not report a concussion to anyone when it occurs. About 40% of high school athletes in the current study and about 50% of high school students in the McCrea et al. (2004) study indicated that they have not reported a concussion in the past.

By not reporting concussion, athletes may be missing out on an educational experience that may occur if they report the concussion to individuals who may be able to provide them with some vital information about concussion (i.e., coaches or medical personnel).

Based on these findings and previous research pertaining to concussion knowledge, it seems likely that high school athletes are simply not being exposed to enough information about concussion. It is also clear that athletes are often not reporting concussion, which may decrease the possibility that they receive important information about concussion.

Concussion attitudes. As indicated, athletic trainers displayed the safest attitudes about concussion. Coaches displayed attitudes that were less safe than athletic trainers but significantly safer than students. Among the students, athletes and non-athletes displayed similar attitude levels.

Given the relationship between knowledge and attitudes that has been identified, the attitudinal differences detected among these groups may be accounted for by differences in concussion knowledge. The positive direction of the correlation introduces the possibility that increases in knowledge about concussion may influence the safety of attitudes (i.e, attitudes become more safe).

The between-group differences in concussion attitudes may also be explained by the differences in the roles that each group plays in sports settings and/or their general attitudes about sports injury (in addition to their specific attitudes about concussion). Athletic trainers' scores suggest that their attitudes are the safest relative to the other groups, and their safer attitudes may be related to their role as primary identifier and manager of sports injuries. Unlike coaches, athletic trainers are focused primarily on the athletes' well-being and are trained to detect and treat injuries, thus predisposing them to view injuries as paramount. Coaches, unlike athletic trainers, tend to manage the activities of the athletes participating in the contest to ultimately win the contest—sometimes this desire to win interferes with their responsibility for the well-being of their athletes (Slobounov, Sebastianelli, & Aukerman, 2006). Hence, in an effort to win, coaches may directly or indirectly promote athletes playing through injuries, and may sometimes fail to recognize or accept the seriousness of an injury (Nixon, 1994). Although, the difference between coaches' and athletic trainers' attitude scores in the current study was not drastic and suggests that coaches attitudes were relatively safe, one of the primary reasons for the difference between groups may be explained by the attitudes toward injury reported by Nixon (1994) and Slobounov, Sebastianelli, and Aukerman (2006) and by the role that coaches play in sports settings.

The attitude differences between coaches/ATCs and athletes is quite marked (about 1.5 to 2 standard deviations higher than the athletes' mean attitude score). One potential explanation for these differences is that sports injuries are simply not as significant to athletes, if they are significant at all. Support for this orientation towards injury among athletes comes from the lack of a distinction between athletes' and non-athletes' attitudes. Because injuries are a relatively common occurrence in high school athletics (estimated 1.4 million injuries across nine high school sports, including football and soccer, in 2005-2006; Comstock, Knox, Yard, & Gilchrist, 2006), but not in daily life, it would be expected that they would be less important to non-athletes. However, the sample of athletes and non-athletes appear to have very similar attitudes, which suggests that athletes, too, may view injuries as relatively unimportant. This may be due to a few factors: 1) youth and enhanced ability of their bodies to heal, thus, any injuries that may have been sustained likely healed relatively quickly without any chronic effects; and/or 2) the well documented sense of invincibility (i.e., immunity from negative events) that adolescents often possess.

The finding showing that athletes with two or more concussions have attitudes that are significantly less safe than athletes with no concussion history was unexpected, and the magnitude of this difference was large. The potential implications of this finding are important and warrant discussion. It may be explained by several factors: Perhaps many of the athletes with multiple concussions recovered from their concussions relatively quickly and did not experience severe, debilitating, or chronic effects after their concussions; they may have downplayed the effects of concussion (McCrea et al., 2004); and/or the athletes with multiple concussions may possess personality characteristics and attitudes that predispose them to take risks that may jeopardize their health.

Although no previous studies have examined the relationship between personality characteristics and concussion history, Nattiv, Puffer, and Green (1997) found that college athletes were more likely than non-athletes to engage in behaviors that placed them at high risk for injury (e.g., exceeding the speed limit by 10 mph and riding bicycles/motorcycles without a helmet), and the findings were duplicated by Baumert, Henderson, and Thompson (1998) in a study comparing health behaviors in high school athletes and non-athletes. These studies suggest that, because athletes are more likely to engage in high injury risk behaviors, they may possess personality attributes (e.g., extraversion) that predispose them to engage in dangerous behaviors.

Extraversion is one of the Big Five personality factors and relates to activity level sought, impulsiveness, assertiveness, sociability, and positive emotionality (Busato, Prins, Elshout, & Hamaker, 2000). By their very nature, athletic activities are risky insofar as they place an athlete at more risk for injury than would be expected during daily activities. Previous research suggests that high school athletes display higher levels of extraversion relative to non-athlete high school students (Newcombe & Boyle, 1995). Additionally, the extraverted traits may, in fact, predispose individuals to seek out stimulating and risky behaviors such as sports (McKelvie, Lemieux, & Stout, 2003). Moreover, Young (1990) found that athletes who were high in sensation seeking (i.e., a characteristic of extraversion) were also the most likely to participate in high risk sports.

Extending these findings to concussion in sports, it seems plausible that the athletes with the highest levels of extraversion may be more likely to not only participate in the sports that place them at highest risk for concussion but to also downplay/ignore symptoms of concussion in lieu of continued activity and stimulation. Thus, these athletes would be placing themselves at higher risk for additional concussions. Hence, high levels of extraversion may have contributed to the lower levels of safe concussion attitudes displayed by athletes with two or more concussions. However, it should be emphasized that this assertion and the other possible explanatory factors listed above are speculative and not necessarily supported by empirical findings.

Concussion rates and athletic trainer availability. There was no difference in the incidence rates of concussion, as reported by athletic directors [ADs], in schools that employed or did not employ an athletic trainer. It is possible that ATC availability does not influence the rate of concussion and that the intervention of ATCs may not serve as a protective factor against the athletes that they work with. However, upon closer examination of the findings, this conclusion appears to be premature and unsubstantiated. The finding showing no difference in concussion incidence rates may be confounded by methodological and measurement issues.

Perhaps, the most obvious confound pertains to the fact that ADs were only asked to provide the *total* number of concussions sustained by athletes during the previous year and were not asked to report the incidence of athletes with multiple concussions. This is an important distinction when attempting to examine the relationship between athletic trainer availability and concussion incidence because of differences in the factors that lead to an athlete's first ever concussion versus the factors contributing to multiple concussions (It should be noted that additional confounds and proposed methods to address the confounds are provided in the "Limitations" section).

It is obvious that one of the factors distinguishing individuals with no concussion history from those with one or more previous concussions is the latter group's history of concussion. However, individuals with one or more concussions are 2.5-3.0 times more likely than individuals with no previous concussions to sustain another concussion (Guskiewicz, et al, 2003). One of the potential reasons for this increased rate of concussions is that, within the first few days to weeks after a concussion—a time when many additional concussions are sustained—the brain is in a physiologically-compromised state (Giza & Hovda, 2001; Lang, Teasdale, MacPherson, & Lawrence, 1994) and, hence, more vulnerable to additional injury. The presence of an athletic trainer to monitor the postconcussive signs and symptoms of the athlete and withhold the athlete from play, when necessary, can be instrumental in protecting the athlete from multiple concussions.

Therefore, although it would seem unlikely that athletic trainers could prevent athletes from sustaining an *initial* concussion, if they are present to appropriately manage an initial concussion, it is quite possible that the athlete would be removed from competition until it is safe for that athlete to return. Moreover, if the incidence of multiple concussions was lower in schools with ATCs, it could be concluded that the presence of an ATC may be contributing to that difference.

In sum, the examination of the relationship between athletic trainer availability and concussion incidence yielded inconclusive findings, and it is unclear as to whether the incidence of *multiple* concussions within the same athlete—an outcome that an athletic trainer could realistically influence—was lower in high schools with an athletic trainer.

Financial resources and availability of medical staff. Most of the HE schools and about half of the ME schools possess enough financial resources to employ an athletic trainer, but only about two out of 10 LE schools possess the necessary financial resources. Yet, across enrollment categories and regardless of ATC availability, it appears that at least half of the coaches are making RTP decisions after concussions occurring during practices or games. Hence, even when a school employs an ATC, the coach may often be left in the position of managing concussion. In schools without an ATC, the situation is amplified, as up to 80% of coaches report being the primary RTP decision makers during practice. Given what has already been mentioned about the training received by coaches and about their primary responsibilities, it is alarming that so many coaches are responsible for these decisions, even when ATC's are available.

General hypothesis. This hypothesis was presented in the previous section and stated that: A relationship between cognitive (knowledge) and emotional (attitude) aspects of the concussion construct will be identified, and these aspects will influence the behavioral (management & reporting) aspects of the concussion construct.

As indicated, a statistically significant positive correlation was found between knowledge and attitudes about concussion. Additionally, the athletes and non-athletes in the study tended to display relatively deficient knowledge and relatively unsafe attitudes. About 40% of the athletes in the study indicated that they had sustained a concussion in the past and had not reported it. Thus, it seems that the relative lack of knowledge and relative lack of safe attitudes may have contributed to this substantial group of students failing to report concussion. Additionally, coaches displayed more knowledge and safer attitudes than students but less knowledge and less safe attitudes than the most knowledgeable and safest group: athletic trainers.

Regardless of school enrollment and the presence of an athletic trainer, about 50% of coaches reported being the primary RTP decision maker at both practices and games. This is a particularly important finding because coaches are, more often than not, unqualified to make these decisions. Previous research shows that coaches are prone to losing objectivity after injuries, and, instead, focus on winning and placing their best players in the competition to give the team the best chance to win (Slobounov, Sebastianelli, & Aukerman, 2006). Therefore, the combination of lower knowledge levels and the orientation toward winning (i.e., relatively unsafe attitude) may lead to sub-optimal concussion management practices on the part of many coaches (e.g., making a RTP decision instead of reporting the injury to a medical professional who can appropriately assess and manage the injury). Therefore, although the study did not establish causal relationships between knowledge, attitudes, and behaviors vis a vis the construct of concussion, the data suggest that these aspects are likely associated.

Limitations

Concussion Attitudes Index (CAI). Despite the fact that the EFA identified four discrete factors and the CFA confirmed the presence of separate attitudinal constructs, the relatively small number of items that comprise the CAI is an area of concern. Due to the small number of items, the internal consistency estimates were difficult to conduct and interpret. Additional attitude-related items should be included in the RoCKAS in order to potentially add to the robustness of the constructs and/or identify additional constructs. Factor 4—Views about Athletic Trainers' Concussion Management—currently includes only two items. It is thus especially important to add items that could potentially expand the size and robustness of this factor. Finally, the addition of attitude-related items to the RoCKAS will facilitate a more meaningful analysis of the internal consistency of the factors and, potentially, better establish the reliability of the factors.

An additional concern about the CAI arose when the statistically significant correlation between the CAI and the Marlowe-Crowne Social Desirability Scale was identified in the small sample of 36 pilot study participants. This finding introduced the possibility that participants' responses on the RoCKAS were subject to a socially-desirable response bias rather than being a measure of participants' "true" attitudes. However, the significance and magnitude of the correlation between CAI scores and Marlowe-Crowne scores dropped well below statistically significant levels when the large sample of pilot students was used. It is important that future studies replicate this latter finding to provide additional evidence for the CAI being a relatively sensitive measure of attitudes uncontaminated by significant social desirability bias.

Finally, it should be noted that all of the participants whose data were included in the EFA attended schools without an athletic trainer on staff. Thus, the responses on the two survey items pertaining to the athletic trainer may be somewhat different from students at schools with an athletic trainer due to possible differences in the personal relevance of the question and due to differences in experience with an athletic trainer. In order to identify whether the factor structure remains stable despite the potential effects of these variables (i.e., personal relevance and experience with ATC), future research should be conducted that involves surveying the attitudes of athletes with athletic trainers and EFA should be conducted to examine the factor structure.

Concussion Knowledge Index (*CKI).* The CKI includes 25 items and scores can range from zero to 25. However, a relatively limited range of responses were displayed, as about 95% of the total scores on the CKI fell between 14 and 25. Although the difference was statistically significant, athletic trainers, on average, scored only about one point higher than coaches. Statistical significance was even higher when comparisons between coaches and athletes and athletic trainers and athletes were made on the basis of knowledge scores. However, the mean differences were about 2 points for the coach-athlete comparison and about 3 points for the athletic trainer-athlete comparison. In a practical sense, these do not appear to be large differences. Thus, it would seem important to add more items to the RoCKAS that pertain to concussion to facilitate the further examination of knowledge and attempt to establish greater between-group variability. Greater variability may produce differences of greater practical significance.

Another potential problem with the CKI was that the test-retest reliability fell slightly below acceptable levels. This finding reflects the fact that some individuals were providing different responses at survey time 1 and time 2 despite the fact that survey time 2 was only two days after time 1. Mean scores were not significantly different across testing times, suggesting the absence of widespread exposure to information about concussion that would have been obtained between times 1 and 2. The finding may be more due to the possibility that participants did not know the answers to the questions and guessed on both occasions.

The use of a binary (i.e., True/False) response method reduces the possibility that uncertainty about the correct response items is detected. Additionally, if several participants were uncertain about how to respond to the item but instead guessed, some important information about concussion knowledge may not have been detected. To account for uncertainty among participants, a three- or five-item Likert scale could be used to in place of the binary response method. The three-item Likert scale could include the following items: True, False, and Unsure. The five-item Likert scale could include the following items: Definitely True, Probably True, Unsure, Probably False, Definitely False. The use of either one of these scales may provide a more dynamic view of concussion knowledge by providing more variability and/or a greater range of responses, and it is possible that the Likert scale response may result in more stable measure of concussion knowledge.

As indicated, participants who were involved in the test-retest portion of the pilot study were surveyed on two occasions that were separated by only two days. This interval is not optimal for the establishment of stability of concussion knowledge. Therefore, future examination of concussion knowledge stability should include a longer interval (e.g., one week or two weeks) between survey time 1 and time 2.

RoCKAS-CH and RoCKAS-AT. The RoCKAS-CH and RoCKAS-AT were not formally validated. Given the differences in knowledge and attitudes between coaches/ATCs and athletes, it is not clear whether the factor structures or the cluster structures of the coaches' and/or athletic trainers' responses are similar to that of the athletes. Additionally, the extent to which the CAI scores derived from the CH and AT versions of the RoCKAS were influenced by social desirability rather than "true" attitudes is not clear. Thus, in order to provide construct validation for each of these versions, the survey and the Marlowe-Crowne should be administered to future samples of coaches and ATCs.

Main Study. There are several limitations that pertain to the sample of students that was obtained. First, the entire sample of students was almost exclusively Caucasian and resided in rural settings in Northeastern and Central New York. It is possible that students with different racial/ethnic backgrounds from other geographic regions and from suburban, urban, and other rural schools would show differences in concussion knowledge and attitudes. Thus, future studies should include samples of students from different racial/ethnic backgrounds and demographic settings to identify any potential similarities and/or differences on the basis of these demographic factors.

The second limitation relates to the relatively small sample size of students from schools with athletic trainers. Of the 744 high school students who satisfactorily completed the survey, only 11% were students from schools with athletic trainers. Among athletes, only 11% came from schools with athletic trainers and close to 11% of non-athletes came from schools with athletic trainers. Therefore, it is clear that students from schools with an ATC were underrepresented in the sample. It is possible that the lack of differences in knowledge and attitudes between these two groups may have been influenced by the disparities in sample size and data variability. Consequently, caution should be used when interpreting analyses comparing students at schools with and without ATCs. Additionally, due to the relatively small sample, the generalizability of the findings to the high school student population and, even to high schools students at rural schools with ATCs, is questionable. Thus, future research should examine concussion knowledge and attitudes in a larger sample of schools with athletic trainers.

The third limitation of the student sample is the extremely low response rate of participants recruited by mail. Despite financial incentives to participate, high school students were quite unlikely to complete a survey when they were recruited by mail. As indicated, about 2500 invitations were sent out to high school students, and only about 100 of the students completed surveys. Several factors may have contributed to the poor response: participants were recruited during the late spring, near the end of the school year and may have been occupied with other activities; participants may not have received the initial postcard and/or reminder; the incentive to participate was appealing enough to persuade them to participate; and/or the participants may simply not have been interested in completing the study. Given technological advances and the rapidly increasing availability of new modes of interpersonal communication, it is possible that using mailed postcards rather than emailed messages, text messages, instant messages, or other forms of media was one of the primary reasons for the low response rate. It seems likely that high school students may simply not respond to mail unless it is highly relevant (e.g., college acceptance letters, information from school, etc.).

Due to the low survey completion rates by high school students with an ATC, it is quite possible that a selection bias occurred. In order to address different potential issues that may indicate selection bias, several follow-up analyses were conducted comparing the participants who were recruited during personal visits (RPV—recruited during personal visit) by the researcher and those who were recruited by mail (RBM—recruited by mail) on several demographic variables. These analyses have not yet been reported because the results will only be mentioned briefly and because they have limited relevance to the primary findings reported above.

It is possible that RBM students chose to complete the survey because concussions were more relevant to them than to the RPV students. The variables believed to address concussion relevance across both groups of students were as follows: athletic status (i.e., athlete or non-athlete); number of concussions in the past year and over the lifetime; presence of concussion in someone close to the participant; and lack of conscientiousness (as measured by percentage of athletes within each group sustaining concussion and not reporting it). Within the RBM and RPV samples, athletes were compared on the basis of level of risk of the sport in which the athlete participated.

The analyses revealed no statistically significant differences between the RBM and RBV groups containing all students on any of the variables. However, when the RBM and RPV athletes were compared according to the risk level of the sports that they participated in, differences were detected. Specifically, there was a higher proportion of RBM athletes (65.1% of RBMs vs. 31.7% of RPVs) that were involved in high risk sports, and a higher proportion of RPV athletes who were involved in moderate risk sports (64.8% of RPV vs. 23.3% of RBM). Thus, it appears that, among the sample of RBM athletes, participants who were involved in high risk sports were more likely to complete the survey. Despite this significant difference between the RBM and RPV samples, the other indicators of relevance/selection bias were not significantly different across groups. Although the indicators that were examined do not rule out selection bias, the fact that non-significant differences were found on all but one of the indicators suggests that the selection bias may be minimal.

It is unclear as to why so few parents returned consent forms. Perhaps parents lacked sufficient motivation and/or were too busy to examine the materials. Given the vast differences in response rates based on the type of parental consent procedure that was used (i.e., opt out versus informed consent), it would seem likely that parents were likely too busy, and because of the lack of incentive for them to return the permission form, they likely disregarded the project. Future researchers should consider offering a financial or material incentive (i.e., monetary reward, gift, etc.) to parents if they plan on using the informed consent procedure. However, without question, the most fruitful recruitment procedure was the opt out consent procedure. When the opt out procedure was combined with school visits to collect data (rather than internet survey) response rates were outstanding and financial resources were optimized.

The use of athletic directors to report the incidence of concussion was not ideal, but was necessary due to recruitment limitations. Although the athletic directors may have been aware of all reported concussions, it was impossible for them to be aware of the number of concussions that were sustained but not reported. Moreover, the athletic directors provided an estimate of the incidence of concussions, and this figure was likely vulnerable to the passage of time and shortcomings in human memory. Finally, athletic directors were not provided with a definition of concussion, and, instead, may have used their personal definition to guide their responses. Given that previous studies have provided high school students with definitions of concussion to assist in the reporting of concussion history (Field et al., 2003; Langburt et al., 2001), it is possible that a formal definition may have produced different estimates in the concussion rates reported by the athletic directors.

As noted, direct comparisons between the knowledge and attitude levels of coaches and athletes were not possible in the current study due to recruitment difficulties. In order to draw more direct comparisons between the actual coaches that work with an athlete and the individual athlete, active recruitment efforts should be undertaken whereby most or all of the coaches at a high school and most or all of the athletes are surveyed. Comparisons of knowledge and attitudes should be made comparing coaches across the risk level of the sports that they coach (using the categorization method described above). This procedure should be repeated with the athletes from the high school. These within- group comparisons would serve two functions: 1) determine the relationship between knowledge and attitudes and sport risk levels in both athletes and coaches (i.e., high risk coach vs. moderate risk coach vs. low risk coach) and 2) help to determine how between-group (i.e., coach vs. athlete) comparisons should be conducted. If knowledge and/or attitude differences are found among coaches or among athletes, then between-group comparisons should be made comparing athletes and coaches within each risk level (i.e., high risk coaches vs. high risk athletes; moderate risk coaches vs. moderate risk athletes, etc.) If knowledge and/or attitude differences are not found among coaches or athletes, the full sample of coaches and of athletes should be compared. This procedure would facilitate more direct comparisons between coaches and athletes within a particular high school and help to establish a relationship between athletes' knowledge/attitudes and that of the coaches that may influence them.

Other future directions. Due to the fact that parents and physicians were among the most commonly reported primary concussion knowledge sources for athletes, efforts should be made to examine the knowledge and attitudes of these populations. The RoCKAS should be altered to create two additional versions that are relevant to parents and physicians, respectively. The data that would be collected would provide important descriptive information relating to knowledge and attitudes of adults in the general population and that pertain to an additional group of medical personnel. It would also facilitate comparisons between these groups and athletes. Thus, relationships, if they do in fact exist, between these knowledge sources and the athletes who specify them could be identified.

As indicated, the findings of this study suggest that athletes are receiving relatively little instruction that could help them to improve concussion knowledge. Additionally, there appears to be a poor relationship between their concussion knowledge and attitudes. It is important for athletes to be exposed to more information about concussion to help preserve their short-term and long-term physical, cognitive, and emotional health (each of these domains has been shown to be affected by concussion, especially in the case of multiple concussions). Social psychology research suggests that message repetition is important in altering attitudes and encouraging personal elaboration of the message (Olson & Zanna, 1993). Elaboration involves infusing a message from an external source with personal meaning. Thus, it is important to provide information about concussion to athletes on multiple occasions and by individuals who are closely involved with athletes (see Olson & Zanna, 1993 for a discussion of the persuasive power of an individual who is part of the group receiving the message) such as a fellow athlete, a former athlete that had their career shortened due to concussions, a beloved coach/medical professional, an expert, a parent, etc.

Efforts should be made to create systemic awareness about concussion detection and management. Interventions should be made to educate not only athletes but their coaches, parents, and other potentially influential individuals. In order to evaluate the effectiveness and impact of the intervention, pre-intervention knowledge and attitude levels should be assessed using the RoCKAS. Additionally, information about the incidence should be obtained from athletes and medical staff to establish incidence rates for the year leading up to the presentation. Ideally, the intervention should be delivered by a variety of sources (e.g., an expert, a previously concussed athlete, a respected figure in school, a parent, etc.) and should involve a comprehensive and concise presentation of the definition, pathophysiology (in a highly simplified form), signs and symptoms of concussion, short and long term effects, and potential chronic and catastrophic outcomes. It is important that coaches, parents, and students receive these messages together to assure consistency of message and to facilitate discussion among them. Follow-up should be conducted at the end of the academic year to assess retention of messages, identify any changes in knowledge and attitudes, and re-assess incidence rates.

By implementing a program like the one described above with athletes and the network of individuals surrounding them, it is possible that a strong relationship between knowledge and attitudes about concussion could develop. This relationship could trickle down to the behavioral level by increasing the likelihood of concussion detection, increasing the frequency of concussion reporting, enhancing concussion management practices in high schools, improving compliance with medical recommendations, and decreasing the prevalence of repeated concussion in athletes. Ultimately, if any or all of these objectives are achieved, young athletes will be better protected from the chronic and catastrophic effects of concussion.

Summary of study. The current study was the first known study to examine concussion knowledge and attitudes in high school athletic samples and the first to examine these domains in non-athletes.

The goals of this study were multifaceted. First, a measure of knowledge about and attitudes towards concussion was created, and a pilot project was conducted to examine the relevance, comprehensiveness, and psychometric characteristics of the measure. The Rosenbaum Concussion Knowledge and Attitudes Survey (RoCKAS) was administered to a large sample of high school students and exhibited acceptable internal and external validity. It was also found to be a relatively comprehensive measure of concussion knowledge and attitudes. The reliability of the measure was acceptable, but future examination of the measure is necessary to fully establish its internal consistency and reliability.

After the RoCKAS was found to be valid and reliable, it was administered to groups of high school coaches, athletic trainers, and an additional sample of students. The remaining goals were as follows: 1) to identify the relationship between concussion knowledge and attitudes within athletic samples (i.e., athletes, coaches, and athletic trainers) and within the general population (i.e., high school non-athletes), 2) identify the level of influence that different sources of information (i.e., coaches and athletic trainers) have on concussion knowledge and attitudes, and 3) identify the relationship between the availability of an athletic trainer and the rates of concussions sustained by athletes at schools with and without an athletic trainer on staff.

There was a moderate correlation found between concussion knowledge and attitudes when all participants included in the study (i.e., coaches, athletic trainers, and non-athletes) were analyzed together. When correlations comparing the knowledge and attitudes of each group separately, only the group of athletes displayed a statistically significant, but relatively weak correlation; the other groups displayed negligible correlations. The correlation that was obtained from the data of all study participants is important and quite promising due to the implications that it has for education about concussion. Specifically, the relationship suggests the possibility that increases in concussion knowledge may influence concussion attitudes and contribute to safer concussion management and more frequent reporting. The within-group correlations were likely an artifact of the restricted range of response choices on the survey.

Athletic trainers were found to have the highest knowledge and safest attitudes followed closely by coaches and the students showed substantially lower levels of knowledge and attitudes. No differences were found between athletes and non-athletes on either knowledge or attitudes suggesting that the general population of high school students is not significantly different than athletes in these domains. The attitude differences found when coaches/ATCs were compared to athletes may be indicative of both the influences of concussion knowledge and a general orientation to sports injury. The knowledge differences suggest that academic training and exposure to information about concussion may be accounting for the between-group differences.

Due to recruitment difficulties, it was not possible to examine the influence that coaches and athletic trainers may have on athletes' knowledge and attitudes. However, the substantial differences in the knowledge and attitudes of coaches and athletic trainers and that of the athletes suggest that there may be relatively little transmission of knowledge or attitudes occurring among these groups.

Schools with high enrollment were more likely than schools with medium enrollment and low enrollment to employ an athletic trainer, but, regardless of athletic trainer availability and school enrollment, at least 50% of coaches reported being the primary decision maker about return to play after concussion at both practices and games. This finding suggests that the most knowledgeable and injury-conscious individuals involved with athletic injuries (i.e., athletic trainers and physicians) are often not making RTP decisions.

No differences were found when concussion incidence rates were compared across schools with and without an athletic trainer on staff. However, this finding should be interpreted with caution due to methodological limitations.

The generalizability of the results of the study was affected by limited geographical and racial/ethnic representation of the sample. Additionally, there were relatively few participants from schools with athletic trainers and a limited response rate from participants recruited by mail rather than in person. Future studies should address each of these demographic and sampling issues. Finally, the results of the study suggest that extensive educational intervention is necessary to disseminate information about concussion to athletes and to their support networks with the hope of reducing the prevalence of multiple concussion and chronic and catastrophic concussion outcomes.

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Appendix A

Post-Concussion Symptoms Scale

Post – Concussion Symptoms Scale*

Name:_______________Code:_____________Date of Concussion:____________

Rating

None			Moderate			Severe
0	1	2	3	4	5	6

Symptoms	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time
Dizziness					
Headache					
Nausea					
Vomiting					
Balance problems					
Trouble falling asleep					
Sleeping more than usual					
Drowsiness					
Sensitivity to light					
Sensitivity to noise					
Irritability					
Sadness					
Nervous / Anxious					
Numbness or tingling					
Feeling slowed down					
Feeling like "in a fog"					
Difficulty concentrating					
Difficulty remembering					
Other:					
Total score					

*Lovell & Collins (1998)

Appendix B

Cantu Return to Play Guidelines

Cantu (1988)

Grade 1

After 1st concussion	Take out of competition, RTP only if asymptomatic at rest and exertion for one week
After 2nd concussion in same season	Take out of competition, RTP only if asymptomatic at rest and exertion for two weeks

Grade 2

After 1st concussion	Take out of competition, RTP only if asymptomatic at rest and exertion for one week
After 2nd concussion in same season	Take out of competition, RTP only if asymptomatic at rest and exertion for two weeks

Grade 3

After 1st concussion	Remove from game, RTP after one month only if asymptomatic at rest and exertion for 1 week
After 2nd concussion in same season	Terminate season

Appendix C

RoCKAS-ST

RoCKAS-ST

NOTE: The phrase "Return to play/competition" refers to being cleared to play in both practice and games

SECTION 1

DIRECTIONS: Please read the following statements and circle TRUE or FALSE for each question.			
1	There is a possible risk of death if a second concussion occurs before the first one has healed.	TRUE	FALSE
2	Running everyday does little to improve cardiovascular health.	TRUE	FALSE
3	People who have had one concussion are more likely to have another concussion.	TRUE	FALSE
4	Cleats help athletes' feet grip the playing surface.	TRUE	FALSE
5	In order to be diagnosed with a concussion, you have to be knocked out.	TRUE	FALSE
6	A concussion can only occur if there is a direct hit to the head.	TRUE	FALSE
7	Being knocked unconscious always causes permanent damage to the brain.	TRUE	FALSE
8	Symptoms of a concussion can last for several weeks.	TRUE	FALSE
9	Sometimes a second concussion can help a person remember things that were forgotten after the first concussion.	TRUE	FALSE
10	Weightlifting helps to tone and/or build muscle.	TRUE	FALSE
11	After a concussion occurs, brain imaging (e.g., CAT Scan, MRI, X-Ray, etc.) typically shows visible physical damage (e.g., bruise, blood clot) to the brain.	TRUE	FALSE
12	If you receive one concussion and you have never had a concussion before, you will become less intelligent.	TRUE	FALSE
13	After 10 days, symptoms of a concussion are usually completely gone.	TRUE	FALSE
14	After a concussion, people can forget who they are and not recognize others but be perfect in every other way.	TRUE	FALSE
15	High school freshmen and college freshmen tend to be the same age.	TRUE	FALSE
16	Concussions can sometimes lead to emotional disruptions.	TRUE	FALSE
17	An athlete who gets knocked out after getting a concussion is experiencing a coma.	TRUE	FALSE
18	There is rarely a risk to long-term health and well-being from multiple concussions.	TRUE	FALSE

SECTION 2

DIRECTIONS: Please read each of the following scenarios and circle TRUE or FALSE for each question that follows the scenarios.			
	Scenario 1: *While playing in a game, Player Q and Player X collide with each other and each suffers a concussion. Player Q has never had a concussion in the past. Player X has had 4 concussions in the past.*		
1	It is likely that Player Q's concussion will affect his long-term health and well-being.	TRUE	FALSE
2	It is likely that Player X's concussion will affect his long-term health and well-being.	TRUE	FALSE

	Scenario 2: *Player F suffered a concussion in a game. She continued to play in the same game despite the fact that she continued to feel the effects of the concussion.*		
3	Even though Player F is still experiencing the effects of the concussion, her performance will be the same as it would be had she not suffered a concussion.	TRUE	FALSE

SECTION 3

	DIRECTIONS: For each question circle the number that best describes how you feel about each statement.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I would continue playing a sport while also having a headache that resulted from a minor concussion.	1	2	3	4	5
2	I feel that coaches need to be extremely cautious when determining whether an athlete should return to play.	1	2	3	4	5
3	I feel that mouthguards protect teeth from being damaged or knocked out.	1	2	3	4	5
4	I feel that professional athletes are more skilled at their sport than high school athletes.	1	2	3	4	5
5	I feel that concussions are less important than other injuries.	1	2	3	4	5
6	I feel that an athlete has a responsibility to return to a game even if it means playing while still experiencing symptoms of a concussion.	1	2	3	4	5
7	I feel that an athlete who is knocked unconscious should be taken to the emergency room.	1	2	3	4	5
8	I feel that most high school athletes will play professional sports in the future.	1	2	3	4	5

:TION 4

ECTIONS: For each question read the scenarios and circle the number that describes your view. (For the questions that ask you what *most athletes* feel, your answers on how you think MOST athletes would feel)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Scenario 1: *Player R suffers a concussion during a game. Coach A decides to keep Player R out of the game. Player R's team loses the game.*					
I feel that Coach A made the right decision to keep Player R out of the game.	1	2	3	4	5
Most athletes would feel that Coach A made the right decision to keep Player R out of the game.	1	2	3	4	5
Scenario 2: *Athlete M suffered a concussion during the first game of the season. Athlete O suffered a concussion of the same severity during the semifinal playoff game. Both athletes had persisting symptoms.*					
I feel that Athlete M should have returned to play during the first game of the season.	1	2	3	4	5
Most athletes would feel that Athlete M should have returned to play during the first game of the season.	1	2	3	4	5
I feel that Athlete O should have returned to play during the semifinal playoff game.	1	2	3	4	5
Most athletes feel that Athlete O should have returned to play during the semifinal playoff game.	1	2	3	4	5
Scenario 3: *Athlete R suffered a concussion. Athlete R's team has an athletic trainer on the staff.*					
I feel that the athletic trainer, rather than Athlete R, should make the decision about returning Athlete R to play.	1	2	3	4	5
Most athletes would feel that the athletic trainer, rather than Athlete R, should make the decision about returning Athlete R to play.	1	2	3	4	5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Scenario 4: *Athlete H suffered a concussion and he has a game in two hours. He is still experiencing symptoms of concussion. However, Athlete H knows that if he tells his coach about the symptoms, his coach will keep him out of the game.*					
I feel that Athlete H should tell his coach about the symptoms.	1	2	3	4	5
Most athletes would feel that Athlete H should tell his coach about the symptoms.	1	2	3	4	5

CTION 5

ECTIONS: Think about someone who has had a concussion. Check off the following signs and symptoms that you believe eone may be likely to experience AFTER a concussion.

✓		✓	
	Hives		Feeling in a "Fog"
	Headache		Weight Gain
	Difficulty Speaking		Feeling Slowed Down
	Arthritis		Reduced Breathing Rate
	Sensitivity to Light		Excessive Studying
	Difficulty Remembering		Difficulty Concentrating
	Panic Attacks		Dizziness
	Drowsiness		Hair Loss

Appendix D

RoCKAS-CH

RoCKAS-CH

NOTE: The phrase "Return to play/competition" refers to being cleared to play in both practice and games

SECTION 1

DIRECTIONS: Please read the following statements and circle TRUE or FALSE for each question.			
1	There is a possible risk of death if a second concussion occurs before the first one has healed.	TRUE	FALSE
2	Running everyday does little to improve cardiovascular health.	TRUE	FALSE
3	People who have had one concussion are more likely to have another concussion.	TRUE	FALSE
4	Cleats help athletes' feet grip the playing surface.	TRUE	FALSE
5	In order to be diagnosed with a concussion, you have to be knocked out.	TRUE	FALSE
6	A concussion can only occur if there is a direct hit to the head.	TRUE	FALSE
7	Being knocked unconscious always causes permanent damage to the brain.	TRUE	FALSE
8	Symptoms of a concussion can last for several weeks.	TRUE	FALSE
9	Sometimes a second concussion can help a person remember things that were forgotten after the first concussion.	TRUE	FALSE
10	Weightlifting helps to tone and/or build muscle.	TRUE	FALSE
11	After a concussion occurs, brain imaging (e.g., CAT Scan, MRI, X-Ray, etc.) typically shows visible physical damage (e.g., bruise, blood clot) to the brain.	TRUE	FALSE
12	If you receive one concussion and you have never had a concussion before, you will become less intelligent.	TRUE	FALSE
13	After 10 days, symptoms of a concussion are usually completely gone.	TRUE	FALSE
14	After a concussion, people can forget who they are and not recognize others but be perfect in every other way.	TRUE	FALSE
15	High school freshmen and college freshmen tend to be the same age.	TRUE	FALSE
16	Concussions can sometimes lead to emotional disruptions.	TRUE	FALSE
17	An athlete who gets knocked out after getting a concussion is experiencing a coma.	TRUE	FALSE
18	There is rarely a risk to long-term health and well-being from multiple concussions.	TRUE	FALSE
19	A "bell ringer or ding" is a concussion.	TRUE	FALSE

SECTION 2

DIRECTIONS: Please read each of the following scenarios and circle TRUE or FALSE for each question that follows the scenarios.			
	Scenario 1: *While playing in a game, Player Q and Player X collide with each other and each suffers a concussion. Player Q has never had a concussion in the past. Player X has had 4 concussions in the past.*		
1	It is likely that Player Q's concussion will affect his long-term health and well-being.	TRUE	FALSE
2	It is likely that Player X's concussion will affect his long-term health and well-being.	TRUE	FALSE
	Scenario 2: *Player F suffered a concussion in a game. She continued to play in the same game despite the fact that she continued to feel the effects of the concussion.*		
3	Even though Player F is still experiencing the effects of the concussion, her performance will be the same as it would be had she not suffered a concussion.	TRUE	FALSE

SECTION 3

DIRECTIONS: For each question circle the number that best describes how you feel about each statement.		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I would continue playing a sport while also having a headache that resulted from a minor concussion.	1	2	3	4	5
2	I feel that coaches need to be extremely cautious when determining whether an athlete should return to play.	1	2	3	4	5
3	I feel that mouthguards protect teeth from being damaged or knocked out.	1	2	3	4	5
4	I feel that professional athletes are more skilled at their sport than high school athletes.	1	2	3	4	5
5	I feel that concussions are less important than other injuries.	1	2	3	4	5
6	I feel that an athlete has a responsibility to return to a game even if it means playing while still experiencing symptoms of a concussion.	1	2	3	4	5
7	I feel that an athlete who is knocked unconscious should be taken to the emergency room.	1	2	3	4	5
8	I feel that most high school athletes will play professional sports in the future.	1	2	3	4	5

CTION 4

ECTIONS: For each question read the scenarios and circle the number that describes your view. (For the questions that ask you what *most athletes* feel, your answers on how you think MOST athletes would feel)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Scenario 1: *Player R suffers a concussion during a game. Coach A decides to keep Player R out of the game. Player R's team loses the game.*					
I feel that Coach A made the right decision to keep Player R out of the game.	1	2	3	4	5
Most coaches would feel that Coach A made the right decision to keep Player R out of the game.	1	2	3	4	5
Scenario 2: *Athlete M suffered a concussion during the first game of the season. Athlete O suffered a concussion of the same severity during the semifinal playoff game. Both athletes had persisting symptoms.*					
I feel that Athlete M should have returned to play during the first game of the season.	1	2	3	4	5
Most coaches would feel that Athlete M should have returned to play during the first game of the season.	1	2	3	4	5
I feel that Athlete O should have returned to play during the semifinal playoff game.	1	2	3	4	5
Most coaches feel that Athlete O should have returned to play during the semifinal playoff game.	1	2	3	4	5
Scenario 3: *Athlete R suffered a concussion. Athlete R's team has an athletic trainer on the staff.*					
I feel that the athletic trainer, rather than Athlete R, should make the decision about returning Athlete R to play.	1	2	3	4	5
Most coaches would feel that the athletic trainer, rather than Athlete R, should make the decision about returning Athlete R to play.	1	2	3	4	5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Scenario 4: *Athlete H suffered a concussion and he has a game in two hours. He is still experiencing symptoms of concussion. However, Athlete H knows that if he tells his coach about the symptoms, his coach will keep him out of the game.*					
I feel that Athlete H should tell his coach about the symptoms.	1	2	3	4	5
Most coaches would feel that Athlete H should tell his coach about the symptoms.	1	2	3	4	5

CTION 5

ECTIONS: Think about someone who has had a concussion. Check off the following signs and symptoms that you believe eone may be likely to experience AFTER a concussion.

✓		✓	
	Hives		Feeling in a "Fog"
	Headache		Weight Gain
	Difficulty Speaking		Feeling Slowed Down
	Arthritis		Reduced Breathing Rate
	Sensitivity to Light		Excessive Studying
	Difficulty Remembering		Difficulty Concentrating
	Panic Attacks		Dizziness
	Drowsiness		Hair Loss

Appendix E

RoCKAS-AT

RoCKAS-AT

NOTE: The phrase "Return to play/competition" refers to being cleared to play in both practice and games

SECTION 1

DIRECTIONS: Please read the following statements and circle TRUE or FALSE for each question.			
1	There is a possible risk of death if a second concussion occurs before the first one has healed.	TRUE	FALSE
2	Running everyday does little to improve cardiovascular health.	TRUE	FALSE
3	People who have had one concussion are more likely to have another concussion.	TRUE	FALSE
4	Cleats help athletes' feet grip the playing surface.	TRUE	FALSE
5	In order to be diagnosed with a concussion, you have to be knocked out.	TRUE	FALSE
6	A concussion can only occur if there is a direct hit to the head.	TRUE	FALSE
7	Being knocked unconscious always causes permanent damage to the brain.	TRUE	FALSE
8	Symptoms of a concussion can last for several weeks.	TRUE	FALSE
9	Sometimes a second concussion can help a person remember things that were forgotten after the first concussion.	TRUE	FALSE
10	Weightlifting helps to tone and/or build muscle.	TRUE	FALSE
11	After a concussion occurs, brain imaging (e.g., CAT Scan, MRI, X-Ray, etc.) typically shows visible physical damage (e.g., bruise, blood clot) to the brain.	TRUE	FALSE
12	If you receive one concussion and you have never had a concussion before, you will become less intelligent.	TRUE	FALSE
13	After 10 days, symptoms of a concussion are usually completely gone.	TRUE	FALSE
14	After a concussion, people can forget who they are and not recognize others but be perfect in every other way.	TRUE	FALSE
15	High school freshmen and college freshmen tend to be the same age.	TRUE	FALSE
16	Concussions can sometimes lead to emotional disruptions.	TRUE	FALSE
17	An athlete who gets knocked out after getting a concussion is experiencing a coma.	TRUE	FALSE
18	There is rarely a risk to long-term health and well-being from multiple concussions.	TRUE	FALSE
19	A "bell ringer or ding" is a concussion.	TRUE	FALSE

SECTION 2

DIRECTIONS: Please read each of the following scenarios and circle TRUE or FALSE for each question that follows the scenarios.			
	Scenario 1: *While playing in a game, Player Q and Player X collide with each other and each suffers a concussion. Player Q has never had a concussion in the past. Player X has had 4 concussions in the past.*		
1	It is likely that Player Q's concussion will affect his long-term health and well-being.	TRUE	FALSE
2	It is likely that Player X's concussion will affect his long-term health and well-being.	TRUE	FALSE
	Scenario 2: *Player F suffered a concussion in a game. She continued to play in the same game despite the fact that she continued to feel the effects of the concussion.*		
3	Even though Player F is still experiencing the effects of the concussion, her performance will be the same as it would be had she not suffered a concussion.	TRUE	FALSE

SECTION 3

DIRECTIONS: For each question circle the number that best describes how you feel about each statement.		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I would continue playing a sport while also having a headache that resulted from a minor concussion.	1	2	3	4	5
2	I feel that coaches need to be extremely cautious when determining whether an athlete should return to play.	1	2	3	4	5
3	I feel that mouthguards protect teeth from being damaged or knocked out.	1	2	3	4	5
4	I feel that professional athletes are more skilled at their sport than high school athletes.	1	2	3	4	5
5	I feel that concussions are less important than other injuries.	1	2	3	4	5
6	I feel that an athlete has a responsibility to return to a game even if it means playing while still experiencing symptoms of a concussion.	1	2	3	4	5
7	I feel that an athlete who is knocked unconscious should be taken to the emergency room.	1	2	3	4	5
8	I feel that most high school athletes will play professional sports in the future.	1	2	3	4	5

CTION 4

ECTIONS: For each question read the scenarios and circle the number that describes your view. (For the questions that ask you what *most athletes* feel, your answers on how you think MOST athletes would feel)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Scenario 1: *Player R suffers a concussion during a game. Coach A decides to keep Player R out of the game. Player R's team loses the game.*					
I feel that Coach A made the right decision to keep Player R out of the game.	1	2	3	4	5
Most athletic trainers would feel that Coach A made the right decision to keep Player R out of the game.	1	2	3	4	5
Scenario 2: *Athlete M suffered a concussion during the first game of the season. Athlete O suffered a concussion of the same severity during the semifinal playoff game. Both athletes had persisting symptoms.*					
I feel that Athlete M should have returned to play during the first game of the season.	1	2	3	4	5
Most athletic trainers would feel that Athlete M should have returned to play during the first game of the season.	1	2	3	4	5
I feel that Athlete O should have returned to play during the semifinal playoff game.	1	2	3	4	5
Most athletic trainers feel that Athlete O should have returned to play during the semifinal playoff game.	1	2	3	4	5
Scenario 3: *Athlete R suffered a concussion. Athlete R's team has an athletic trainer on the staff.*					
I feel that the athletic trainer, rather than Athlete R, should make the decision about returning Athlete R to play.	1	2	3	4	5
Most athletic trainers would feel that the athletic trainer, rather than Athlete R, should make the decision about returning Athlete R to play.	1	2	3	4	5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Scenario 4: *Athlete H suffered a concussion and he has a game in two hours. He is still experiencing symptoms of concussion. However, Athlete H knows that if he tells his coach about the symptoms, his coach will keep him out of the game.*					
I feel that Athlete H should tell his coach about the symptoms.	1	2	3	4	5
Most athletic trainers would feel that Athlete H should tell his coach about the symptoms.	1	2	3	4	5

CTION 5

ECTIONS: Think about someone who has had a concussion. Check off the following signs and symptoms that you believe eone may be likely to experience AFTER a concussion.

✓		✓	
	Hives		Feeling in a “Fog”
	Headache		Weight Gain
	Difficulty Speaking		Feeling Slowed Down
	Arthritis		Reduced Breathing Rate
	Sensitivity to Light		Excessive Studying
	Difficulty Remembering		Difficulty Concentrating
	Panic Attacks		Dizziness
	Drowsiness		Hair Loss

Appendix F

Key for Abbreviations of Measures

PCSS—Post Concussion Symptoms Scale

RoCKAS—Rosenbaum Concussion Knowledge and Attitudes Survey

-ST—Student form

-CH—Coach form

-AT—Athletic Trainer form

-PD—Preliminary Direct form

-PI—Preliminary Indirect form

RoCKAS Sup—RoCKAS-Supplement

-HSST Sup—High School Student Supplement

-HSATC Sup—High School Athletic Trainer Supplement

-HSCH Sup—High School Coach Supplement

PCQ—Previous Concussion Questionnaire

CIQ-HSCH—Concussion Incidence Questionnaire—High School Coach version

CIQ-HSAT—Concussion Incidence Questionnaire—High School Athletic Trainer version

CKI—Concussion Knowledge Index

CAI—Concussion Attitudes Index

VS—Validity Scale

Appendix G

RoCKAS-HSST Sup

RoCKAS-HSST Sup

SECTION 1—DEMOGRAPHIC INFORMATION

1. Sex (Circle one) Male Female
2. Age__________________________
3. Race/Ethnicity_________________

SECTION 2—ACADEMIC INFORMATION

1. How many years of high school have you FULLY completed (Circle one) 0 1 2 3 4 5 6
2. What is your mother's/caregiver's highest level of education achieved? (Circle one)

✓		✓		✓	
	8th Grade		College Degree (associates, bachelors, etc.)		Not Applicable
	High School/GED		Graduate Degree (masters, Ph.D., J.D., M.D., MBA, etc.)		
	Some College		Other:_________________		

3. What is your father's/caregiver's highest level of education achieved? (Circle one)

✓		✓		✓	
	8th Grade		College Degree (associates, bachelors, etc.)		Not Applicable
	High School/GED		Graduate Degree (masters, Ph.D., J.D., M.D., MBA, etc.)		
	Some College		Other:_________________		

4. What is your current grade point average? (Please provide it in ONE of the two formats; if you don't know the exact value, just provide your best estimate)
   Format 1:_____out of______ (for example, 3.1 out 4.0)
   Format 2:______% (for example, 87%)

SECTION 3—SPORTS PARTICIPATION AND HIGH SCHOOL INFORMATION

1. Do you currently play HIGH SCHOOL sports or have you played HIGH SCHOOL sports in the past? (AAU, summer league, etc. are not considered high school sports) Circle one YES NO

--IF YOU ANSWERED NO TO QUESTION 1, PLEASE SKIP TO SECTION 4

2. Please think about the HIGH SCHOOL sports that you played, will play, or are currently playing. (AAU, summer league, etc. are not considered high school sports)

	Please list the sports in the spaces below	Which level are you playing this sport at during the current academic year? If you no longer play this sport, which level did you play this sport at when you played? (Circle one) *N/A=Not Applicable					If you consider the total number of games/matches that you have played in this sport, have you started 50% or more of the games/matches? (Circle one) *N/A=Not Applicable		
Sport 1		Varsity	JV	Freshman/Modified	Other	N/A	YES	NO	N/A
Sport 2		Varsity	JV	Freshman/Modified	Other	N/A	YES	NO	N/A
Sport 3		Varsity	JV	Freshman/Modified	Other	N/A	YES	NO	N/A
Sport 4		Varsity	JV	Freshman/Modified	Other	N/A	YES	NO	N/A
Sport 5		Varsity	JV	Freshman/Modified	Other	N/A	YES	NO	N/A

NOTE: THE PHRASE "Return to play" REFERS TO BEING CLEARED TO PLAY IN BOTH PRACTICE & GAMES.

3. Consider the following scenario: An athlete gets a concussion during a **practice**. Therefore, a decision needs to be made about whether that athlete can safely return to play during the same practice or if the athlete needs to remain out of the practice.
When you think about the team(s) that you play on, who typically makes that decision (i.e., who makes the decision greater than 60% of the time)?
CIRCLE ONLY ONE
Coach Athletic trainer Physician The Athlete Other:_______________________

4. Consider the following scenario: An athlete gets a concussion during a **game**. Therefore, a decision needs to be made about whether that athlete can safely return to play during the same game or if the athlete needs to remain out of the game.
When you think about the team(s) that you play on, who typically makes that decision (i.e., who makes the decision greater than 60% of the time)?
CIRCLE ONLY ONE
Coach Athletic trainer Physician The Athlete Other:_______________________

SECTION 4—CONCUSSION QUESTIONS

		A little knowledge		An average amount of knowledge		A lot of knowledge
1.	When compared to the average high school student, how much knowledge do you have about concussions? (Circle one)	1	2	3	4	5

2. Have you ever received what you thought was a concussion and kept playing without telling anyone about it? (Circle one) YES NO

3. Which source(s) has/have contributed to your knowledge about concussion? (Check all that apply)

✓		✓		✓	
	Coach		Neuropsychologist/Neurologist		Courses/Workshops
	Athletic trainer		Parent/Caregiver		Personal/Teammate/Opponent Concussion
	Team physician		Magazines/Periodicals/Newspapers		Concussion or other brain injury of someone you know who isn't an athlete
	Family physician		Sports related and non-sports related television programs		Friend(s)

Other Source (Please list the source(s)____

3a. Of the source(s) that you've chosen above, which source has contributed the **MOST** to your knowledge about concussion? (Write **ONLY ONE** source)___________________

4. Have you ever attended a presentation (workshop, seminar, etc.) or been presented with any materials (pamphlet, newsletter, etc.) about concussions? (Circle one) YES NO NOT SURE

5. Has anyone close to you (for example, parent, sibling, friend, fellow athlete, etc.) ever had a concussion? (Circle one) YES NO

5a. If yes, what is their relationship to you? __________________________

6. Do you know the criteria that coaches, athletic trainers, physicians, etc. use to label (grade) the severity of concussion? (Circle one) YES NO

SECTION 5—CONCUSSION RANKING LISTS

1. When considering the severity of concussion, rank the importance of the following symptoms on a scale of 1-5. (1=Most important, 5=Least important)

Loss of consciousness (knocked out) _____
Amnesia (loss of memory before or after injury) _____
Headache for 2 days or more _____ **PLEASE USE EACH NUMBER ONLY ONCE!**
Headache for less than 2 days _____
Confusion _____

2. When considering the severity of an injury, rank the importance of the following injuries on a scale of 1-6. (1=Most serious, 6=Least serious)

Torn knee ligament _____
Pulled back muscle _____
Sprained ankle _____
Concussion _____ **PLEASE USE EACH NUMBER ONLY ONCE!**
Cut on head _____
Elbow soreness _____

SCENARIO: Athlete X receives a concussion but is conscious. Athlete X's coach runs onto the field to check on Athlete X. An athletic trainer and physician also run onto the field to check on Athlete X.

1. When considering whose opinion is the most important with regard to when Athlete X can safely return to play, rank the importance of each decision maker's opinion on a scale of 1-5 (1=Most important opinion, 5=Least important opinion)

   The athlete _____
   The coach _____
   The athletic trainer _____
   The physician _____ **PLEASE USE EACH NUMBER ONLY ONCE!**
   The parent _____

Would you like to know more about concussion, and if so, what would you like to know more about?

____

____

____

Appendix H

RoCKAS-HSATC Sup

RoCKAS-HSATC Sup

SECTION 1—DEMOGRAPHIC INFORMATION

1. Sex (Circle one) Male Female

2. Age__________________________

3. Race/Ethnicity_________________

SECTION 2—OCCUPATIONAL INFORMATION

1. How many years have you been working as a certified athletic trainer?____

2. Have you ever provided a formal and/or informal presentation (e.g., workshop, seminar, class, etc.) that included some information about concussion to coaches at your school? (Circle one)
   YES NO

3. Have you ever provided a formal and/or informal presentation (e.g., workshop, seminar, class, etc.) that included some information about concussion to athletes at your school? (Circle one) YES NO

4. What type of information do you typically provide to athletes after sustaining a concussion (Circle all that apply)
   a. None b. Written materials c. Verbal instructions d. Referral to various media (e.g., websites, texts, videos about concussi

   Other_______________________

SECTION 3—SCHOOL INFORMATION

NOTE: THE PHRASE "Return to play" REFERS TO BEING CLEARED TO PLAY IN BOTH PRACTICE & GAMES.

1. Consider the following scenario: An athlete sustains a concussion during a **practice**. Therefore, a decision needs to be made about whether that athlete can safely return to play during the same practice or if the athlete needs to remain out of the practice.
   When you think about the team(s) that you are responsible for, who typically (i.e., greater than 60% of the time) makes that decision?
   CIRCLE ONLY ONE
   Coach Athletic trainer Physician The Athlete Other:_______________________

2. Consider the following scenario: An athlete sustains a concussion during a **game**. Therefore, a decision needs to be made about whether that athlete can safely return to play during the same game or if the athlete needs to remain out of the game.
   When you think about the team(s) that you are responsible for, who typically (i.e., greater than 60% of the time) makes that decision?
   CIRCLE ONLY ONE
   Coach Athletic trainer Physician The Athlete Other:_______________________

SECTION 4—CONCUSSION QUESTIONS

		A little knowledge		An average amount of knowledge		A lot of knowledge
1.	When compared to the average high school coach, how much knowledge do you have about concussions? (Circle one)	1	2	3	4	5

2. When considering the severity of concussion, rank the importance of the following symptoms on a scale of 1-5. (1=Most important, 5=Least important)
   - Loss of consciousness (knocked out) _____
   - Amnesia (loss of memory before or after injury) _____
   - Headache for longer than 2 days _____
   - Headache for shorter than 2 days _____
   - Confusion _____

   PLEASE USE EACH NUMBER ONLY ONCE!

3. When considering the severity of an injury, rank the importance of the following injuries on a scale of 1-6. (1=Most serious, 6=Least serious)
   - Torn knee ligament _____
   - Pulled back muscle _____
   - Sprained ankle _____
   - Concussion _____
   - Cut on head _____
   - Elbow soreness _____

   PLEASE USE EACH NUMBER ONLY ONCE!

SCENARIO: Athlete X receives a concussion but is conscious. Athlete X's coach runs onto the field to check on Athlete X. An athletic trainer and physician also run onto the field to check on Athlete X.

4. When considering whose opinion is the most important with regard to when Athlete X can safely return to play, rank the importance of each decision maker's opinion on a scale of 1-5 (1=Most important opinion, 5=Least important opinion)

The athlete _____
The coach _____
The athletic trainer _____ **PLEASE USE EACH NUMBER ONLY ONCE!**
The physician _____
The parent _____

Would you like to know more about concussion, and if so, what would you like to know more about?

____

____

____

Appendix I

RoCKAS-HSCH Sup

<u>RoCKAS-HSCH Sup</u>

SECTION 1—DEMOGRAPHIC INFORMATION

1. Sex (Circle one) Male Female
2. Age__________________________
3. Race/Ethnicity_________________

SECTION 2—OCCUPATIONAL INFORMATION

1. How many years of coaching experience do you have (include years as assistant coach, grad assistant, etc.)?______
2. Have you received a college degree? (i.e., bachelors or associates) Circle one: YES NO **IF NO, PLEASE SKIP TO QUESTION 3**

   2a. What did you major in during college? ____
3. Please indicate the number of college courses that you have taken throughout your lifetime that have devoted some portion of the course to issues related to concussion (Circle one)

   0 1 2 3 4 5+
4. Please list the number of presentations (i.e., workshops, seminars, conferences, symposia, etc.) that you have attended over your lifetime that have devoted some portion of the presentation to issues related to concussion (Circle one)

   0 1 2 3 4 5+
5. Which HIGH SCHOOL sport(s) are you currently coaching? (please list all of the HIGH SCHOOL sports that you are currently coaching or have coached during the current academic year and the sports that you will be coaching during the current academic year)

		What is the sex of the athletes on this team? (Circle one)			What is your coaching position on this team? (Circle one)		At which level are you coaching this sport? (Circle one)			
Sport 1		Male	Female	Both Sexes	Head Coach	Assistant Coach	Varsity	JV	Modified/ Freshman	Other
Sport 2		Male	Female	Both Sexes	Head Coach	Assistant Coach	Varsity	JV	Modified/ Freshman	Other
Sport 3		Male	Female	Both Sexes	Head Coach	Assistant Coach	Varsity	JV	Modified/ Freshman	Other
Sport 4		Male	Female	Both Sexes	Head Coach	Assistant Coach	Varsity	JV	Modified/ Freshman	Other

SECTION 3—SCHOOL INFORMATION

NOTE: THE PHRASE "Return to play" REFERS TO BEING CLEARED TO PLAY IN BOTH PRACTICE & GAMES.

1. Consider the following scenario: An athlete sustains a concussion during a **practice**. Therefore, a decision needs to be made about whether that athlete can safely return to play during the same practice or if the athlete needs to remain out of the practice.
   When you think about the team(s) that you coach, who typically (i.e., greater than 60% of the time) makes that decision?
   CIRCLE ONLY ONE

   Coach Athletic trainer Physician The Athlete Other:______________________
2. Consider the following scenario: An athlete sustains a concussion during a **game**. Therefore, a decision needs to be made about whether that athlete can safely return to play during the same game or if the athlete needs to remain out of the game.
   When you think about the team(s) that you coach, who typically (i.e., greater than 60% of the time) makes that decision?
   CIRCLE ONLY ONE

   Coach Athletic trainer Physician The Athlete Other:______________________

SECTION 4—CONCUSSION QUESTIONS

		A little knowledge		An average amount of knowledge		A lot of knowledge
1.	When compared to the average high school coach, how much knowledge do you have about concussions? (Circle one)	1	2	3	4	5

2. When considering the severity of concussion, rank the importance of the following symptoms on a scale of 1-5. (1=Most important, 5=Least important)
   Loss of consciousness (knocked out) _____
   Amnesia (loss of memory before or after injury) _____
   Headache for longer than 2 days _____
   Headache for shorter than 2 days _____ **PLEASE USE EACH NUMBER ONLY ONCE!**
   Confusion _____

3. When considering the severity of an injury, rank the importance of the following injuries on a scale of 1-6. (1=Most serious, 6=Least serious)
   Torn knee ligament _____
   Pulled back muscle _____
   Sprained ankle _____
   Concussion _____ **PLEASE USE EACH NUMBER ONLY ONCE!**
   Cut on head _____
   Elbow soreness _____

SCENARIO: Athlete X receives a concussion but is conscious. Athlete X's coach runs onto the field to check on Athlete X. An athletic trainer and physician also run onto the field to check on Athlete X.

3. When considering whose opinion is the most important with regard to when Athlete X can safely return to play, rank the importance of each decision maker's opinion on a scale of 1-5 (1=Most important opinion, 5=Least important opinion)
   The athlete _____
   The coach _____
   The athletic trainer _____ **PLEASE USE EACH NUMBER ONLY ONCE!**
   The physician _____
   The parent _____

Would you like to know more about concussion, and if so, what would you like to know more about?

____

Appendix J

Previous Concussion Questionnaire

PREVIOUS CONCUSSION QUESTIONNAIRE

Please read the following information about concussion and answer the subsequent questions:

-Two things need to occur for an individual to be diagnosed with a concussion:

1) The individual needs to receive a direct blow to the head **OR** the individual's head is shaken or jarred by a blow to the face, neck, or torso.

AND

2) After the head is directly struck or is shaken/jarred, the individual must experience ***ONE OR MORE OF THE FOLLOWING SYMPTOMS***:

-Loss of consciousness/knocked out for one minute or less

-Amnesia for 30 minutes or less (Amnesia means forgetting some events that happen before and or after the injury)

-Brain imaging (MRI, CT, etc.) shows a small amount of brain damage

-Confusion	-Disorientation	-Dizziness	-Nausea
-Vomiting	-Trouble falling asleep	-Drowsiness	-Headache
-Difficulty concentrating	-Sleeping more than usual	-Irritability	-Sadness
-Sensitivity to light	-Sensitivity to noise	-Nervous/anxious	-Numbness/tingling
-Feeling in a fog	-Feeling slowed down	-Difficulty remembering	-Balance problems

1) Have you ever experienced ***ANY*** of these symptoms following a direct blow to the head or after receiving a blow to the face, neck, or torso that shook or jarred your head? (Circle one)   YES   NO

If you answered* NO *to question 1, you have never had a concussion. Please stop here.

If you answered* YES *to question 1, YOU HAVE HAD A CONCUSSION(S). Please answer questions 2&3.

2) Based on the definition of concussion provided above, how many concussions have you had during the past academic year? (*If you are currently in the 2006-2007 academic year, please list the number of concussions that you had during the 2005-2006 academic year*)________

3) Based on the definition of concussion provided above, how many concussions have you had throughout your life (including concussions that you had during the current academic year)?__________

Appendix K

Concussion Incidence Questionnaire-HSCH

CONCUSSION INCIDENCE QUESTIONNAIRE-HSCH

--Please read the following information about concussion and answer the subsequent questions:

-Two things need to occur for an individual to be diagnosed with a concussion:
1) The individual needs to receive a direct blow to the head **OR** the individual's head is shaken or jarred by a blow to the face, neck, or torso.

AND

2) After the head is directly struck or is shaken/jarred, the individual must experience ***ONE OR MORE OF THE FOLLOWING SYMPTOMS***:

-Loss of consciousness/knocked out for one minute or less

-Amnesia for 30 minutes or less (Amnesia means forgetting some events that happen before and/or after the injury)

-Brain imaging (MRI, CT, etc.) shows a small amount of brain damage

-Confusion	-Disorientation	-Dizziness	-Nausea
-Vomiting	-Trouble falling asleep	-Drowsiness	-Headache
-Difficulty concentrating	-Sleeping more than usual	-Irritability	-Sadness
-Sensitivity to light	-Sensitivity to noise	-Nervous/anxious	-Numbness/tingling
-Feeling in a fog	-Feeling slowed down	-Difficulty remembering	-Balance problems

BASED PURELY ON THESE DEFINING FEATURES OF CONCUSSION (rather than basing your answer on your personal definition, a diagnosis from a physician, etc.), please estimate the number of athletes who have sustained a concussion on the team(s) that you coached within the previous academic year (i.e., if you are currently in the 2006-07 academic year, please consider the 2005-06 academic year)

1. # of athletes on your team(s) who sustained only 1 concussion during the last academic year (estimate)_______
2. # of athletes on your team(s) who sustained 2 or more concussions during the last academic year (estimate)_______

NOTE: THE PHRASE "Return to play" REFERS TO BEING CLEARED TO PLAY IN BOTH PRACTICE & GAMES.

1. In your opinion, provide a rough estimate of what percentage of HIGH SCHOOL coaches return an athlete to play while the athlete is still displaying signs and/or symptoms of concussion?______%

	Low Confidence		Moderate Confidence		High Confidence
How confident are you about the estimates that you made in questions 1-3? (Circle one)	1	2	3	4	5

Appendix L

Concussion Incidence Questionniare-HSAT

CONCUSSION INCIDENCE QUESTIONNAIRE-HSAT

--Recent reports from a consensus committee on sports concussion and from experts in sports neuropsychology indicate that the features listed below are evidence that a concussion has occurred.

--Please read the following information about concussion and answer the subsequent question:

-Two things need to occur for an individual to be diagnosed with a concussion:

1) The individual needs to receive a direct blow to the head **OR** the individual's head is shaken or jarred by a blow to the face, neck, or torso.

AND

2) After the head is directly struck or is shaken/jarred, the individual must experience ***ONE OR MORE OF THE FOLLOWING SYMPTOMS***:

-Loss of consciousness/knocked out for one minute or less

-Amnesia for 30 minutes or less (Amnesia means forgetting some events that happen before and/or after the injury)

-Brain imaging (MRI, CT, etc.) shows a small amount of brain damage

-Confusion	-Disorientation	-Dizziness	-Nausea
-Vomiting	-Trouble falling asleep	-Drowsiness	-Headache
-Difficulty concentrating	-Sleeping more than usual	-Irritability	-Sadness
-Sensitivity to light	-Sensitivity to noise	-Nervous/anxious	-Numbness/tingling
-Feeling in a fog	-Feeling slowed down	-Difficulty remembering	-Balance problems

BASED PURELY ON THESE DEFINING FEATURES OF CONCUSSION (rather than basing your answer on your personal definition, a diagnosis from a physician, etc.), please estimate the number of athletes who have sustained a concussion at your high school within the previous academic year (i.e., if you are currently in the 2006-07 academic year, please consider the 2005-06 academic year)

# of athletes who sustained only 1 concussion during the last academic year (estimate)_______

# of athletes who sustained 2 or more concussions during the last academic year (estimate)_______

What percentage of the total number of concussions sustained by athletes at your high school occurred during:
Practices_____% Games_____% Other activities_____% (the total must equal 100%)

	Low Confidence		Moderate Confidence		High Confidence
How confident are you about the estimates that you made in questions 1-3? (Circle one)	1	2	3	4	5

Appendix M

Marlowe-Crowne Social Desirability Scale

Marlowe-Crowne

Directions: Please read the following statements and circle **T—for TRUE** if the statement is true for you or **F—for FALSE** if the statement is false for you.

T—TRUE **F—FALSE**

1. I have never intensely disliked anyone.
   T **F**

2. I sometimes feel resentful when I don't get my way.
   T **F**

3. There have been times when I felt like rebelling against people in authority even though I knew they were right.
   T **F**

4. I sometimes try to get even, rather than forgive and forget.
   T **F**

5. There have been occasions when I felt like smashing things.
   T **F**

6. I would never think of letting someone else be punished for my wrongdoings.
   T **F**

7. I never resent being asked to return a favor.
   T **F**

8. I have never been irked when people expressed ideas very different from my own.
   T **F**

9. There have been times when I was quite jealous of the good fortune of others.
   T **F**

10. I have almost never felt the urge to tell someone off.
T **F**

11. I am sometimes irritated by people who asks favors of me.
T **F**

12. I have never felt that I was punished without cause.
T **F**

13. I sometimes think when people have a misfortune, they only got what they deserved.
T **F**

14. I have never deliberately said something that hurt someone’s feelings.
T **F**

15. Before voting, I thoroughly investigate the qualifications of all the candidates.
T **F**

16. I never hesitate to go out of my way to help someone in trouble.
T **F**

17. I am always careful about my manner of dress.
T **F**

18. My table manners at home are as good as when I eat out in a restaurant.
T **F**

19. If I could get into a movie without paying and be sure I was not seen, I would probably do it.
T **F**

20. I like to gossip at times.
T **F**

21. No matter who I’m talking to, I’m always a good listener.
T **F**

22. I can remember “playing sick” to get out of something.
T **F**

23. There have been occasions when I took advantage of someone.
T **F**

24. I always try to practice what I preach.
T **F**

25. I don't find it particularly difficult to get along with loud mouthed, obnoxious, people.
T **F**

26. I am always courteous, even to people who are disagreeable.
T **F**

27. At times, I have really insisted on having things my own way.
T **F**

28. I never make a long trip without checking the safety of my car.
T **F**

29. It is sometimes hard for me to go on with my work if I am not encouraged.
T **F**

30. On occasion I have had doubts about my ability to succeed in life.
T **F**

31. On a few occasions, I have given up doing something because I thought too little of my ability.
T **F**

32. I'm always willing to admit it when I make a mistake.
T **F**

33. When I don't know something, I don't at all mind admitting it.
T **F**

Appendix N

Intercorrelations Among Factors in Exploratory Factor Analysis 1

Factor Comparison	*r*
Factor 1-Factor 2	.117
Factor 1-Factor 3	.374
Factor 1-Factor 4	.073
Factor 1-Factor 5	.297
Factor 2-Factor 3	.030
Factor 2-Factor 4	.070
Factor 2-Factor 5	.119
Factor 3-Factor 4	.206
Factor 3-Factor 5	.286
Factor 4-Factor 5	.191
MEDIAN Intercorrelation	.155
Range of Intercorrelations	.030-.374

Appendix O

Most Important Concussion Knowledge Source as Reported by High School Athletes

Source	Athletes w/out ATC % athletes (# athletes)	Athletes w/ ATC % athletes (# athletes)	Total %
Parents	18.2 (49)	13.6 (6)	17.6
Coach	9.7 (26)	4.5 (2)	8.9
Athletic trainer	2.2 (6)	25.0 (11)	5.4
Family physician	15.6 (42)	9.1 (4)	14.7
Personal/teammate/opponent concussion	12.3 (33)	18.2 (8)	13.1
Friend	17.1 (46)	6.8 (3)	15.7
Television	7.8 (21)	6.8 (3)	7.7
Magazines/periodicals	3.0 (8)	4.5 (2)	3.2
Courses/workshops	3.3 (9)	2.3 (1)	3.2
Neuropsychologist/neurologist	1.9 (5)	2.3 (1)	1.9
Other	7.1 (19)	6.8 (3)	7.0

Appendix P

Number of Athletes Playing Sports Organized by Level of Injury Risk

High Risk				Moderate Risk				Low Risk			
Sports	Pilot	Main	Total	Sports	Pilot	Main	Total	Sports	Pilot	Main	Total
Field Hockey	0	2	2	Baseball	56	4	60	Boys' Bowling	7	11	18
Football	70	5	75	Boys' Basketball	47	10	57	Girls' Bowling	5	4	9
Ice Hockey	22	2	24	Girls' Basketball	41	2	43	Boys' Cross-country	8	4	12
Boys' Lacrosse	1	9	10	Girls' Gymnastics	19	0	19	Girls' Cross Country	11	0	11
Girls' Lacrosse	0	21	21	Boys' Skiing	0	6	6	Golf	12	9	21
Boys' Soccer	52	0	52	Girls' Skiing	0	1	1	Boys' Swimming	0	0	0
Girls' Soccer	47	0	47	Softball	49	2	51	Girls' Swimming	22	0	22
Wrestling	21	0	21	Boys' Volleyball	0	0	0	Boys' Tennis	10	0	10
				Girls' Volleyball	39	0	39	Girls' Tennis	9	0	9
								Boys' Track and Field	36	0	36
								Girls' Track and Field	35	0	35
								Riflery	0	3	3
		Total	252			Total	276			Total	186

[a] Most of the athletes reported participating in more than one sport during the previous academic year. Thus, several of the athletes included in the table are represented more than once.

CURRICULUM VITA

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EDUCATION

1/04-Present Pennsylvania State University, University Park, PA
Major: Psychology
G.P.A: 3.7 cumulative

8/01-12/03 Pennsylvania State University, University Park, PA
Major: Master of Science, Psychology
G.P.A: 3.7 cumulative

1/98-5/01 Plattsburgh State University of New York, Plattsburgh, NY
Major: Bachelor of Science, Psychology
G.P.A.: 3.8 major; 3.79 cumulative

8/97-12/97 Springfield College, Springfield, MA
Major: Athletic Training
G.P.A.: 3.75 cumulative

RESEARCH INTERESTS

Development and implementation of a survey to assess knowledge and attitudes about concussion in high school and college athletes, coaches, and athletic trainers.

Neuropsychological effects of concussion on athletes. Serial assessment of cognitive deficits and postconcussive symptomatology in the acute stages of concussion.

PUBLISHED REFEREED ABSTRACTS & CONFERENCE PROCEEDINGS

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Rosenbaum, A. M., Arnett, P. A., Bailey, C. M., & Echemendia, R. J. (2006). Neuropsychological assessment of sports-related concussion: Measuring clinically significant change. In S. M. Slobounov and W. J. Sebastianelli (Eds.) Foundations of Sports-Related Brain Injuries (pp. 137-169). Springer: New York.