CONCUSSION KNOWLEDGE AND REPORTING BEHAVIORS IN COLLEGIATE ATHLETES

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Introduction: Current concussion education programs are designed to increase knowledge of concussion, signs and symptoms, potential dangers, and return to play guidelines. However, increasing knowledge may not be sufficient to change reporting behaviors. **Purpose**: The purpose of this study was to better understand the relationship between concussion knowledge, subjective norms, and the likelihood of reporting symptoms. **Methods**: A web-based survey was distributed to all student-athletes at Oklahoma State University. This survey was designed to evaluate participants' concussion knowledge and reporting behaviors. **Results**: Most participants possessed a sound knowledge of concussions. No significant relationships were found between concussion knowledge and reporting behavior ($r=.155$, $p=.138$). Significant relationships were found between risk level ($r=.250$, $p=.016$), perception of teammates' reporting behavior ($r=.369$, $p=.000$), and perceptions of coaches' expectations ($r=.445$, $p=.000$) and reporting behavior. **Discussion**: This study suggests that a student-athlete's perception of their teammates' reporting behavior and coach's expectations may influence their own reporting behavior more than their knowledge of concussion.

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INTRODUCTION

Attitudes towards concussion, assessment, treatment, and return to play guidelines have changed drastically over the last twenty years.[1-3] This is largely due to the increasing rates of neurodegenerative disorders in former athletes and catastrophic head injuries in youth sports.[1-3] The research and health communities are working together to prevent these tragic events from occurring. Changing assessment, disqualification, management, and return to play guidelines for concussions is only the beginning. This cannot be done until the public perception of concussions changes from simply "getting your bell rung" to a serious brain injury.[4]

The lack of appreciation for the seriousness of concussions is a major problem facing athletic trainers and physicians alike. Athletes fail to report concussion symptoms because they do not think it is serious enough to warrant medical attention, they do not recognize the signs and symptoms, or they do not want to let their team down.[5-8] Educating athletes, coaches, parents, referees, medical personnel, and the general public is essential.[9-14] They must be taught that a concussion is a brain injury, the signs and symptoms of a concussion, the risks associated with concussion, return to play

guidelines, and the risks associated with returning to activity while still symptomatic.[14] However, current education programs aimed to increase knowledge may not be effective in changing concussion-reporting behavior. Further research is needed to develop the most effective education, prevention, assessment, and treatment programs.[15]

Statement of the Problem

Currently, concussion education programs aim to increase concussion knowledge, however research suggests this is not sufficient to change concussion-reporting behavior.[15]

Purpose

The purpose of this study is to better understand the relationship between concussion knowledge, subjective norms, and reporting behaviors in collegiate athletes.

Hypotheses

The hypotheses will address the relationships between concussion knowledge, subjective norms, and reporting behavior. They will also address the effectiveness of current concussion education programs.

H_{01}: No relationship exists between symptom recognition and reporting behavior.

H_{02}: No relationship exists between knowledge of potential dangers associated with concussion and reporting behavior.

H_{03}: No significant difference exists between increased concussion knowledge and reporting behavior.

H_{04}: No relationship exists between subjective norms and reporting behavior.

Delimitations

The study will be conducted within the following parameters:

1. All subjects must be college students.
2. All subjects must be student-athletes participating on an Oklahoma State University athletic team.
3. All subjects must be between the ages of 18 and 24.

Limitations

1. The sample may not be representative of the population.
2. Subjects may be from different backgrounds.
3. Subjects may have received different concussion education or training.

Assumptions

1. Each subject will answer the questions in the survey truthfully.
2. Each subject is able to read and understand the questions in the survey.

Definition of Terms

Attitude: beliefs regarding what an individual think will happen if they perform a behavior[16,17]

Chronic Traumatic Encephalopathy (CTE): CTE is a neurodegenerative disorder that presents with symptoms similar to those of Alzheimer's Disease, progressive supranuclear palsy, post-encephalitic Parkinsonism, and the amyotrophic lateral sclerosis/Parkinson-dementia complex; however it is a "neuropathologically distinct progressive tauopathy with a clear environmental etiology."[4]

Concussion: brain injury resulting in changes in cognition, behavior, and/or overall neurological function. It is usually caused by a blow to the head or body resulting in rapid movement of the head[18]

Countercoup Injury: damage to tissues on the opposite side of the brain from the point of contact, result from a stationary skull being struck by a moving object[19]

Coup Injury: damage to tissues directly under or near the site of contact, result from a mobile skull striking an immobile object[19]

Knowledge Transfer: the exchange, synthesis, and ethically-sound application of knowledge within a complex system of interactions among researchers and users to accelerate the capture of the benefits of research through improved health, more effective services and products, and strengthened health care system[20]

Perceived Behavioral Control: beliefs regarding one's ability to perform a behavior, also known as self-efficacy[16,17]

Risk Compensation Theory: theory suggesting heavily protected athletes will take greater risks, therefore negating the protective effects of the equipment[21]

Second Impact Syndrome: severe condition causing rapid swelling and herniation of the brain, caused by suffering a second concussive force before the initial concussion has adequate time to heal[5]

Subjective Norms: beliefs about what an individual thinks others expect them to do[16,17]

Theory of Planned Behavior: theory suggesting behavior is determined by three factors: attitude, subjective norms, and perceived behavioral control[16,17]

CHAPTER II

REVIEW OF LITERATURE

Traumatic brain injuries (TBI) are disabling injuries and have been shown to affect an individual's ability to perform daily activities and return to work due to long-term physical, cognitive, behavioral, and emotional consequences.[22] TBIs are classified as mild, moderate, and severe depending on the severity of damage to the brain. An individual with a mild traumatic brain injury (MTBI) may present with headache, confusion, lightheadedness, dizziness, blurred vision, tinnitus (ringing in the ears), or fatigue.[23] MTBI may also present with loss of consciousness ranging from a few seconds to minutes.[23] The terms MTBI and concussion are often used interchangeably in the literature and from this point on the term concussion will be used because it is most commonly used in the athletic community. Moderate to severe TBI often present with similar symptoms to concussions, but the symptoms often worsen, and the individual experiences repeated vomiting or nausea, convulsions or seizures, inability to wake from sleep, dilation of one or both pupils, slurred speech, weakness or numbness in the extremities, loss of coordination, and increased confusion, restlessness, or agitation.[23]

TBI Rates

The Center for Disease Control (CDC) estimates 1.7 million Americans suffer TBIs annually.[22,24] These injuries result in approximately 1.4 million emergency department visits, 275,000 hospitalizations, and 52,000 deaths in the United States each year.[23,24] The CDC further estimates that 300,000 TBIs are sports-related, however this estimation only includes injuries resulting in loss of consciousness.[22] Research has indicated that TBIs involving loss of consciousness only account for 8-19% of injuries. Therefore, it is more likely that 1.6-3.8 million sports-related TBIs occur each year.[22]

While these are national statistics, the National Athletic Trainer Association Injury Surveillance Program was developed to provide more information on the frequency and impact of injuries among high school varsity athletes. A study by Powell and Barber-Foss[25] utilized data from this program to provide information on TBI frequency in high school athletes. The results of this study estimate 62,816 cases of concussion occur each year and make up 5.5% of all reported injuries.[25] Table 1 depicts concussions as a percentage of total injuries for the 10 varsity sports included in the study. Covassin et al[26] utilized the National Collegiate Athletic Association Injury Surveillance System to identify concussion frequency in 15 collegiate sports. Concussions accounted for 6.2% of all injuries.[26] Table 2 presents concussions as a percentage of all competition and practice injuries for the sports included in the study.

Table 1. Concussions as a percentage of total injuries in high school athletes.[25]

Sport	Percentage of Total Injuries
Football	7.3
Boys' Wrestling	4.4
Baseball	1.7
Softball	2.7
Boys' Basketball	2.6
Girls' Basketball	3.6
Boys' Soccer	3.9
Girls' Soccer	4.3
Girls' Field Hockey	2.5
Girls' Volleyball	1.0

Table 2. Concussions as a percentage of all competition and practice injuries in collegiate athletes.[26]

Sport	Percentage of Competition Injuries	Percentage of Practice Injuries
Football	6.7	8.8
Men's Wrestling	4.5	6.6
Men's Ice Hockey	6.3	10.3
Women's Field Hockey	3.7	7.2
Men's Lacrosse	4.0	10.1
Women's Lacrosse	5.3	13.9
Men's Soccer	1.7	7.0
Women's Soccer	2.4	11.4
Men's Basketball	4.1	5.0
Women's Basketball	4.7	8.5
Baseball	2.9	6.4
Softball	4.1	7.2
Women's Volleyball	1.3	4.1
Men's Gymnastics	0	0
Women's Gymnastics	0	0

Concussions are becoming more of a public concern due to the short and long-term cognitive, behavioral, and neurological problems seen in athletes.[15] Currently, there is not a technology or protective equipment to prevent concussions from occurring, however, research has prompted legal responsibility and provided improved assessment, management, and return to play guidelines to improve injury outcomes.[21] Self-reporting

of symptoms to a coach, athletic trainer, or physician is critical to concussion diagnosis and management because diagnostic imaging is unable to detect changes associated with the injury. Lack of knowledge about concussion signs and symptoms and an understanding and appreciation of the severity of the injury prevents athletes from reporting concussive symptoms and increases their likelihood of suffering adverse effects.[21]

Concussion

Until recently, concussion education has been difficult due to the lack of a standardized definition of concussion. After three International Conferences on Concussion in Sports, a standard definition has been developed.[1-3] This definition states,

> "A concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an impulsive force transmitted to the head. A concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, a concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather that structural injury. Concussion results in a graded set of symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course. Concussion is typically associated with grossly normal structural imaging studies."[1-3]

Simply stated, a concussion is a brain injury resulting in changes in cognition, behavior, and/or overall neurological function. It is usually caused by a blow to the head or body resulting in rapid movement of the head.[18]

Brain Anatomy

To understand why concussions present with such a wide variety of symptoms and why brain injuries can be catastrophic, it is important to understand the anatomy and function of the brain. The brain is housed and protected by the skull.[19] Three membranes separate the brain and the skull. They are the dura mater, arachnoid, and pia mater. The

subarachnoid space contains cerebrospinal fluid that surrounds and protects the Central Nervous System (CNS).[19]

The human brain is approximately 1,400 grams (3 pounds) of soft, gelatinous gray and white matter.[19] Within this gray and white matter lie 100 billion neurons, and ten times that number of glial cells. The system of neurons is highly connective, with each neuron making contact with at least 10,000 other neurons. Most of the brain's neurons, in excess of 99%, are classified as interneurons, which process information occurring between sensory input and motor output. The brain is composed of three parts, the brain stem, the cerebellum, and the cerebrum. The brain stem is composed of the midbrain, pons, and medulla. It is essential in motor and sensory function. The caudal (lower) brain stem houses areas for control of respiration and cardiac function. The cerebellum works with gray matter nuclei in the hemispheres and the brain stem to produce fine motor coordination and postural control.[19] The medulla, base of the brain, exits the skull through the foramen magnum and merges with the spinal cord. This is the most caudal portion of the CNS.[19]

The cerebrum is associated with higher function and contains paired cerebral hemispheres and the diencephalon.[19] The corpus collosum connects the two hemispheres and allows for the exchange of information. The hemispheres contain ridges (gyri) and grooves (sulci or fissures). These ridges and grooves provide the foundation for the hemispheres to be divided into four lobes. The four lobes are the frontal, temporal, parietal and occipital. Table 3 displays the function of each lobe. The diencephalon is deep within the brain and plays a key part in sensory, motor, arousal, and limbic functions. It is made up of the thalamus and the hypothalamus. All sensory information,

except for olfaction, is routed through the thalamus. The thalamus is also critical in wakefulness. The hypothalamus controls the sympathetic and parasympathetic branches of the Autonomic Nervous System (ANS). It also works with the pituitary gland to facilitate neuroregulation of the endocrine system.[19]

Table 3. Lobes of the brain and their functions.[19]

Lobe	Function
Frontal	Voluntary movement Language production (left) Motor prosody (right) Comportment Executive function Motivation
Parietal	Tactile sensation Visuospatial Function (right) Calculation
Temporal	Audition Language comprehension (left) Sensory prosody (right) Memory Emotion
Occipital	Vision Visual perception

Pathophysiology of Concussion

Concussions are caused by rotational or angular acceleration forces resulting in shear forces acting on the underlying neural tissue.[13] Coup injuries, damage to tissues directly under or near the site of contact, generally result from a mobile skull striking an immobile object while countercoup injuries, damage to tissues on the opposite side of the brain from the point of contact, generally result from a stationary skull being struck by a moving object.[19] Concussions and their long-term effects are referred to as silent or invisible because no current imaging can detect concussions.[3] Researchers have been able to measure changes in neuronal function with imaging technology, but these

advancements are still in their infancy.[15] Diffusion tensor imaging has been used to measure changes in white matter in subjects who have suffered a concussion and functional magnetic resonance imaging (fMRI) has been used in conjunction with neuropsychological examinations to measure functional impairments in subjects after injury. Incidentally, changes in the blood-brain barrier have also been identified in concussed subjects.[15] This technology has helped identify that changes in neuronal function are occurring, but why these changes are happening is still not well understood.

Animal studies may provide a better understanding of the effects of concussive forces at the molecular level.[13, 27-30] Experimental research suggests that the altered state of consciousness after head injuries, development of secondary brain damage, and increased vulnerability of the brain after the initial trauma are the result of altered cerebral blood flow, ion fluxes, and metabolic changes.[31] Concussive forces may lead to cerebral edema, which may be the cause of symptoms such as loss of consciousness, memory impairments, disorientation, and headache.[31] The brain's autoregulatory mechanisms limit cerebral blood flow in order to compensate for the mechanical and physiological stress of edema and to protect against diffuse swelling.[31]

Altered cerebral blood flow interferes with ion transfer across the neuronal membranes resulting in excess potassium entering the extracellular space.[13,27-30] This increased potassium concentration causes the release of the calcium dependent excitatory amino acid glutamate, which causes more potassium to enter the extracellular space. The increased potassium concentration stimulates neuronal depolarization, and then neuronal suppression while the sodium potassium pumps work to reestablish homeostasis.[13, 27-30] The large amount of energy required increases glycolysis resulting in lactic acid

accumulation and intracellular acidosis.[13,28,31] Cerebral metabolism is also altered leading to decreased protein synthesis and oxidative capacity.[31] Mitochondrial dysfunction, decreased oxidative metabolism, and decreased cerebral glucose metabolism were evident within 24 hours of the initial increase in glycolysis. These irregularities lasted up to 10 days in experimental models.[13,28,31]

Signs and Symptoms of Concussion

The complex and extensive functions of each part of the brain help explain why damage can result in such a wide variety of signs and symptoms. They can include cognitive signs, subjective symptoms, and physical signs. The most commonly reported symptoms are headache, dizziness, difficulty concentrating, confusion, photophobia, and nausea.[10,11,32] Table 4 contains a list of signs and symptoms from the 2nd International Conference on Concussion in Sport. Approximately 27% of signs and symptoms resolve within 24 hours of the initial injury, 36.2% resolve between one and three days, 20.2% between four and six days, 15.1% last longer than one week but less than one month, and 1.5% last longer than one month.[1]

Table 4. Signs and symptoms of concussions.[2]

Cognitive Signs	Disorientation Confusion Amnesia
Subjective Symptoms	Headache Pressure in head Balance problems Dizziness Nausea Feeling "dinged," in a fog, stunned, or dazed Blurred Vision Double Vision Seeing "stars," flashing lights, or spots Tinnitus (ringing in ears) Sensitivity to light (photophobia) or sound Irritability Emotional or personality changes
Physical Signs	Loss of consciousness/altered levels of consciousness Poor coordination or balance Concussive convulsion/impact seizure Gait unsteadiness/loss of balance Slow to answer questions or follow directions Easily distracted/poor concentration Displaying inappropriate emotions (laughing or crying) Vomiting Vacant stare/glossy eyed Slurred speech Personality changes Inappropriate playing behavior (running in the wrong direction) Significantly decreased playing ability

Concussion Assessment

As previously stated, structural imaging studies are generally deemed normal in individuals with concussion.[3] Therefore, the complex presentation of concussions between individuals and between injuries within one individual demands a multifaceted approach to assessment. This approach should include a comprehensive history, baseline

tests, self-reported symptoms, balance and postural stability assessments, and assessments of cognitive functioning.[33]

Comprehensive History and Baseline Testing

A comprehensive history containing neurologic history, pre-morbid self-report symptoms, physical examination, and medication use is necessary to identify any pre-existing conditions that may affect injury outcomes.[34] These conditions include, but are not limited to learning disabilities, attention deficit hyperactivity disorder (ADHD), psychiatric conditions, and previous history of head injury, including concussion.[33] Baseline motor control and neurocognitive assessments should also be conducted. Baseline testing is necessary to determine if deficits exist post-injury.[33,35] Baseline assessments theoretically increase diagnostic accuracy by limiting variance associated with pre-existing confounding variables.[33] However, baseline assessments may introduce error due to a practice or learning effect.[33,35-38]

According to the most recent NATA Position Statement on the Management of Sport Concussion[34] baseline testing should be conducted annually. Annual assessments are crucial for adolescents because of their developing brains and those who have sustained a concussion since their previous test. It also recommends that all athletes should undergo baseline assessments, however at minimum those participating in contact and collision sports.[34]

Self-Report Symptom Assessment

Concussions can present with a wide range of subjective symptoms. Symptom checklists or scales that measures both the duration and severity of symptoms are

recommended to monitor post-injury changes.[34] A variety of concussion symptom inventories are available for clinical use including the Head Injury Scale, Graded Symptom Checklist, Concussion Symptom Inventory, and Sport Concussion Assessment Tool 3 (SCAT-3). Research has shown these assessment tools are sensitive to changes resulting from concussive injury, however their specificity is limited by the nature and physical demands of athletics.[34] However, concussion-like symptoms are commonly reported in athletes who are dehydrated and in those who have performed strenuous activity. Their efficacy is further limited because some athletes may under-report symptoms in order to continue activity after injury.[34] Therefore self-report symptom assessments should not be used in isolation.

Balance and Postural Stability Assessments

Concussive injury is also associated with motor control deficits affecting gait, postural control, and balance.[34] Balance problems associated with concussions are attributed to failure to integrate sensory information arising from the vestibular and visual components of the balance mechanism.[34] Assessments for one or more motor control systems should be included in concussion assessments. Examples of these assessments include the Sensory Organization Test, Balance Error Scoring System (BESS), Romberg test, and gait evaluation.[34]

Mental Status and Neurocognitive Testing

Altered mental status is an important component of concussive injury; however few athletes present with easily identifiable signs of injury such as loss of consciousness

or posttraumatic amnesia.[34] Neurocognitive tests are used to detect subtle changes in cognitive function and are the most objective component of concussion evaluation.[39]

Three types of neurocognitive tests are available to the sports medicine community: traditional, computerized, and hybrid.[33] Traditional tests, such as the Standardized Assessment of Concussion (SAC) or Standardized Concussion Assessment Tool 2 (SCAT2), are paper-based exams that assess orientation, immediate memory, concentration, and delayed recall. Research has shown these tests to be valid and reliable measures that are sensitive to the effects of concussion.[40-42] However, these tests require a face-to-face examination which can introduce variance in test administration and scoring. These tests are also labor and time intensive when conducting baseline assessments for large numbers of student-athletes.[33] It is also important to note that these brief assessments are not a substitute for complete neuropsychological evaluations.[3] Computerized tests, such as the Immediate Post-concussion Assessment and Cognitive Test (ImPACT), measure verbal and visual memory, processing speed, and reaction time. These tests are easily administered to individual or groups of student-athletes; portable; efficient for collection, synthesis, and storage of large amounts of data; and they also provide immediate results.[33] However, some researchers question the reliability and validity of this new technology.[36,43,44] Hybrid assessments are a combination of traditional and computerized tests.[45] Computerized tests are typically used for baseline assessments and both traditional and computerized tests for post injury evaluation. Currently there is not enough research on hybrid testing to determine its clinical applicability.[33,45]

These examinations are easy for most health care professional to administer, but some researchers are concerned they provide a generic approach to interpreting neurocognitive results. The traditional tests only require the examiner to find the sum of all components of the test and the computerized assessments provide reports with simplified coding highlighting findings that may be significant.[38]

Experimental Assessment Tools

Experimental assessment tools involving electrophysiological recording techniques such as evoked response potential, cortical magnetic stimulation, electroencephalography, and biochemical serum and cerebral spinal fluid markers have correctly identified brain injuries in experimental subjects.[3] Despite these promising findings, more research is needed to determine the reliability and clinical applicability of these techniques. Therefore, assessments are still based on initial self-reported symptoms, which supports the importance of education and pre-participation exams to identify athletes with a history of concussion and other factors relevant to concussion risk and recovery.[3] Table 5 contains a list of relevant factors associated with concussion risk and recovery.

Table 5. Factors associated with concussion risk and recovery.[3]

Symptoms (number, duration, severity)
Signs (loss of consciousness, amnesia)
Sequelae (concussion convulsion)
Temporal (frequency, timing, recurring injury)
Threshold (decreasing amount of force necessary for recurring injury)
Age (less than 18 years old)
Co- and pre-morbidities (migraine, mental health disorders, attention deficit hyperactivity disorder, learning disabilities, sleep disorders)
Medication (psychoactive drugs, anticoagulants)
Behavior (dangerous style of play)
Sport (high-risk activity)

Diagnosing a Concussion

Prior to the concussion examination, the athletic trainer should assess acute trauma and rule out cervical spine injury and other more severe injuries.[34] The concussion examination should include injury history, observation of the patient, palpation for more severe orthopedic or neurologic injury, and special tests for mental status, motor control, and cranial nerves (Table 6).[34] The NATA position statement on concussion states that any athlete presenting with signs and symptoms of concussion after contact to the head or body resulting in rapid movement of the head should be treated as if they have a concussion.[39] An athletic trainer or physician should monitor the athlete from the time of the initial injury until the condition clears or they are referred for further treatment. If an athletic trainer or physician is not present, it is the responsibility of the coach to ensure an athletic trainer or physician immediately sees the athlete.[39] Table 7 provides a list of signs and symptoms that require immediate referral to a physician for further evaluation and treatment. The position statement also stresses the importance of documenting the time, mechanism of injury, initial signs and symptoms, state of consciousness (Table 8), and a

serial graded symptoms checklist (Figure 1).[39] Regular assessment of neuropsychological function, postural stability, and symptom severity are also necessary to identify changes in the athlete's condition.[34] An increase in number or worsening of symptoms may indicate further injury.[23]

Table 6. Cranial nerve assessments.[46]

Cranial Nerve	Function	Assessment
I. Olfactory	Smell	Assess quality of sense of smell
II. Optic	Vision	Assess quality of vision (i.e. double vision)
III. Oculomotor	Eye movement, opening of eyelid, constriction of pupil, focusing	PEARL (Pupils equal and reactive to light) Open/close eyes
IV. Trochlear	Inferior and lateral movements of eye	H-Test
V. Trigeminal	Sensation to the face, mastication	Assess facial dermatomes Bite down
VI. Abducens	Lateral movements of the eye	H-Test
VII. Facial	Motor nerve of facial expression; taste, control of tear, nasal, sublingual salivary, and submaxillary glands	Smile/Frown
VIII. Vestibulocochlear	Hearing and equilibrium	Romberg's test
IX. Glossopharyngeal	Swallowing, salivation, gag reflex, sensation from tongue and ear	Swallow
X. Vagus	Swallowing; speech; regulation of pulmonary, cardiovascular, and gastrointestinal functions	Swallow
XI. Accessory	Swallowing, innervation of sternocleidomastoid muscle	Swallow Shoulder Shrug
XII. Hypoglossal	Tongue movement, speech, swallowing	Swallow Stick tongue out

Table 7. Signs and symptoms of concussion requiring immediate referral to a physician.[39]

Day of Injury Referral	Loss of Consciousness Amnesia lasting longer than 15 minutes Deterioration of neurologic function* Decreasing level of consciousness* Decrease/irregularity in respirations* Decrease/irregularity in pulse* Increase in blood pressure Unequal, dilated, or unreactive pupils* Cranial nerve deficits Any signs or symptoms of associated injuries, spine or skull fracture, or bleeding* Mental status changes: lethargy, difficulty maintaining arousal, confusion, agitation* Seizure activity* Vomiting Motor deficits subsequent to initial on-field assessment Sensory deficits subsequent to initial on-field assessment Balance deficits subsequent to initial on-field assessment Cranial nerve deficits subsequent to initial on-field assessment Post-concussion symptoms that worsen Additional post-concussion symptoms as compared with those on the field
Delayed Referral	Any of the findings in the day of injury referral category Post-concussion symptoms worsen or do not improve over time Increase in the number of post-concussion symptoms reported Post-concussion symptoms begin to interfere with the athlete's daily activities (sleep disturbances or cognitive difficulties)

*Requires immediate transport to nearest emergency department.

Table 8. Glasgow Coma Scale for determining state of consciousness.[46]

		Points
Best Motor Response To verbal command To painful stimulus	Obeys Localizes pain Flexion—withdraws Flexion—abnormal (decorticate) Extension (decerebrate) No response	6 5 4 3 2 1
Best Verbal Response With painful stimulus if necessary	Oriented/converses Disoriented and converses Inappropriate Incomprehensible sounds No response	5 4 3 2 1
Eye Opening	Spontaneously To verbal command To pain No response	4 3 2 1
	Total	3-15

Figure 1. Graded Symptoms Checklist.[1]

Graded Symptom Checklist (GSC)

Symptom	Time of injury	2-3 Hours postinjury	24 Hours postinjury	48 Hours postinjury	72 Hours postinjury
Blurred vision					
Dizziness					
Drowsiness					
Excess sleep					
Easily distracted					
Fatigue					
Feel "in a fog"					
Feel "slowed down"					
Headache					
Inappropriate emotions					
Irritability					
Loss of consciousness					
Loss or orientation					
Memory problems					
Nausea					
Nervousness					
Personality change					
Poor balance/coordination					
Poor concentration					
Ringing in ears					
Sadness					
Seeing stars					
Sensitivity to light					
Sensitivity to noise					
Sleep disturbance					
Vacant stare/glassy eyed					
Vomiting					

NOTE: The GSC should be used not only for the initial evaluation but for each subsequent follow-up assessment until all signs and symptoms have cleared at rest and during physical exertion. In lieu of simply checking each symptom present, the ATC can ask the athlete to grade or score the severity of the symptom on a scale of 0-6, where 0=not present, 1=mild, 3=moderate, and 6=most severe.

Previously, grading scales determined the severity of a concussion at the time of the injury.[1,2] Table 9 outlines three commonly used concussion grading scales. Current research has shown that these grading scales should be abandoned because concussion severity is determined by the severity and persistence of symptoms, the results of cognitive and stability tests, and previous patterns of recovery and not based on loss of consciousness as once thought.[3]

Table 9. Concussion grading scales.[47]

Classification	Grade	Signs/Symptoms
Colorado Medical Society Guidelines	1 (mild)	Confusion without amnesia, no LOC
	2 (moderate)	Confusion with amnesia, no LOC
	3 (severe)	LOC
Cantu Grading System	1 (mild)	No LOC, amnesia lasting no more than 30 minutes
	2 (moderate)	LOC lasting less than 5 minutes, or amnesia lasting between 30 minutes and 24 hours
	3 (severe)	LOC lasting more than 5 minutes or amnesia lasting more than 24 hours
American Academy of Neurology Guidelines	1 (mild)	Confusion, no LOC, symptoms or abnormalities last less than 15 minutes
	2 (moderate)	Confusion, no LOC, symptoms or abnormalities last more than 15 minutes
	3 (severe)	LOC (lasting seconds or minutes)

Concussion Assessment and the Adolescent Athlete

Concussion assessment in adolescent athletes presents even more complications due to their rapidly developing brains.[48] The adolescent brain undergoes an immense reorganization between the ages of 12 and 25 as the brain becomes more sophisticated at

information processing. The brain reorganizes posteriorly to anteriorly beginning with the occipital lobe and ending with the frontal lobe. This reorganization with more efficient basic behavioral functions such as vision, movement and fundamental processing occurs and ends with more complex thinking behaviors. Their developing brains make them more vulnerable to the effects of concussion and recovery time is increased in adolescents compared to adults. Learning disabilities, ADHD, and motivation levels can all effect neurocognitive and balance testing in adolescents and interpreting the results of these tests is further complicated by potential learning and practice effects. Continued motor development and the ability to learn new tasks makes determining what is "normal" for that adolescent athlete difficult because they are changing every day. More research is needed to better understand the effects of concussion on the adolescent brain and to develop assessment tools specific to this age group.[48]

Associated Injuries

When evaluating an athlete for a potential concussion, it is also important to rule out other injuries associated with head trauma. Injuries associated with concussions include intracranial hematomas, cerebral contusions, fractures, and second impact syndrome.[4,6,13,25,49]

Intracranial Hemorrhaging

Intracranial hemorrhaging refers to bleeding in or around the brain resulting in epidural or subdural hematomas.[47] An epidural hematoma is characterized by the accumulation of blood in the space between a detached dura and the cranium.[47] It is generally an acceleration-deceleration injury in which the skull withstands a majority of the impact forces and absorbs the resultant kinetic energy. This type of injury is generally

accompanied by a skull fracture and is isolated to the skull, dura, and dura vessels. A period known as a lucid interval is a critical clinical factor associated with an epidural hematoma.[47] After the initial injurious blow, the patient will often experience an altered state of consciousness resulting from the forces transmitted to the brain followed by a period where he or she is seemingly asymptomatic with a normal neurologic examination. The length of this lucid interval is determined by the rate of bleeding into the epidural space and may last until the hematoma reaches a critically large size and begins to compress the underlying brain tissue.[47] The athlete's condition can rapidly decline from asymptomatic to neurologic dysfunction, brain herniation, and possible death. Epidural hematomas are rare in athletics; however any athlete who experiences an altered state of consciousness due to head trauma should be referred for further examination.[47]

Unlike epidural hematomas, subdural hematomas are associated with primary brain injury and are classified as acute or chronic.[47] Acute subdural hematomas are the most common catastrophic head injury in athletics and generally present within 48-72 hours of the initial injury. Bleeding due to tearing or stretching of the subdural arteries can be isolated within the subdural space (simple) or more complicated due to parenchymal injury.[47] The clinical presentation of acute subdural hematomas varies from awake and alert with no focal neurologic deficits to those with altered consciousness and significant neurologic deficits.[47]

Chronic subdural hematomas are the result of tearing or stretching of subdural veins and may take 3 or more weeks to cause symptoms. Low pressure within the veins results in a small continuous hemorrhage that over time begins to compress the brain.[47]

After one week, fibroblasts begin to create inner and outer membranes that encapsulate the hematoma. The membrane allows the hematoma to interact with the production and absorption of cerebrospinal fluid and the effusion of protein.[47] Diagnosing a chronic subdural hematoma is difficult because of the wide variety of clinical symptoms associated with the injury. An individual may present with symptoms suggesting increased intracranial pressure or mental disturbance such as personality changes or dementia.[47]

Cerebral Contusion

A cerebral contusion is damage to an area of the brain consisting of hemorrhage, cerebral infarction, necrosis, and edema.[47] Cerebral contusions are a frequent sequela of head injury. This type of injury is often the result of acceleration-deceleration forces causing inward defamation of the skull compressing the brain.[47] Contusions are classified as coup and countercoup.[47] Coup lesions occur on the same side as the initial impact and countercoup lesions occur on the opposite side of impact due to the brain rebounding within the skull. Contusions often manifest with a variety of symptoms ranging from normal function to neurologic deterioration or coma. Behavioral or mental changes are common with contusions to the frontal or temporal lobes.[47]

Fractures

Skull fractures are rare, but recognition is important because they are potentially fatal injuries.[47] Skull fractures are classified as depressed, linear, non-depressed, comminuted, and basal.[50] Depressed skull fractures occur when a portion of the skull is indented towards the brain.[50] Linear and non-depressed fractures involve limited indentation of the skull.[50] Comminuted fractures consist of multiple fracture fragments

and basal fractures involve the base of the skull.[50] Palpation of the skull may reveal defects such as an indentation or crepitus.[50,51] Observation of ecchymosis posterior to the ear over the mastoid process (Battle's sign) or around the eyes (raccoon eyes) is also indicative of a skull fracture.[46,51] Additional signs of fracture include bleeding from an open wound, ears, nose, or eyes; drainage of cerebrospinal fluid (Halo sign); or changes in the pupils.[46,51]

Second Impact Syndrome

Athletes who suffer a second concussion before the brain has recovered from a previous concussion are at risk of developing second impact syndrome.[5] Second impact syndrome is a severe condition resulting in rapid swelling and herniation of the brain.[5] Immediate recognition of athletes suffering from this condition is imperative because nearly all cases of second impact syndrome in adolescents are catastrophic.[3] Signs and symptoms of second impact syndrome are listed in Table 10. Second impact syndrome is a medical emergency and all suspected cases should be immediately transported to the nearest emergency department.[39]

Table 10. Signs and symptoms of Second Impact Syndrome.[5]

Athlete appears to be stunned before losing consciousness (may last seconds to minutes)
Athlete then becomes semiconscious
Rapidly dilating pupils
Fixed eye movements
Respiratory and brainstem failure (usually within 2 to 5 minutes)

Altered cerebral blood flow, ion fluxes, and decreased cerebral metabolism resulting from a concussion make the brain more vulnerable and susceptible to death.[31] The pathophysiology of second impact syndrome is not well understood, however research suggests it is the result of increased cerebral blood flow due to the failure of the

cerebral vascular autoregulatory mechanisms.[31,52-54] The increase in blood flow causes an increase in intracranial pressure leading to herniation of the brain stem through the foramen magnum.[31,52-54]

There is limited epidemiological data regarding second impact syndrome and most of the literature is in the form of case reports.[31] The overall incidence rate of second impact syndrome is unknown, largely due to the lack of consensus regarding an exact definition. The National Center for Catastrophic Sports Injury Research identified 35 probable cases of second impact syndrome among American football players from 1980-1993. There have been no reports in the Australian or European literature regarding this condition.[31] Researchers are now beginning to question if this condition is truly the result of a second head injury or part of the natural sequelae of head injury because in nearly half of the published cases detailing suspected cases of second impact syndrome there was no second injury or impact.[31,53-55]

Approximately 15% of individuals who sustain traumatic brain injuries suffer from delayed cerebral deterioration and in 75% of these patients it is due to intracranial hemorrhaging.[54] This leaves a small sub-group of individuals whose deterioration is not due to a mass lesion, but posttraumatic diffuse cerebral swelling known as malignant brain edema.[54] More research is needed to determine if malignant brain edema and second impact syndrome are related or if they occur from the same process.[55]

Concussion Management

Athletes who are symptomatic at rest and after exertion for at least 20 minutes after the time of the initial injury or experienced loss of consciousness or amnesia for any

length of time should be disqualified from play.[39] Disqualification should be based on a physical exam, self-reported symptoms, balance and postural assessments, and neurocognitive assessments. Athletes with a past history of concussion should be treated more conservatively because they are at an increased risk of suffering a recurrent injury. Athletes under the age of 18 should also be treated with caution because almost all cases of second impact syndrome in young athletes have been fatal.[3,14,39]

Current research has forced return to play guidelines to evolve. The 3rd International Conference on Concussion in Sport outlined gradual return to play guidelines after an athlete is asymptomatic to be used in conjunction with clinical evaluations, cognitive assessments, and postural and stability assessments.[3] Table 11 outlines the return to play guidelines from the 3rd International Conference on Concussion in Sport. If at any point during the progression the athlete becomes symptomatic, activity must be stopped until all symptoms have resolved. At this point the athlete repeats the previous symptom free stage.[3,12] These guidelines were developed to reduce the athlete's risk of returning to activity too soon and suffering further injury and should be explained to coaches and athletes to ensure adherence. However, a study by Yard and Comstock[12] found that 15-40.5% of athletes return to play too soon after injury and 15.8% of football players returned to play in less than 1 day after losing consciousness. They also found that males are more likely than females to return to activity too soon.[12]

Table 11. Graduated return to play guidelines.[3]

Stage	Exercise
No activity	Complete physical and cognitive rest
Light aerobic exercise	Walking, swimming, or stationary cycling (less than 70% maximum heart rate) No resistance training
Sport specific exercise	Running or skating drills No contact
Non-contact training drills	Progress to more complex training drills May begin progressive resistance training
Full contact practice	After medical clearance may participate in normal training activities
Return to play	Normal game play

Long-Term Consequences of Concussion

Approximately 5.3 million Americans, 2% of the population, are living with long-term or lifelong disabilities associated with TBI.[22] Lifetime costs of TBI in the United States, including medical costs and lost productivity, total an estimated $60 billion annually.[22] Multiple, or recurrent, concussions may reduce an individual's ability to rapidly process information, increase recovery time, and increase risk of long term cognitive, emotional, and behavioral consequences.

Cognitive Deficits

Research investigating the effect of concussion on cognitive function has produced a wide variety of results. The most common acute cognitive impairments are deficits in global functioning, memory acquisition, and delayed memory.[56] Leininger et al[57] found that patients with post-concussive symptoms performed poorer on neuropsychological tests than healthy controls. The greatest deficits were seen on tests of reasoning, information processing, and verbal learning. These individuals also had impaired organizational skills, poor attention to detail, and faulty error recognition.

Neuropsychological test results within three months of injury were similar to test results more than three months post injury, suggesting, "minor head injuries are not always innocuous, fully reversible conditions which resolve within days or a few weeks of injury."[57]

The academic implications of temporary and permanent cognitive impairment are critical for student-athletes.[58] Cognitive domains such as executive functioning and information processing are necessary for academic success; therefore decreased cognitive function due to concussion may prevent student-athletes from succeeding in school.[58] Laubscher et al[59] found a significant decrease in academic performance in rugby players one year post injury while Collins et al[58] found a significant interaction between history of concussion and the development of a learning disability.

Cognition is also directly related to emotional and behavioral functioning, therefore, subtle cognitive impairments can significantly affect daily life, interpersonal relationships, and independent living skills.[60] Research has found a relationship between the degree of cognitive impairment and the number and severity of concussions.[58,60,61] Neuroimaging has shown these deficits are directly correlated with white matter abnormalities and altered cerebral blood flow.[61]

Emotional Problems

The relationship between concussion and psychological symptoms of concussion such as depression, anxiety, and irritability has been a common topic of research, however it is unclear whether or not they are a response to being injured and/or a pathophysiological consequence of concussion.[37] Approximately 10-20% of individuals

with a history of TBI meet the criteria for major depression.[60] Table 12 outlines the symptoms of depression as listed in the Beck Depression Inventory (BDI-II). The link between severity of head injury and increased rates of depression has been a common topic of research, but the results have been inconclusive. Some studies suggest those with severe injuries such as intracerebral hemorrhaging are at increased for depression, but Konrad et al[60] found increased rates of depression in subjects with a history of concussion. Didehbani et al[62] found a significant correlation between number of concussions and symptom severity. They also suggest repeated head injuries are associated with cognitive symptoms of depression such as sadness, guilt, self-criticism, suicidal thoughts, and worthlessness.[62]

Table 12. Depressive symptoms from the BDI-II.[62]

Cognitive Factors	Sadness Pessimism Past failure Guilty feelings Punishment feelings Self-dislike Self-criticalness Suicidal thoughts or wishes Worthlessness
Affective Factors	Loss of pleasure Crying Loss of interest Indecisiveness
Somatic Factors	Agitation Loss of energy Changes in sleep pattern Irritability Changes in appetite Concentration difficulty Tiredness or fatigue Loss of interest in sex

Behavioral Changes

History of TBI is also associated with impulsivity and aggressiveness.[63] These behavioral changes have been attributed to frontal lobe damage.[63] Hampshire, MacDonald, and Owen[64] found that abnormal frontal lobe function was correlated with the number of concussions experienced by retired professional football players. History of concussion is also associated with substance abuse.[22] Individuals who have suffered a TBI are 1.8 times likelier to report binge drinking than their healthy counterparts.[21] Cottler et al[65] found that over 70% of retired NFL athletes who report opioid use also report misuse. Substance abuse can lead to medical, psychiatric, and social problems.

Suicide

Individuals with a history of TBI are at an increased risk of suicide.[63] Simpson and Tate[63] found that 23% of patients who had suffered a TBI had suicidal ideations and 18% of patients attempted suicide. Severity of injury may also influence suicide risk.[63] Those who suffer intracerebral hemorrhaging have a significantly higher risk of suicide than those with a history of concussion. However, those with a history of concussion have a significantly higher risk of suicide than those without a history of TBI.[63] Risk factors for suicide include cognitive and motor disturbances due to brain injury; increased impulsivity; post-injury changes in mental and physical capacity; changes in work status, income, and quality of life; and psychiatric problems.[63]

Chronic Traumatic Encephalopathy

Post mortem studies of athletes who suffered recurrent concussions and presented with neurocognitive disorders, psychiatric problems, or died at a young age showed distinct neurodegenerative changes.[49] These changes are associated with a condition

known as chronic traumatic encephalopathy (CTE). Approximately 17% of people who suffer multiple concussions develop CTE, but researchers estimate this number to be higher due to its recent discovery.[4] CTE has been seen in sports such as boxing, wrestling, soccer, and skiing; however, researchers suggest any individual who experiences post-concussive symptoms is at risk.[4] CTE presents with symptoms similar to those of other neurodegenerative disorders such as Alzheimer's Disease, progressive supranuclear palsy, postencephalitic Parkinsonism, and the amyotrophic lateral sclerosis/Parkinson-dementia complex, however it is a "neuropathologically distinct progressive tauopathy with a clear environmental etiology[4]." CTE is the only preventable form of dementia.[4] Table 13 outlines the progression of symptoms of CTE.

Table 13. Stages of CTE.[67]

Stage 1	Headache Loss of attention Loss of concentration
Stage 2	Depression Explosivity Short-term memory loss
Stage 3	Executive dysfunction Cognitive impairment
Stage 4	Dementia Word-finding difficulty Aggression

Concussion Prevention

Preventing injuries is the best form of treatment; therefore preventing concussions is the best way to protect athletes from the long-term effects associated with this injury. Effective injury prevention strategies require epidemiological research, rule enforcement, development of protective equipment, and education programs.[21]

Epidemiological studies provide information regarding the effects of gender, age, sport, position of play, and mechanisms of injury in order to identify injury risk factors. Concussions can occur in any sport, but research has shown specific groups are at higher risk than others. Most concussion research has focused on high-risk collision sports such as football, ice hockey, and rugby.[68] However, researchers are beginning to identify risk factors in other sports and among specific populations. Epidemiological information can be used during pre-participation exams to help identify athletes who are at risk for concussion.[21] Knowing which athletes may be predisposed to injury allows for necessary precautions to be made to reduce their risk. Hiring certified athletic trainers prepared to handle potential catastrophic injuries and developing an emergency action plan that is distributed to all individuals involved in coaching, care, and treatment of athletes will reduce the risk of further injury.[21] Immediately treating athletes who present with head trauma and requiring clearance by a physician or certified athletic trainer before progressively returning an athlete to activity can also reduce the risk of suffering further injury.[21]

At Risk Groups

Football and ice hockey players suffer the highest rates of concussion, however research has identified soccer, basketball, wrestling, lacrosse, volleyball, cheerleading, gymnastics, and field hockey as high-risk sports as well.[6,10,11,25,32,69] Table 14 describes the most common mechanisms of injury based on sport. Concussion incidence rates are higher in competition than practice in all sports except for cheerleading.[11,13,25,69] Meehan et al[70] suggest fatigue may be responsible for increased concussion rates during

competition. Fatigue increases reaction time, which may cause athletes to be less likely to react to concussive forces.[70]

Table 14. Common mechanisms of concussive injury by sport.

Sport	Position	Mechanism of Injury
Football	Linebacker[25,2] Running Back[25,32] Offensive Lineman[25]	Tackling or being tackled[6,25,32]
Soccer	Goalie[25,32] Forward[25] Halfback[25]	Heading the ball[25,32,69] Colliding with other player[25,32,70] Contact with ground[25,70] Contact with ball[32] Contact with playing apparatus[70]
Baseball/Softball		Collide with other player[25] Hit by bat[25] Hit by batted ball[25] Hit by pitch/thrown ball[6,25] Collide while sliding/head first slide[6,25]
Wrestling		Takedowns[25,32,69]
Volleyball	Outside Hitter[69]	Hit by ball[25] Digging[25] Collide with other player[25] Contact with playing surface[69]
Cheerleading		Player to player contact while stunting[69]
Track and Field		Pole Vaulting[6] Struck by thrown discus, shot put, or javelin[6]
Field Hockey		Hit with stick[25] Hit by ball[25] Collide with other player[25]

Age, competitive level, and style of play may also be contributing factors to concussion risk.[13] Children and adolescents who suffer a concussion are difficult to assess and treat because of their developing brains, unreliability to report subjective symptoms, and their variability in cognitive functions.[70] These factors increase their risk of second impact syndrome, which is almost always fatal in athletes under the age of 18.[39] Increased playing time increases an athlete's risk of concussion because they are exposed to more forces as a result of more minutes of play.[13] Athletes competing at a

higher competitive level are at risk because they are exposed to greater forces as a result of the strength of players, playing time, and intensity of play. Athletes competing at a lower level are also at risk due to lack of skill.[13] An athlete's style of play may also predispose them to concussion due to their intensity and aggressiveness.[13]

Gender has also been shown to be a risk factor. Females across sports have shown higher incidence rates than their male counterparts and concussions make up a greater proportion of injuries overall.[10,32,69,71] Research has also shown gender differences in mechanism of injury, reported signs and symptoms, and recovery time.[14,25,69,71-73] Table 15 outlines the gender differences for mechanism of injury across sports. A meta-analysis performed by Farace and Alves[74] indicated that women experience more severe symptoms overall. Table 16 provides a list of the most common severe signs and symptoms based on gender. Studies have found that females experience longer recovery times, more post concussive symptoms, and are at a higher risk of experiencing post concussive symptoms three months post injury.[71,72] Kraus et al[73] found that females are 1.28 times likelier to die following a traumatic brain injury and 1.57 times likelier to suffer poor outcomes such as severe disability or permanent vegetative state than males.

Table 15. Common mechanisms of concussive injury by gender and sport.

Sport	Mechanism of Injury
Women's Soccer	Contact with ground[32] Contact with ball[32]
Men's Soccer	Contact with other player[32]
Women's Basketball	Defending[69] Rebounding[69]
Men's Basketball	Shooting[69]
Women's Lacrosse	Contact with equipment[69]
Men's Lacrosse	Contact with other player[69]

Table 16. Most common severe signs and symptoms by gender.

Gender	Signs and Symptoms
Female	Poor memory[74]
	Dizziness[74]
	Fatigue[74]
	Photophobia[74]
	Noise sensitivity[74]
	Impaired concentration[74]
	Headache[74]
	Anxiety[74]
	Depression[74]
	Cognitive impairment[71]
	Slower reaction times[71]
	Declines from baseline levels[71]
Male	Vomiting[14]
	Sadness[14]

More research is needed to better understand the relationship between gender and concussion risk and outcomes. Researchers have suggested biomechanical, cultural and hormonal factors to explain the differences seen between males and females.[69,71,72] One theory states that females have weaker neck musculature which decreases their ability to react to concussive forces, therefore increasing their risk of injury.[69,71,72] Another explains that hormonal differences between males and females result in varied brain chemistry, which may predispose females to concussive injury, more severe symptoms, and longer recovery times.[72] An alternative theory suggests that females are more protected by society; therefore it is more socially acceptable to report signs and symptoms of a concussion which may explain the larger number of concussion incidences.[69,72]

Individuals with a history of concussion and those recovering from concussions are at increased risk of recurrent injury.[13] Those who have experienced loss of consciousness as a result of a concussion are six times likelier to sustain another

concussion than those who did not experience loss of consciousness.[13] Athletes are at the greatest risk of suffering a second concussion within seven to ten days of their initial injury.[13,70] An epidemiological study by Meehan et al[70] found that more than 50% of athletes were symptom free in three days or less and more than 50% of athletes were returned to play within nine days or less of their initial injury.

Suffering from multiple concussions increases an athlete's risk of developing post-concussive symptoms such as anxiety and depression.[72] The degree of these symptoms may be worse in patients with a history of mood disorders or learning disorders which further stresses the importance of baseline assessments. Further research is needed to explain the potential relationship between these two neuronal dysfunctions and to determine if one increases the risk or severity of the other.[72] Current research has also found a possible relationship between history of migraine headaches and increased concussion recovery time.[72] More research is required to decipher this complicated relationship due to their similar clinical presentation and potentially similar pathophysiological pathway.[72] Athletes who have a history of learning disorders may also experience more severe symptoms such as difficulty focusing and memory problems.[72] A possible explanation for these risk factors is altered brain chemistry, which may predispose these individuals to concussive injury. Another possible explanation is that these individuals are better at recognizing abnormal symptoms and are more likely to report them.[72]

Rule Changes

Epidemiological information has been used to develop safer techniques for initiating contact and rule changes.[6,21] The early 1960s to the early 1970s was a time

known for spearing, butt blocking, and players being taught to make contact with their head and face first in football.[6] This time also marked the greatest increase in football related fatalities. Increased knowledge, the development and implementation of safer and more effective hitting techniques, and a rule change in 1976 prohibiting butt blocking and spearing resulted in a significant decline of football related deaths.[6]

Protective Equipment

Identifying injury risk factors is also essential in developing protective equipment.[21] In order for protective equipment to be effective it must fit correctly and be worn properly. Football helmets are designed to protect against major brain injuries such as skull fractures, bleeding into and around the brain, contusions, and lacerations. There is no evidence that they protect against concussions and some experts are skeptical that they ever will. This is because the most common mechanism for concussion is rotary acceleration and helmets are better suited to control linear acceleration.[21] However, a study by Torg et al[75] suggests that certain factors in helmet design may increase risk of suffering a concussion. They found that a properly fitted helmet makes an athlete 80% less likely to suffer loss of consciousness. They also found that helmets lined with air filled bladders increase risk of loss of consciousness and foamed lined helmets increase risk of amnesia.[75] There is some evidence to suggest that headgear in soccer may decrease risk of concussion, but little research has been done outside of a laboratory setting.[76] The findings of this study did suggest that headgear in soccer decreases the risk of suffering an abrasion, laceration, or contusion to the front, back, side, and top of the head.[76] It is also a common belief that the use of mouth guards will decrease the risk of concussion, but there is a lack of scientific evidence to support this theory.[77] A study

performed by Mihalik et al[78] investigated the effect of mouth guards on decreasing neurocognitive deficits after a concussion. The results of this study found that mouth guards decreased the risk of dental injury, but found no observable difference in neurocognitive performance following a concussion.[78]

Some experts suggest that providing athletes with more protective equipment will actually increase their risk of suffering an injury.[21] This is based on the Risk Compensation Theory that suggests heavily armored athletes will take greater risks, which negate the effects of protective equipment.[21] For example, the football helmet is often used as an offensive weapon, which is dangerous for both the attacker and the defender.[21]

Education

Epidemiological information can also help guide the development of education programs. Research has shown a negative correlation between concussion knowledge and incidence rates.[78] Studies show athletes, coaches, parents, teachers, medical personnel, and the general public need to be educated.[1,3,12,14,70] It is important that these groups understand what a concussion is, signs and symptoms of a concussion, risks associated with concussions, related injuries, return to play guidelines, and the risks associated with returning to activity too soon. Current studies show a lack of knowledge among athletes and that less than 50% of athletes stated having an understanding of concussion or the problems that can occur as a result of concussion.[13]

Concussion Legislation

In an attempt to increase concussion knowledge all 50 states have enacted legislation to standardize concussion protocols and education programs.[15,20,79-81] In 2009,

Washington became the first state to pass concussion legislation.[15,20,78-80] This legislation was passed in response to a thirteen-year-old football player who was left with permanent neurological deficits after suffering a concussion. He was dazed after being hit during a game, removed from play for a short time, then was allowed to finish the third and fourth quarters. After the game, he collapsed and was rushed to the hospital to undergo multiple craniotomies to treat intracerebral hemorrhaging and edema. The bill, known as the Zackery Lystedt Law, requires any young athlete to be removed from play if they are suspected of suffering a concussion. It also requires that the athlete be cleared by a licensed health care professional trained in evaluating head injuries before returning to play.[15,21,79] Since its implementation, all 50 states and the District of Colombia have adopted concussion legislation in an attempt to standardize the approach to sport-related concussion in youth athletes.[80,81]

Each state's legislation requires some form of concussion education for coaches and parents.[79,81] Additionally, in most states, coaches are required to be educated to some degree in concussion recognition, sequelae, treatment, and return to play criteria. Some states require coaches to read and sign an information sheet, while others require coaches to undergo formal concussion training in a classroom or online. Most states also require parents to read and sign an information sheet. This makes parental awareness and involvement in concussion recognition and management mandatory.[79,81] A study performed in Washington one year after the implementation of the Lystedt Law found that 85% of the population was aware of the law and 90% of those aware of the law were also found to have a good understanding of the definition, diagnosis, and potential severity of concussion.[80]

Concussion education for athletes generally consists of information sheets, but most are not designed specifically for adolescent athletes. [79,81] Concussion legislation also only applies to athletes under the age of 18 participating in organized sports. These bills do not affect collegiate or professional athletes; governing this group is left to organizations such as the National Collegiate Athletic Association (NCAA) and the National Football League (NFL).[79]

NCAA Concussion Management Plan

In 2010 the NCAA adopted legislation requiring all member institutions to implement a concussion management plan because the determination of appropriate care for a student-athlete with a concussion is best done through an institutional medical model under the supervision and direction of a physician.[18,82] Each institution's concussion management plan must include a process ensuring all student-athletes presenting with signs or symptoms of a concussion are evaluated by a health care professional experienced in the evaluation and management of concussions.[82] The plan must also include policies preventing a student-athlete with a concussion from returning to activity on the same day as the initial injury and requiring medical clearance before returning to activity. The legislation also aims to ensure student-athletes are aware of the potential harmful effects of concussion on overall health by requiring student-athletes be engaged in understanding the risks, acknowledge they understand these risks, and take responsibility for reporting any injury to the medical staff.[82] The mandate requires that all student-athletes receive yearly concussion education regarding the signs and symptoms of concussion. Student-athletes must also acknowledge that they received this information and accept the responsibility to report all concussion related injuries to a medical staff

member. The NCAA provides educational materials such as videos, forms, and posters (Figure 2) for student-athletes, coaches, administrators, and athletic trainers.[82] The NCAA also funds research to provide student-athletes, athletic staff, and sport officials with up to date concussion prevention and return to play criteria.[18] It also uses current research to make changes to playing rules to make competition safer.

Figure 2. NCAA concussion fact sheet for student-athletes.[18]

CONCUSSION

A FACT SHEET FOR STUDENT-ATHLETES

WHAT IS A CONCUSSION?

A concussion is a brain injury that:

- Is caused by a blow to the head or body.
  - From contact with another player, hitting a hard surface such as the ground, ice or floor, or being hit by a piece of equipment such as a bat, lacrosse stick or field hockey ball.
- Can change the way your brain normally works.
- Can range from mild to severe.
- Presents itself differently for each athlete.
- Can occur during practice or competition in ANY sport.
- **Can happen even if you do not lose consciousness.**

HOW CAN I PREVENT A CONCUSSION?

Basic steps you can take to protect yourself from concussion:

- Do not initiate contact with your head or helmet. You can still get a concussion if you are wearing a helmet.
- Avoid striking an opponent in the head. Undercutting, flying elbows, stepping on a head, checking an unprotected opponent, and sticks to the head all cause concussions.
- Follow your athletics department's rules for safety and the rules of the sport.
- Practice good sportsmanship at all times.
- Practice and perfect the skills of the sport.

WHAT ARE THE SYMPTOMS OF A CONCUSSION?

You can't see a concussion, but you might notice some of the symptoms right away. Other symptoms can show up hours or days after the injury. Concussion symptoms include:

- Amnesia.
- Confusion.
- Headache.
- Loss of consciousness.
- Balance problems or dizziness.
- Double or fuzzy vision.
- Sensitivity to light or noise.
- Nausea (feeling that you might vomit).
- Feeling sluggish, foggy or groggy.
- Feeling unusually irritable.
- Concentration or memory problems (forgetting game plays, facts, meeting times).
- Slowed reaction time.

Exercise or activities that involve a lot of concentration, such as studying, working on the computer, or playing video games may cause concussion symptoms (such as headache or tiredness) to reappear or get worse.

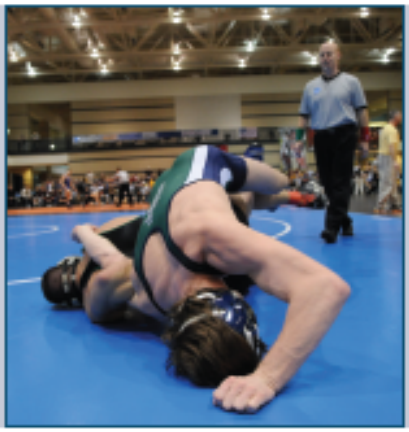
WHAT SHOULD I DO IF I THINK I HAVE A CONCUSSION?

Don't hide it. Tell your athletic trainer and coach. Never ignore a blow to the head. Also, tell your athletic trainer and coach if one of your teammates might have a concussion. Sports have injury timeouts and player substitutions so that you can get checked out.

Report it. Do not return to participation in a game, practice or other activity with symptoms. The sooner you get checked out, the sooner you may be able to return to play.

Get checked out. Your team physician, athletic trainer, or health care professional can tell you if you have had a concussion and when you are cleared to return to play. A concussion can affect your ability to perform everyday activities, your reaction time, balance, sleep and classroom performance.

Take time to recover. If you have had a concussion, your brain needs time to heal. While your brain is still healing, you are much more likely to have a repeat concussion. In rare cases, repeat concussions can cause permanent brain damage, and even death. Severe brain injury can change your whole life.



IT'S BETTER TO MISS ONE GAME THAN THE WHOLE SEASON. WHEN IN DOUBT, GET CHECKED OUT.

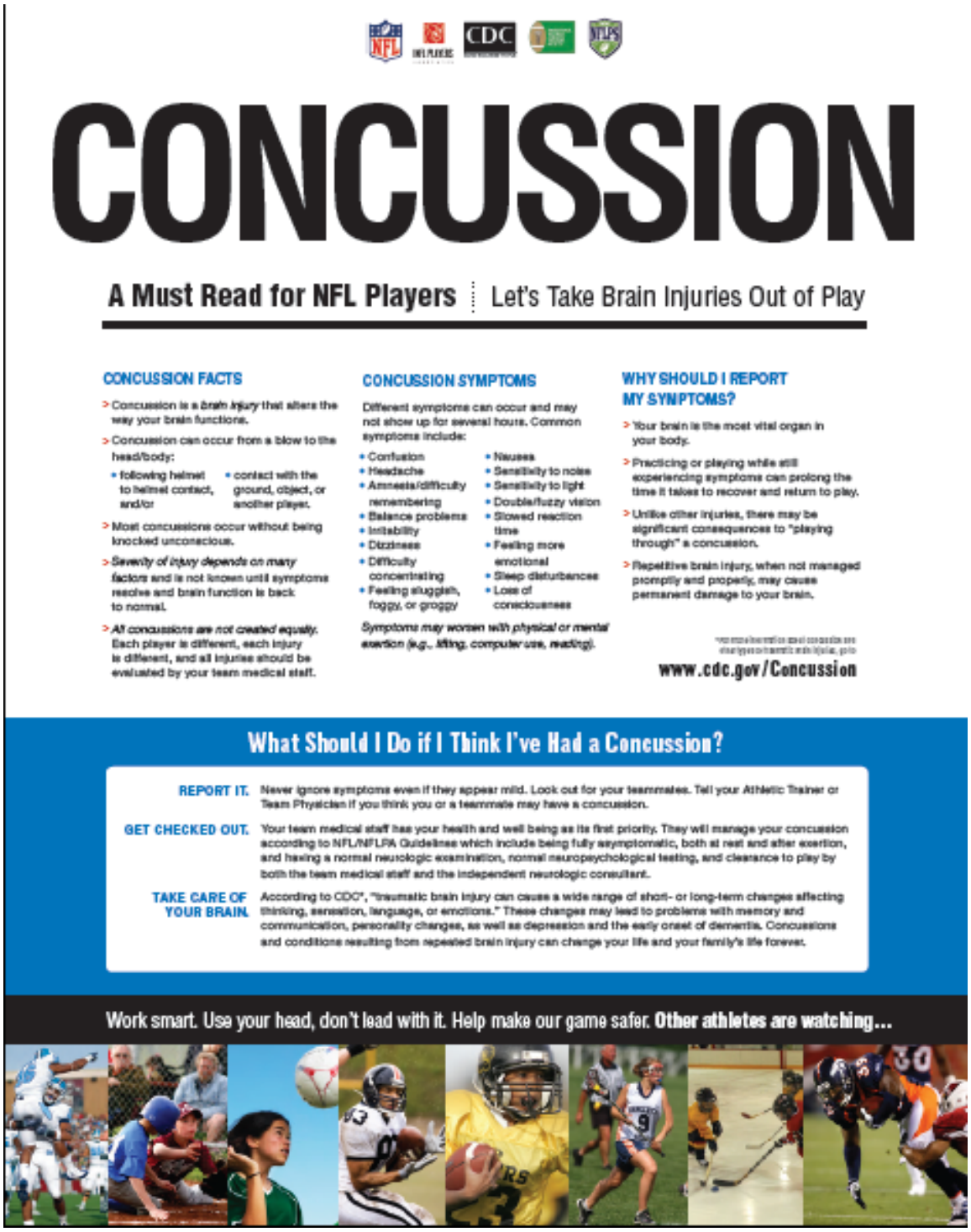
For more information and resources, visit www.NCAA.org/health-safety and www.CDC.gov/Concussion.

Reference to any commercial entity or product or service on this page should not be construed as an endorsement by the Government of the company or its products or services.

NFL Concussion Management Plan

In 1994 the NFL established the Mild Traumatic Brain Injury Committee to better understand the effects of concussion on NFL players.[83] The committee was created in response to two players who were forced to retire due to post-concussion syndrome.[83] Protocols were also developed regarding the diagnosis and management of concussion.[84] The protocol includes the development of an emergency action plan, preseason assessment, concussion management during practice and competition, and return to play guidelines. The preseason assessment includes a physical examination regarding the athlete's concussion history and baseline measurements including neuropsychological testing.[84] Management of concussion during practice or competition requires any athlete presenting with signs or symptoms of concussion be evaluated by the medical staff. The protocol clearly states that no athlete who is diagnosed with a concussion should be returned to play on the same day as the initial injury.[84] The concussion management plan also requires athletes to undergo concussion education during the preseason. Athletes are given educational materials outlining the importance of identifying and reporting signs and symptoms to the medical staff (Figure 3). Athletes are also encouraged to report their teammates who present with signs and symptoms of concussions.[84]

Figure 3. Concussion fact sheet for NFL players.[85]



Reporting Behaviors of Concussed Athletes

Unfortunately, increasing athletes' knowledge of concussion may not be sufficient to alter reporting behavior. A study performed by Kroshus et al[15] found that current concussion education programs do little to change attitudes towards concussion reporting and behavioral intentions.

Chrisman et al[17] performed a study focusing on concussion symptom reporting behaviors in high school football and soccer players in Washington one year after the implementation of the Lystedt Law. The law requires student-athletes to sign a concussion information form annually and to be removed from activity until cleared by a health care provider if suspected of a concussion.[17] Most subjects displayed a sound knowledge of concussions, were able to report numerous signs and symptoms, and recognized the dangers of continuing play while symptomatic (long term disability or death).[17] Despite this knowledge, most subjects said they would continue to play even if they experienced concussive symptoms. The most common reasons for this behavior were the belief that they were expected to play injured and fear of being punished. Punishment was defined as being removed from their starting position, a reduction in future playing time, and being seen as "weak."[17]

A significant difference exists between reported concussion values and those calculated from other observational strategies.[13] A study by McCrea et al[86] found that only 15.3% of a sample of high school varsity football players reported suffering a concussion. They also found that less than 50% of these reports were made during the actual season.[86] Sye et al[8] found that 38% of high school rugby players failed to report symptoms and Broglio et al[9] found that 62.1% of Italian soccer players also failed to

report symptoms. Table 17 lists the most common reasons for not reporting symptoms. The lack of knowledge regarding mechanisms of injury, signs and symptoms of concussion, risks associated with concussion, and return to play guidelines among athletes, coaches, parents, and athletic trainers may lead to underreporting and under treatment of concussions which can have detrimental acute and long-term effects.[87]

Table 17. Common reasons for not reporting signs and symptoms of concussions.

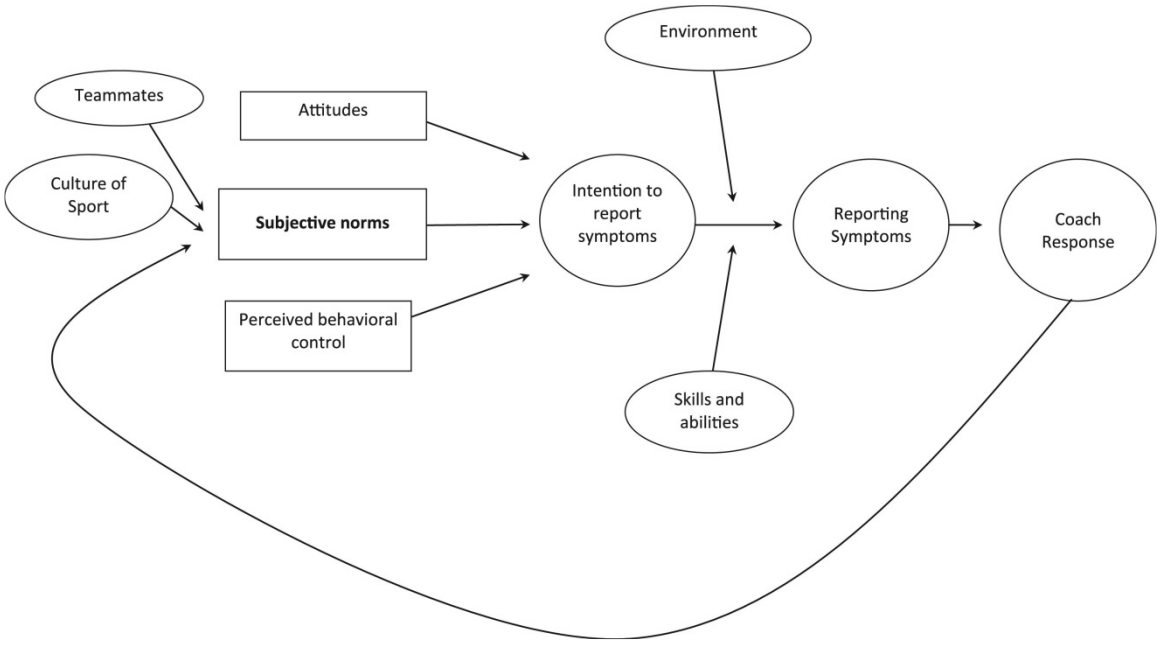
Not serious enough to warrant medical attention[9, 86]
Unaware he/she suffered a concussion[9, 13]
Believe concussions are simply part of the game[9]
Peer pressure to continue playing[8, 13]
Did not want to leave practice/competition[9]
Did not want to let team down[8, 9]
Big game[8-10]
Fear of jeopardizing future career and financial benefits[13]
Lack of education[8-11]
Fear of approaching coach[15]

Theory of Planned Behavior

The Theory of Planned Behavior developed by Icek Ajzen has been used to explain the lack of concussion reporting as shown in Figure 4.[16,17] This theory states that behavior is determined by three factors: attitude, subjective norms, and perceived behavioral control.[16] Attitudes are beliefs regarding what an individual thinks will happen if they perform a behavior.[16] Subjective norms are beliefs about what an individual thinks others expect them to do.[16] Perceived behavioral control, also known as self-efficacy, is one's beliefs regarding their ability to perform a behavior.[16] Athletes' attitudes toward concussion are based on their knowledge of the injury.[17] In the study performed by Chrissman et al[17] athletes understood what a concussion was and the dangers associated with continuing to play while concussed. Subjective norms are formed by the culture of

sports, teammates, and coaches. These factors created the belief that athletes are expected to continue playing despite being injured and refrain from reporting their symptoms. Subjective norms have a strong influence over perceived behavioral control, and in concussion reporting behavior athletes had a tendency to follow these norms even though they went against their own concussion knowledge.[17]

Figure 4: Theory of Planned Behavior model to explain concussion-reporting behavior.[17]



Evaluating Concussion Education

Evaluating the effectiveness of concussion education programs in changing reporting behavior needs to identify relevant cognitive constructs.[15] Most programs are centered on symptom identification and reporting protocol and evaluations of these programs focus on changes in knowledge even though the goal is to change reporting behavior. Implementing knowledge transfer principles may be important when developing and evaluating concussion education.[15]

Knowledge Transfer Principles

Knowledge Transfer (KT) has been defined as,

> "The exchange, synthesis, and ethically-sound application of knowledge within a complex system of interactions among researchers and users to accelerate the capture of the benefits of research through improved health, more effective services and products, and strengthened health care system."[20]

KT is characterized as the steps taken from the creation of knowledge to the application of this new knowledge.[20] It is interdisciplinary and interactive, requiring multidirectional communication and ongoing collaborations between all parties involved. KT is also impact oriented, utilizing evidence-based practices to create user and context specific approaches.[20]

Provvidenza and Johnston[88] identified KT principles that may be most effective for developing concussion education programs for athletes. The first is multiple intelligences.[88] This approach recognizes that each student-athlete has strengths and weakness in various areas, a different intellectual profile, and requires different uses of intelligence. Once identified, an individualized approach is taken to help the student-athlete become more self-directed, gain confidence, understand their own abilities and those of others, and improve on their weaknesses.[88] Provvidenza and Johnston suggest developing individualized return to activity plans with student-athletes and interactive online concussion training courses.[88] Another approach utilizes peer support groups. Peer support groups are shown to reduce anxiety, depression, anger, confusion, and frustration.[88] They are also shown to enhance coping strategies and improve mood.[88] Provvidenza and Johnston also suggest implementing peer support groups to enhance concussion knowledge and facilitate peer interaction and support.[88] Overall, learning

strategies are enhanced by focusing on the leaning needs of the target audience, the type of content, and the quality of the information being presented.[88]

Further research is needed to assess the effectiveness of concussion education programs in changing concussion-reporting behavior. Research is also needed to better understand concussion knowledge and attitudes among collegiate athletes to evaluate and develop new concussion education programs. The purpose of this study is to better understand the relationship between concussion knowledge, subjective norms, and reporting behaviors in collegiate athletes.

CHAPTER III

METHODS

IRB Approval

The protocols utilized in this study were approved by the Oklahoma State University (OSU) Institutional Review Board (IRB) prior to recruitment and data collection (Appendix A).

Participants

Participants in this study were NCAA Division I student-athletes from OSU. These student-athletes represented 12 sports. Table 18 outlines the sports included in this study.

Table 18. OSU sports teams based on gender

Men's Sports Teams	Women's Sports Teams
Football	Basketball
Wrestling	Softball
Basketball	Soccer
Baseball	Cross Country
Cross Country	Track and Field
Track and Field	Equestrian
Golf	Golf
Tennis	Tennis
Cheer	Cheer/Pom

Recruitment

Participants were recruited through the OSU Office of Athletics Compliance. A recruitment letter outlining the purpose and potential benefits of the study was sent to the Assistant Athletic Director of Compliance via email (Appendix B). The Office of Athletics Compliance then sent a recruitment letter to all OSU athletes via email (Appendix B). This recruitment letter also described the purpose and potential benefits of the study. A reminder email was sent to all student-athletes two weeks after the initial email was sent.

Informed Consent

Prior to participation, all potential subjects were presented with a participant information document. This document explained the purpose, risks, benefits, and incentives of this study. It also provided the participant with the contact information of the Principal Investigator as well as the Faculty Advisor to address any questions or concerns of the student-athlete. This participation information document can be found in Appendix C. After reading the information document, the participant was able to select the option to continue as a participant. By selecting this option they consented to participate. Documentation of consent was not required because no personally identifying information was collected; therefore there was no risk to participants' anonymity.

Survey

This study utilized a web-based survey created on the online survey generator Qualtrics. The survey used in this study was modified and adapted from surveys utilized in previous studies.[9,10,17,68,86,89] The survey consisted of 4 sections. Section 1,

Demographics, contained questions about age, gender, race/ethnicity, year in school, and sport. Section 2, Concussion Education, contained questions regarding types of concussion education. Section 3, Concussion Knowledge, contained questions assessing the student-athletes overall knowledge of concussion, their ability to identify signs and symptoms of concussion, and knowledge of return to play guidelines. Section 4, Concussion History, contained questions regarding incidences of concussion and attitudes towards the injury. The full survey can be found in Appendix D. A Chronbach's alpha analysis determined this survey measure to be reliable (α=.606).

Statistical Analysis

Statistical analysis was performed using the IBM SPSS Statistics (Version 21) software. Frequencies and percentages were found to identify concussion incidence rates, rates of under-reporting, most common reasons for under-reporting, and most commonly identified signs and symptoms. Pearson correlation analyses were used to identify associations between specific variables (Table 19). Finally, t-tests were performed to determine if increased knowledge of concussion (definition, identification of signs and symptoms, and knowledge of dangers) increases the likelihood of student-athletes reporting potential concussions.

Table 19. Summary of correlations performed.

Demographic variables	Concussion definition Symptom identification Knowledge of associated dangers Knowledge of return to play guidelines Overall concussion knowledge
Concussion history	Overall concussion knowledge
Under-reporting	Demographic variables Concussion knowledge variables Subjective norms
Returning to play too soon	Knowledge of associated dangers Knowledge of return to play guidelines
Knowledge of return to play guidelines	Returning to play too soon
Concussion scenarios	Demographic variables Concussion history Overall concussion knowledge Subjective norms

CHAPTER IV

FINDINGS

Surveys were sent out to 536 student-athletes and 106 were returned for a response rate of 20%. Thirteen were incomplete, and therefore not included in the analysis. Ninety-three student-athletes were included in this study.

Demographics

Participants ranged in age from 18 to 24 years of age (M=20, SD=1.47). More than half were female (63.4%, N=56) and white (69.9%, N=65). A majority of participants were members of the track and field (36.6%, N=34), cross country (12.9%, N=12), football (10.8%, N=10), and soccer (9.7%, N=9) teams. Tables 20-22 detail participant demographics.

Table 20. Age of participants.

Age	N	Percentage
18	9	9.7
19	20	21.5
20	24	25.8
21	11	11.8
22	9	9.7
23	6	6.5
24	1	1.1
Missing	13	14.0

Table 21. Race/ethnicity of participants.

Race/Ethnicity	N	Percentage
White	65	69.9
African American	11	11.8
Latino/Hispanic	4	4.3
Native American	7	7.5
Asian	2	2.2
Pacific Islander	0	0
Other	4	4.3

Table 22. Athletic teams of participants.

Sport	N	Percentage
Football	10	10.8
Soccer	9	9.7
Baseball	1	1.1
Softball	5	5.4
Basketball	2	2.2
Equestrian	7	7.5
Cross Country	12	12.9
Track and Field	34	36.6
Wrestling	6	6.5
Tennis	2	2.2
Golf	4	4.3
Cheer/Pom	0	0.0

Frequencies and Percentages

Formal Concussion Education

Nearly half of participants reported receiving some type of formal concussion education (47.3%, N=45). Of those who had received formal education, 53.3% reported only one source of information regarding concussion (Table 23). Presentations (i.e. power point) were the most commonly reported form of formal education (60.0%, N=27). Table 24 outlines the various types of formal education student-athletes reported receiving. Concussion knowledge was also gained through academic courses focused on care and prevention of athletic injuries, baseline concussion assessments, previous history of

concussion, athletic trainers, and reading the NATA position statement on concussion. An overwhelming majority of those who had received formal concussion education (88.9%, N=40) stated that they felt more knowledgeable about concussion after receiving this information.

Table 23. Number of sources of concussion information.

Number of Information Sources	N	Percentage
1	24	53.3
2	8	17.8
3	8	17.8
4	3	6.7
5	2	4.4

Table 24. Sources of concussion information.

Source of Concussion Information	N	Percentage
Presentation (ex: power point)	27	60.0
Pamphlet/Flyer	18	40.0
Website	13	28.9
Video	19	42.2
Other	9	20.0

Concussion Knowledge

Concussion knowledge was defined as the ability to define a concussion, identify symptoms and dangers associated with the injury, and identify correct return to play guidelines.

Three-quarters of participants (75.3%, N=70) were able to correctly define a concussion as a "brain injury resulting in changes in thinking, emotions, and/or balance." Fifteen participants (16.1%) defined a concussion as a "brain injury requiring being hit in the head," and seven (7.5%) defined it as a "brain injury requiring losing consciousness (blacking out)." No participants defined a concussion as "just a headache."

The most commonly identified symptoms of a concussion were headache (98.9%, N=92), balance problems (91.4%, N=85), blurry vision (90.3%, N=84), confusion/disorientation (88.2%, N=82), photophobia (87.1%, N=81), and difficulty concentrating (84.9%, N=79). Table 25 provides a detailed list of correctly identified concussion symptoms. Twenty-two potential symptoms of concussion were presented. The mean number of correctly identified symptoms was 15.38 (SD=4.84). Table 26 outlines the number of correctly identified symptoms.

Table 25. Correctly identified concussion symptoms.

Signs and Symptoms of Concussion	N	Percentage
Headache	92	98.9
Balance problems	85	91.4
Blurry vision	84	90.3
Confusion/disorientation	82	88.2
Sensitivity to light (photophobia)	81	87.1
Difficulty concentrating	79	84.9
Memory problems	76	81.7
Dizziness	76	81.7
Pressure in the head	73	78.5
Drowsiness	73	78.5
Loss of consciousness (blacking out)	72	77.4
Nausea	67	72.0
Vomiting	65	69.9
Feeling in a “fog”	64	68.8
Ringing in ears (tinnitus)	64	68.8
Sensitivity to noise	54	58.1
Inappropriate emotions	48	51.6
Sleep problems	43	53.8
Irritability	41	44.1
Vacant stare	40	43.0
Sleep disturbances	40	43.0
Sadness	31	33.3

Table 26. Number of correctly identified concussion symptoms.

Number Correct	N	Percentage
1	1	1.1
2	1	1.1
3	0	0
4	0	0
5	1	1.1
6	2	2.2
7	1	1.1
8	0	0
9	3	3.2
10	1	1.1
11	9	9.7
12	5	5.4
13	7	7.5
14	11	11.8
15	10	10.8
16	3	3.2
17	4	4.3
18	5	5.4
19	6	6.5
20	5	5.4
21	4	4.3
22	14	15.1

Almost all participants (96.8%, N=90) were aware that an athlete should not return to play until all signs and symptoms of a concussion have completely resolved. Two participants (2.2%) stated an athlete could return to play when symptoms are 90% gone, and one participant (1.1%) reported that an athlete could return to play immediately after injury.

More than half of participants (59.1%, N=55) were able to correctly identify that bleeding in the brain, swelling of the brain, long-term cognitive problems, long-term emotional problems, long-term physical disability, and death were all potential dangers associated with concussions. Table 27 details the potential dangers of concussion as

identified by the participants. Table 28 outlines the number of correctly identified potential dangers by participants.

Table 27. Potential dangers of concussions.

Which of the following are potential dangers associated with concussions? (Check all that apply)	N	Percentage
Bleeding in the brain	80	86.0
Swelling of the brain	86	92.5
Long-term cognitive problems	83	89.2
Long-term emotional problems	67	72.0
Long-term physical disability	69	74.2
Death	72	77.4
None	2	2.2

Table 28. Number of correctly identified potential dangers associated with concussions.

Correctly identified potential dangers associated with concussion	N	Percentage
0	2	2.1
1	5	5.4
2	4	4.3
3	10	10.8
4	7	7.5
5	10	10.8
6	55	59.1

Overall concussion knowledge scores were calculated using the sum of all concussion knowledge variables. These variables included correctly defining concussion (1), number of symptoms identified (possible 22), correctly identifying return to play guidelines (1), and number of dangers identified (possible 6) for a possible total of 30 points. The mean concussion knowledge score was 22.01 (SD=6.18). Table 29 outlines concussion knowledge scores.

Table 29. Concussion knowledge scores.

Concussion knowledge score	N	Percentage
1	1	1.1
2	0	0.0
3	1	1.1
4	0	0.0
5	0	0.0
6	0	0.0
7	0	0.0
8	0	0.0
9	2	2.2
10	0	0.0
11	0	0.0
12	0	0.0
13	2	2.2
14	3	3.2
15	5	5.4
16	3	3.2
17	3	3.2
18	6	6.5
19	5	5.4
20	2	2.2
21	10	10.8
22	4	4.3
23	6	6.5
24	3	3.2
25	7	7.5
26	2	2.2
27	8	8.6
28	3	3.2
29	5	5.4
30	12	12.9

Concussion History

Less than one-third of participants (29.0%, N=27) reported suffering a concussion. The mean number of concussions suffered was 2.41 (SD=2.29). Table 30 outlines the number of concussions experienced by participants.

Table 30. Number of concussions.

Number of Concussions	N	Percentage
0	66	70.9
1	11	11.8
2	11	11.8
3	1	1.1
4	1	1.1
7	1	1.1
8	1	1.1
10	1	1.1

Nearly one quarter of participants (26.9%, N=25) reported experiencing signs and symptoms of a concussion, but did not report them. The most common reason for not reporting concussion symptoms was not thinking it was serious enough to warrant medical attention (44.0%, N=11) followed by not wanting to leave practice or a competition (24.0%, N=6). Table 31 outlines the reasons why participants did not report their symptoms. Fifteen (16.1%) participants reported returning to play while still experiencing signs and symptoms of a concussion.

Table 31. Reasons why participants did not report concussion symptoms

Why did you not report experiencing signs and symptoms of a concussion?	N	Percentage
I did not think it was serious enough to warrant medical attention	11	44.0
I did not know it was a concussion at the time	0	0.0
Concussions are just part of the game	1	4.0
I did not want to let my coach or team down	1	4.0
I did not want to come out of practice or competition	6	24.0
I did not want to risk losing playing time	1	4.0
I was afraid of losing my spot on the team	0	0.0
Other—I was uncomfortable communicating with my athletic trainer	1	4.0
Did not answer	4	16.0

Concussion Scenarios

Two sets of scenarios were presented to assess participants' attitudes towards reporting concussion symptoms. The first scenario asked participants how likely they would be to report a headache and feeling disoriented to their coach or athletic trainer after being struck in the head. A majority (71.0%, N=66) said they would be likely or very likely to report this incident. The second scenario presented a potential mechanism of injury for a concussion that did not result from being hit in the head. Fewer participants (65.6%, N=61) stated they would be likely or very likely to report this incident. Tables 32 and 33 outline responses to scenarios 1 and 2.

Table 32. Scenario 1

You are struck in the head and begin to feel disoriented and have a headache. How likely are you to report your symptoms to your coach or athletic trainer?	N	Percentage
Very unlikely	3	3.2
Unlikely	17	18.3
Undecided	7	7.5
Likely	38	40.9
Very likely	28	30.1

Table 33. Scenario 2.

You are hit in the back and begin to feel dizzy and have a headache. How likely are you to report you symptoms to your coach or athletic trainer?	N	Percentage
Very unlikely	4	4.3
Unlikely	22	23.7
Undecided	5	5.4
Likely	35	37.6
Very likely	26	28.0
No answer	1	1.1

The second pair of scenarios was presented after subjects underwent a brief review of concussion. This review included the definition of a concussion, potential signs and symptoms, dangers associated with the injury, and basic return to play guidelines. This review can be found as part of the survey in Appendix D. In response to the first scenario, a hit to the head resulting in blurry vision and a headache, 79.6% (N=74) of participants stated they would be likely or very likely to report this incident to their coach or athletic trainer. The second scenario, like in the pre-review section presented a scenario that did not result from a direct blow to head. The mechanism was a fall to the

ground resulting in seeing stars and the development of a headache and 80.6% (N=75) of participants said they were likely or very likely to report this to the coach or athletic trainer. Tables 34 and 35 outline responses to scenarios 3 and 4.

Table 34. Scenario 3.

You are struck in the back of the head and your vision becomes slightly blurry and your head begins to hurt. How likely are you to report your signs and symptoms to your coach or athletic trainer?	N	Percentage
Very unlikely	3	3.2
Unlikely	11	11.8
Undecided	5	5.4
Likely	29	31.2
Very likely	45	48.4

Table 35. Scenario 4.

You are knocked to the ground and begin to see stars and develop a headache. How likely are you to report your symptoms to your coach or athletic trainer?	N	Percentage
Very unlikely	4	4.3
Unlikely	10	10.8
Undecided	4	4.3
Likely	32	34.4
Very likely	43	46.2

Scenarios 1 and 3 were grouped together because they included symptoms resulting from a blow to the head. Scenarios 2 and 4 were grouped together because they included symptoms resulting from mechanisms not involving a blow to the head. Paired sample t-tests were performed for each group of scenarios to determine if participants'

answers regarding reporting behavior differed after undergoing a brief educational intervention. Significant differences were found between pre- and post-intervention responses (Table 36). However, pre- and post-intervention responses to the second group of scenarios were not significantly different for high-risk sports (football, soccer, basketball, and wrestling).

Table 36. Paired sample t-test results

T-Test	N	Mean	SD	CI	t	df	p
Scenarios 1 and 3	93	-.333	.970	-.533, -.133	-3.312	92	.001
Scenarios 1 and 3 (high-risk)	27	-.519	.935	-.888, -.148	-2.881	26	.008
Scenarios 2 and 4	92	-.446	1.80	-.690, -.201	-2.881	26	.000
Scenarios 2 and 4 (high-risk)	27	-.444	1.311	-.963, .074	-1.762	26	.090

Subjective Norms

When asked if their teammates would report experiencing these signs and symptoms, 62.4% (N=58) said yes or definitely yes (Table 37). When asked if their coaches would want them to report experiencing these signs and symptoms, most participants (83.9%, N=78) said yes or definitely yes (Table 38).

Table 37. Teammate reporting behavior

Do you think your teammates would report experiencing these signs and symptoms to your coach or athletic trainer?	N	Percentage
Definitely no	0	0.0
No	7	7.5
Not sure	28	30.1
Yes	45	48.4
Definitely yes	13	14.0

Table 38. Expectations of coaches

Do you think your coach would want you to report experiencing these signs and symptoms?	N	Percentage
Definitely no	1	1.1
No	6	6.5
Not sure	7	7.5
Yes	30	32.3
Definitely yes	48	51.6

Reporting Behavior Correlations

Correlations were performed to identify potential relationships between demographic, concussion knowledge, concussion history, subjective norms, and reporting behavior variables. Sports considered to be high-risk (football, soccer, basketball, and wrestling) were then analyzed separately to determine if differences exist between the two groups.

Concussion Knowledge

No significant relationships were found between demographic variables and the ability to define a concussion, symptom identification, knowledge of potential dangers, knowledge of return to play guidelines, and overall concussion knowledge. These

relationships were also insignificant for high-risk sports. Tables 39-48 detail the results of these correlation analyses.

Table 39. Demographic variables and concussion definition correlations.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Concussion definition	.101	.373
Class standing and concussion definition	.081	.441
Team and Concussion definition	.072	.493

Table 40. Demographic variables and concussion definition correlations for high-risk sports.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Concussion definition	.118	.575
Class standing and concussion definition	.272	.170
Team and Concussion definition	.042	.837

Table 41. Demographic variables and concussion symptom identification correlations.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Number of symptoms identified	.012	.917
Class standing and Number of symptoms identified	.095	.365
Team and Number of symptoms identified	.103	.330

Table 42. Demographic variables and concussion symptom identification correlations for high-risk sports.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Number of symptoms identified	-.170	.417
Class standing and Number of symptoms identified	-.114	.572
Team and Number of symptoms identified	.200	.316

Table 43. Demographic variables and knowledge of concussion dangers correlations.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Number of potential dangers identified	-.017	.878
Class standing and Number of potential dangers identified	.000	1.00
Team and Number of potential dangers identified	.106	.312

Table 44. Demographic variables and knowledge of concussion dangers correlations for high-risk sports.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Number of potential dangers identified	-.013	.950
Class standing and Number of potential dangers identified	.063	.755
Team and Number of potential dangers identified	.180	.368

Table 45. Demographic variables and knowledge of return to play guidelines correlations.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Return to Play Guidelines	-.113	.318
Class standing and Return to Play Guidelines	-.047	.654
Team and Return to Play Guidelines	.082	.439

Table 46. Demographic variables and knowledge of return to play guidelines correlations for high-risk sports.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Return to Play Guidelines	-.295	.153
Class standing and Return to Play Guidelines	-.099	.624
Team and Return to Play Guidelines	.126	.530

Table 47. Demographic variables and overall concussion knowledge correlations.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Concussion knowledge	.008	.944
Class standing and Concussion knowledge	.079	.454
Team and Concussion knowledge	.116	.271

Table 48. Demographic variables and overall concussion knowledge correlations for high-risk sports.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Concussion knowledge	-.132	.530
Class standing and Concussion knowledge	-.053	.791
Team and Concussion knowledge	.202	.312

No significant relationship was found between history of a concussion and overall concussion knowledge (r=-.018, p=.863). This relationship was also insignificant for

high-risk sports (r=.079, p=.694). No significant relationship was found between number of concussions suffered and overall concussion knowledge (r=-.183, p=.362). The relationship was insignificant for high-risk sports as well (r=-.313, p=.299).

Under-Reporting of Concussion Symptoms

No significant relationships were found between demographic variables and failing to report concussion symptoms (Table 49). Team values were then recoded into two groups, high-risk and low-risk sports. A significant, positive, fair relationship was found between level of risk of sport and failing to report concussion symptoms (r=.250, p=.016) suggesting that as risk level increased, the likelihood of not reporting symptoms of a concussion also increased.

Table 49. Demographic variables and under-reporting concussion symptoms

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Age and Under-reporting	-.099	.348
Class standing and Under-reporting	-.034	.744
Team and Under-reporting	.178	.090
Risk level and Under-reporting	.250	.016

No significant relationships were found between concussion knowledge variables and failing to report concussion symptoms (Table 50). No significant relationships were found between concussion knowledge variables and failing to report symptoms for high-risk sports either (Table 51).

Table 50. Concussion knowledge and under-reporting of symptoms correlations.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Formal education and Under-reporting	-.040	.702
Concussion definition and Under-reporting	.158	.129
Number of symptoms identified and Under-reporting	.153	.142
Number of dangers identified and Under-reporting	.073	.489

Table 51. Concussion knowledge and under-reporting of symptoms correlations for high-risk sports.

Correlation	Pearson Correlation Coefficient (r)	Significance (p)
Formal education and Under-reporting	-.240	.228
Concussion definition and Under-reporting	.316	.108
Number of symptoms identified and Under-reporting	.158	.431
Number of dangers identified and Under-reporting	.145	.471

No significant relationship was found between number of potential dangers identified and returning to play with signs and symptoms (r=.049, p=.641). There was also no significant relationship between these variables for high-risk sports (r=.060, p=.767). No significant relationship was found between knowledge of return to play guidelines and returning to play too soon (r=.085, p=.416). This relationship was also insignificant for high-risk sports (r=.229, p=.250).

No significant relationship exists between overall concussion knowledge and underreporting of concussions (r=.155, p=.138). This relationship was also insignificant

for high-risk sports (r=.187, p= .351). No significant relationship existed between overall concussion knowledge and returning to play too soon (r=.039, p=.712). This relationship was also insignificant for high-risk sports (r=.162, p=.419).

Significant relationships exist between subjective norms and underreporting of concussion symptoms. The first norm, how participants view the reporting behaviors of their teammates, and underreporting of their own symptoms was a significant, positive fair relationship (r=.369, p=.000) indicating that student-athletes are more likely to report potential concussions if they believe their teammates are likely to report potential concussions. This relationship was also positive and fair for high-risk sports, but did not reach statistical significance (r=.350, p=.074). The second norm, perception of coaches expectations for reporting symptoms, and underreporting of symptoms was also significant, positive and fair to moderate (r=.445, p=.000) suggesting that student-athletes are more likely to report symptoms of a concussion if they believe their coaches want them to report symptoms. This relationship was also positive, moderate, and significant for high-risk sports (r=.548, p=.003).

Concussion Reporting Behavior Scenarios

Correlations were performed between reporting behaviors and demographic, concussion history, concussion knowledge, and subjective norm variables for each scenario. These correlations were repeated for high-risk sports. Tables 52 to 59 outline the results of the correlation analyses. Significant relationships were found between reporting behavior and age, class standing, risk level, history of concussion, and subjective norms. A negative, fair to moderate, and significant relationship only existed between age and reporting behavior for high-risk sports in scenario 1 (r=-.442, p=.027)

indicating that as age increases, the likelihood of reporting potential concussions decreases. Similarly, a negative, fair, and significant relationship between class standing reporting behaviors only existed for high-risk sports in scenario 3 (r=-.383, p=.048) suggesting that as class standing increases, the likelihood of reporting potential concussions decreases. Positive, fair, and significant relationships between history of concussion and reporting behavior were found in scenario 1 (r=.299, p=.004) and scenario 2 (r=.313, p=.002) indicating that a history of previous concussions increases the likelihood of reporting potential concussions. However, a negative, fair relationship approached statistical significance between number of concussions and reporting behavior in scenario 1 (r=-.378, p=.052) suggesting that as the number of concussions suffered increases, the likelihood of reporting potential concussions decreases. A negative, fair, and significant relationship existed between risk level and reporting behavior for scenario 1 (r=-.380, p=.000), scenario 2 (r=-.263, p=.012), scenario 3 (r=-.285, p=.006), and scenario 4 (r=-.291, p=.005) indicating that as risk level increases, the likelihood of reporting potential concussions decreases. A positive, fair to moderate, and significant relationship existed between subjective norm 1 and reporting behaviors for scenario 1 (r=.487, p=.000), scenario 2 (.407, p=.000), scenario 3 (r=.398, p=.000), and scenario 4 (r=.364, p=.000) indicating that student-athletes are more likely to report potential concussions if they believe their teammates are likely to report potential concussions. A positive, fair to moderate, and significant relationship between subjective norm 1 and reporting behaviors was only present in scenario 1 (r=.449, p=.019) for high-risk sports. A positive, poor to fair, and significant relationship existed between subjective norm 2 and reporting behaviors for scenario 1 (r=.321, p=.002), scenario 3

(r=.248, p=.017), and scenario 4 (r=.242, p=.020) indicating that student-athletes are more likely to report potential concussions if they believe their coaches want them to report experiencing symptoms of a concussion. This relationship was not significant for high-risk sports in any scenario.

Table 52. Scenario 1 correlations

Variable	Pearson Correlation Coefficient (r)	Significance (p)
Age	-.198	.078
Class standing	-.138	.187
Team	.189	.071
Risk level	-.380	.000
Formal education	.030	.778
History of concussion	.299	.004
Number of concussions	-.378	.052
Concussion knowledge	.070	.506
Norm 1	.487	.000
Norm 2	.321	.002

Table 53. Scenario 1 correlations for high-risk sports

Variable	Pearson Correlation Coefficient (r)	Significance (p)
Age	-.442	.027
Class standing	-.353	.071
Team	-.124	.538
Formal education	-.229	.129
History of concussion	-.063	.754
Number of concussions	-.380	.200
Concussion knowledge	.148	.462
Norm 1	.449	.019
Norm 2	.227	.254

Table 54. Scenario 2 correlations

Variable	Pearson Correlation Coefficient (r)	Significance (p)
Age	-.113	.317
Class standing	.015	.887
Team	.180	.088
Risk level	-.263	.012
Formal education	-.006	.952
History of concussion	.313	.002
Number of concussions	.212	.278
Concussion knowledge	.183	.081
Norm 1	.407	.000
Norm 2	.194	.066

Table 55. Scenario 2 correlations for high-risk sports

Variable	Pearson Correlation Coefficient (r)	Significance (p)
Age	-.236	.257
Class standing	.097	.629
Team	.057	.778
Formal education	-.116	.565
History of concussion	.024	.907
Number of concussions	-.125	.683
Concussion knowledge	.264	.184
Norm 1	.345	.078
Norm 2	.086	.670

Table 56. Scenario 3 correlations

Variable	Pearson Correlation Coefficient (r)	Significance (p)
Age	-.151	.180
Class standing	-.171	.101
Team	.138	.152
Risk level	-.285	.006
Formal education	.138	.189
History of concussion	.180	.085
Number of concussions	.067	.742
Concussion knowledge	.161	.122
Norm 1	.398	.000
Norm 2	.248	.017

Table 57. Scenario 3 correlations for high-risk sports

Variable	Pearson Correlation Coefficient (r)	Significance (p)
Age	-.321	.118
Class standing	-.383	.048
Team	-.023	.909
Formal education	-.354	.070
History of concussion	-.133	.510
Number of concussions	.120	.696
Concussion knowledge	.061	.763
Norm 1	.226	.258
Norm 2	.065	.747

Table 58. Scenario 4 correlations

Variable	Pearson Correlation Coefficient (r)	Significance (p)
Age	-.019	.865
Class standing	-.047	.486
Team	.152	.148
Risk level	-.291	.005
Formal education	.100	.342
History of concussion	.166	.112
Number of concussions	.113	.574
Concussion knowledge	.093	.376
Norm 1	.364	.000
Norm 2	.242	.020

Table 59. Scenario 4 correlations for high-risk sports

Variable	Pearson Correlation Coefficient (r)	Significance (p)
Age	-.146	.486
Class standing	-.220	.270
Team	-.106	.599
Formal education	-.317	.107
History of concussion	-.209	.296
Number of concussions	.172	.574
Concussion knowledge	-.016	.935
Norm 1	.130	.520
Norm 2	.032	.827

CHAPTER V

CONCLUSION

The purpose of this study was to better understand the relationships between factors influencing concussion-reporting behaviors of Division I collegiate athletes and to evaluate the effectiveness of concussion education programs. This study is unique in its evaluation of the effectiveness of concussion education programs in that it focused on more than assessing concussion knowledge. Most education programs are focused on symptom identification, risk awareness, and return to play protocols.[15] Evaluations of these programs generally assess changes in knowledge, even though the overall goal is to change behavior.[15] Therefore, this study aimed to evaluate concussion knowledge, reporting behaviors, subjective norms, and the relationships between them.

Concussion Education and Knowledge

The NCAA mandates annual concussion education for all student-athletes.[18,82] This education is designed to make student-athletes aware of the signs and symptoms of concussions and the potential short- and long-term effects of concussion on overall health in order to encourage them to take responsibility for reporting concussion symptoms.[82] However, the implementation of education programs is not well regulated and less than 50% of participants reported undergoing any type of formal education.

Despite the lack of formal education, a majority of participants possessed a firm understanding of concussions. They were able to correctly define a concussion, list signs and symptoms, identify return to play guidelines, and were aware of the potential dangers associated with concussions. Previous research by Chrisman et al[17] also found that a majority of student-athletes were knowledgeable about concussion.

Concussion Reporting Behavior

However, even with knowledge of concussions 26.9% of participants reported experiencing symptoms of a concussion without reporting them. Previous research suggests rates of under-reporting are higher than those found in this study, but these studies only included high-risk sports such as football, soccer and rugby.[8,9,87] This study included both high-risk and low-risk sports which may account for the variance in under-reporting rate as indicated by the significant relationship between level of risk and reporting behavior. This relationship suggests that as concussion risk increases, the likelihood of not reporting symptoms also increases. This indicates that the culture of the sport also influences reporting behavior.

The reasons for not reporting symptoms were similar to those found in previous studies.[8-11,13,15,87] The most common reason was the belief that the injury was not serious enough to warrant medical attention. This supports the need for increased knowledge regarding the severity of this injury. Other reasons for not reporting symptoms included thinking the injury was part of the game, not wanting to be removed from participation, not wanting to lose playing time, and not wanting to let their coach or teammates down.

Concussion reporting behavior is a complex phenomenon. It is influenced by a variety of factors, including attitude towards the injury, subjective norms, and perceived

behavioral control according to the Theory of Planned Behavior.[16,17] The reasons reported for not reporting concussion symptoms support this theory. Attitudes are what an individual believes will happen if they perform a specific behavior and are formed by their knowledge of the injury.[16] Within this sample, the common belief was that no serious consequences would result if they refrained from reporting symptoms to their coach or athletic trainer despite their knowledge of concussion and the risks associated. Contrarily, they believed that if they did report signs and symptoms they would be penalized by being removed from practice or competition, and/or losing playing time in the future. Subjective norms are what an individual believes others expect them to do and are formed by the culture of the sport, coaches, and teammates.[16] Subjective norms are responsible for the belief that concussions are simply part of the game. Within this sample, some participants believed that their coaches and teammates would want them to play and would be letting them down if they reported symptoms. Perceived behavioral control is an individual's belief regarding their ability to perform a behavior.[16]

Behavioral research suggests that subjective norms heavily influence perceived behavioral control. Chrisman et al[17] also found that despite athletes' knowledge of concussions and dangers associated with playing while concussed, they still failed to report symptoms. This is further supported by the significant relationships between subjective norms and under-reporting of concussion symptoms found in this study. The results of this study suggest that if a student-athlete thinks their teammates are likely to report symptoms of a concussion, that student-athlete will be more likely to report symptoms of a concussion. Similarly, if a student-athlete believes their coach wants them to report symptoms of a concussion, they are more likely to report symptoms.

Previous research also suggests that increased knowledge does little to change reporting behaviors.[15] This study found no significant relationships between concussion knowledge variables such as correctly defining a concussion, symptom recognition, identifying potential dangers associated with concussion, and knowledge of return to play guidelines and reporting behaviors. However, this study did find a significant difference between pre- and post-concussion review scenario responses. This finding suggests that regular reminders of concussion, signs and symptoms, potential risks, and return to play guidelines may be effective in changing reporting behavior. While there were overall significant differences, the differences in scores were not significant for high-risk sports. Most concussion research involves these sports, which may explain the lack of effect of education programs seen in the literature.

Recommendations for Concussion Education

Though promising, simply increasing concussion knowledge is not enough to change reporting behaviors. The findings of this study and previous research by Chrisman et al[17] indicate that subjective norms have a significant influence over student-athletes' reporting behavior. The relationships between risk level, subjective norms, and reporting behavior found in this study support the need for strategies designed to not only increase concussion knowledge, but to cause a paradigm shift in athletic culture. Provvidenza and Johnston[88] recommend implementing knowledge transfer principles into the development and evaluation of concussion education programs. Knowledge transfer involves the creation and application of knowledge.[20] The knowledge transfer principles of multiple intelligences and peer support may be the most effective in changing symptom reporting behavior. The principle of multiple intelligences recognizes that each

student-athlete has a specific set of strengths and weakness, a different intellectual profile, and requires different uses of intelligence. Once these factors are identified, a targeted approach to help the student-athlete become more self-directed, gain confidence, understand their own abilities and those of others, and improve on their weaknesses is created.[88] Interactive concussion training courses are one way of implementing the principle of multiple intelligences. Peer support groups are also suggested because they are shown to reduce anxiety, depression, anger, confusion, and frustration; they are also shown to enhance coping strategies.[88] This is an opportunity for student-athletes to share knowledge and support one another.[88] It is also a way to facilitate dialogue in order to improve subjective norms regarding the reporting behaviors of their teammates.

Limitations

The results of this study must be weighed in conjunction with the limitations. First, this sample may not be representative of all student-athletes. Concussion knowledge and reporting behaviors of adolescent athletes and those participating at varying levels of competition may be different from those participating in Division I athletics. Student-athletes participating in this study may also have different education and cultural backgrounds which may have affected their ability to understand and answer questions in the survey. The scenarios included in the study were not sport specific. They were designed to be applicable to student-athletes participating in all sports, however this may have affected responses. Finally, participants may have not been honest in regards to their reporting behaviors in order to provide answers they believed the researcher was looking for.

Future Research

Future research is needed to better understand differences in reporting behavior between sports because student-athletes participating in low-risk sports are under-represented in the current literature. Research involving sport specific education programs is also needed. Finally, further research is necessary to better understand the complex relationships between subjective norms and reporting behavior.

Conclusion

In conclusion, student-athletes appear to have a sound understanding of concussion and the associated risks. However, despite this knowledge some still do not report experiencing signs and symptoms of concussions. Their perceptions of their teammates and coaches expectations and the culture of their sport significantly influence their reporting behavior. Therefore, culture change, changing the perception of subjective norms, and the individualization of education programs is necessary.

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APPENDICES

Appendix A

Institutional Review Board Approval

Oklahoma State University Institutional Review Board

Date:	Wednesday, November 27, 2013
IRB Application No	ED13192
Proposal Title:	Concussion Knowledge, Attitudes, and Reporting Behavior in Collegiate Athletes
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 11/26/2016

Principal Investigator(s):

Kathleen O. Olson
428 Willard
Stillwater, OK 74078

Jennifer Volberding
180 Colvin Center
Stillwater, OK 74078

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

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

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

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI, advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

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

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

Appendix B

Recruitment Letters

Office of Athletics Compliance Recruitment Letter

Dear Office of Athletics Compliance,

I am writing you to request your participation in a research study titled: Concussion knowledge and reporting behavior in collegiate athletes. My name is Kathleen Olson and I am a Graduate Student in the Athletic Training Program at Oklahoma State University, as well as a Graduate Research Assistant for Dr. Julie Croff. I will be conducting this study to fulfill the requirements of a Master's Thesis to complete a Master of Science degree in Health and Human Performance (Athletic Training).

The overall purpose of this study is to evaluate the effectiveness of concussion education in Division I athletes. This will be done by assessing concussion knowledge, attitudes, and incidences of under-reporting. This study has been approved by the Oklahoma State University Institutional Review Board (IRB).

The goal is to use the information collected from this study to better understand why athletes fail to report signs and symptoms of concussion in an effort to develop more effective concussion education programs.

If you choose to participate in this study you will be asked to forward an email to the OSU student-athletes containing a link to the survey. The study consists of a brief online survey to be completed by student-athletes. The survey should take no more than 15 minutes. Two weeks after the initial email, a reminder email will be sent to you to forward to the student-athletes. Student-athletes who participate in the study will be entered into a raffle to win 1 of 2 $50 Amazon gift cards.

Your participation in this study is important and will provide an opportunity to evaluate the current concussion education program at OSU and better understand why student-athletes fail to report signs and symptoms of concussions. Your participation will not affect your employment status, and if you choose to participate all responses will be kept confidential.

Sincerely,

Kathleen M. Olson, ATC

kathleen.olson@okstate.edu

Student-Athlete Recruitment Letter

Dear Student-Athlete,

You are being asked to participate in a short web-based survey. Participating in this survey gives you the option to enter a raffle to win 1 of 2 $50 Amazon gift cards.

Link:

My name is Kathleen Olson and I am a graduate student in the Athletic Training Education Program here at Oklahoma State University. I am conducting a survey as part of my Master's Thesis to fulfill the requirements of a Master of Science Degree in Health and Human Performance. The brief survey will ask you questions about your concussion knowledge, attitudes, and experiences. The purpose of the study is to better understand attitudes toward concussion to develop more effective concussion education programs for collegiate athletes.

Participation in this study is voluntary and completely anonymous. No identifying information will be requested that can be linked to your answers. No individual data will be given to your coaches, athletic trainers, or other administration at your school. You may withdraw from the study at any time with no penalty to participation status, position on your team, or medical treatment received.

The link provided above will take you to the website to take the survey. It is approximately 20 questions and should take you no longer than 15 minutes.

I ask that you participate in this study because the information gathered can guide the academic, medical, and athletic communities in their development of concussion education programs to better protect you, the athletes. Please contact Kathleen Olson at (562) 774-7878 or olsonkm@ostatemail.okstate.edu with any questions or concerns.

Sincerely,

Kathleen Olson, ATC

kathleen.olson@okstate.edu

Appendix C

Participant Information Document

Participant Information

Before you give your consent to be a volunteer, it is important that we give you the following information so that you understand what you will be asked to do.

Investigator: Kathleen M. Olson, ATC, Oklahoma State University (kathleen.olson@okstate.edu)

Advisor: Jennifer L. Volberding, PhD, ATC, LAT, Oklahoma State University (jennifer.volberding@okstate.edu)

Purpose of the Study: I am interested in evaluating the effectiveness of concussion education in Division I athletes.

Description of Study: The survey will take approximately 15 minutes. It will ask you questions about your knowledge and attitudes towards concussions.

Risks and Discomforts: During the survey you will be asked questions about your personal medical history regarding concussion. To minimize the risk of discomfort, please remember that your answers are completely confidential. You may refuse to answer any question and end your participation at any time. All information collected during the survey will be reported in grouped form (no individual responses will be reported).

Incentive: For your time today you will be entered into a raffle to win 1 of 2 $50 Amazon gift cards.

Benefits of the Study: It is the hope that the data collected from this study will help guide future concussion education programs to limit the long-term effects associated with concussions.

Voluntary Nature of Participation: Participation in this study is voluntary. Your choice to participate or not will not influence your position on an Oklahoma State University athletic team. If you choose to participate, you are free to withdraw your consent at any time without penalty.

If you have any questions about the research, please contact Kathleen Olson at kathleen.olson@okstate.edu, or Dr. Volberding at jennifer.volberding@okstate.edu. If you have any questions regarding your rights as a human subject and participation in this study, you may call the OSU Office of University Research Compliance at 405-744-3377.

Agreement: Do you understand what is required of you and agree to participate in this web-based survey?

- I agree to participate.
- I do not agree to participate.

Appendix D

Survey

Demographic Questions

What is your age? _____

What is your gender?

- Male
- Female

To what ethnic/racial group do you belong?

- White
- African American
- Latino/Hispanic
- Native American
- Asian
- Pacific Islander
- Other
    - _____

What is your class standing?

- Freshman
- Sophomore
- Junior
- Senior

To what team do you belong?

- Football
- Soccer
- Baseball
- Softball
- Basketball
- Equestrian
- Cross Country
- Track and Field
- Wrestling
- Tennis
- Golf
- Cheer/Pom

Scenarios

You are struck in the head and begin to feel disoriented and have a headache. How likely are you to report your symptoms to your coach or athletic trainer?

1	2	3	4	5
Very Unlikely		Undecided		Very Likely

You are knocked in the back and begin to feel dizzy and have a headache. How likely are you to report your symptoms to your coach or athletic trainer?

1	2	3	4	5
Very Unlikely		Undecided		Very Likely

Concussion Education Questions

Have you ever received any formal concussion education?

- Yes
- No

If yes, how was the information presented? (Check all that apply)

- Presentation (ex: power point)
- Pamphlet/Flier
- Website
- Video
- Other
    - _____

Did you feel more knowledgeable about concussion after receiving this information?

- Yes
- No

Concussion Knowledge Questions

What is a concussion?

- Brain injury requiring losing consciousness (blacking out)
- Brain injury requiring being hit in the head
- Brain injury resulting in changes in thinking, emotions, behavior, and/or balance
- Just a headache

Which of the following are signs and symptoms of a concussion? (Please check all that apply)

- Blurry vision
- Drowsiness
- Headache
- Palpitating heart
- Neck pain
- Sleeping too much
- Sadness
- Vomiting
- Balance problems
- Inappropriate emotions
- Difficulty concentrating
- Confusion/Disorientation
- Sensitivity to light
- Ringing in ears
- Nausea
- Sleep disturbances
- Nasal drainage
- Pressure in the head
- More energy than usual
- Nose bleed
- Memory problems
- Irritability
- Increased appetite
- Vacant stare
- Sensitivity to Noise
- Dizziness
- Hearing problems
- Increased respirations
- Loss of consciousness
- Feeling in a fog

When is it okay to return to play after suffering a concussion?

- Right away
- When symptoms are 50% gone
- When symptoms are 90% gone
- When all symptoms are gone

Which of the following are potential dangers associated with concussions? (Please check all that apply)

- Bleeding in the brain
- Swelling of the brain
- Long-term cognitive problems
- Long-term emotional problems
- Long-term physical disability
- Death
- None

Concussion Education

Please read the following information about concussion before continuing on to the next question.

What is a concussion?

> A concussion is brain injury that changes a person's behavior, thinking, or physical functioning. They are typically caused by forceful blows to the head or body that result in rapid movement of the head (NCAA Sports Medicine Handbook).

Potential Signs and Symptoms of Concussion (2nd International Conference on Concussion)

• Headache • Pressure in head • Balance problems • Dizziness • Nausea • Feeling "dinged," in a fog, stunned, or dazed • Blurred Vision • Double Vision • Seeing "stars," flashing lights, or spots • Ringing in ears • Irritability • Emotional or personality changes • Disoriented • Confusion	• Amnesia • Loss of consciousness/altered levels of consciousness • Poor coordination or balance • Convulsion/Seizure • Gait unsteadiness/loss of balance • Slow to answer questions or follow directions • Easily distracted/poor concentration • Displaying inappropriate emotions (laughing or crying) • Vomiting • Vacant stare/glossy eyed • Slurred speech • Personality changes

Return to play guidelines—

An athlete should be gradually returned to activity when all symptoms are gone. If at any point during the return to play process the athlete's symptoms return, activity must be stopped until all symptoms have resolved. When symptoms resolve, the athlete begins at the previous symptom free stage. The following table shows the return to play guidelines as outlined during the 3rd International Conference on Concussion in Sport.

Stage
1. No activity
2. Light aerobic exercise
3. Sport specific exercise
4. Non-contact training drills
5. Full contact practice
6. Return to play

Potential dangers associated with concussion—

Concussions are known to cause changes in thinking, behavior, emotions, and balance which can affect your academic and sport performance. Improperly managed concussions can lead to a variety of problems. Returning to play before a concussion has properly healed can also increase your risk of suffering a second concussion or second impact syndrome. Second impact syndrome causes the brain to swell and can lead to permanent disability or death. Injuries such as subdural or epidural hematomas (bleeding in the brain), cerebral contusions (brain bruise), and skull fractures present with symptoms similar to concussion. These injuries can result in long-term disability and death if not treated immediately.

Scenarios

You are struck in the back of the head and your vision becomes slightly blurry and your head begins to hurt. How likely are you to report your symptoms to your coach or athletic trainer?

1	2	3	4	5
Very Unlikely		Undecided		Very Likely

You are knocked to the ground and begin to “see stars” and develop a headache. How likely are you to report your symptoms to your coach or athletic trainer?

1	2	3	4	5
Very Unlikely		Undecided		Very Likely

Perceived Norms

Do you think your teammates would report experiencing these signs and symptoms to your coach or athletic trainer?

1	2	3	4	5
Definitely No		Not Sure		Definitely Yes

Do you think your coach would want you to report experiencing these signs and symptoms?

1	2	3	4	5
Definitely No		Not Sure		Definitely Yes

Concussion History Questions

Have you ever suffered a concussion?

- Yes
- No

If yes, how many? _____

Have you ever experienced any of the signs/symptoms listed above and not reported them to your coach or athletic trainer?

- Yes
- No

If you did not report them, why not?

- I did not think it was serious enough to need medical attention
- I did not know it was a concussion
- Concussions are just part of the game
- I did not want to let team/coach down
- I did not want to come out of practice/game
- I did not want to risk losing playing time
- I was afraid of losing spot on the team
- Other
    - _____

Have you ever returned to play while still experiencing symptoms of a concussion, but told your coach, athletic trainer, or doctor that your symptoms were gone?

- Yes
- No

Would you report a teammate whom you suspect has a concussion?

- Yes
- No

Raffle

Do you want to be entered into the raffle to win 1 of 2 $50 Amazon gift cards?

- Yes
- No

This link will take you to a second anonymous survey. The survey will ask for your first name and e-mail address. This information cannot be traced back to your answers to this survey. Please copy this link into a second window and submit your answers for this survey before continuing on to the raffle.

Link to second survey:

Secondary Survey

What is your first name? _____

What is your e-mail address? _____

VITA

Kathleen M. Olson

Candidate for the Degree of

Master of Science

Thesis: CONCUSSION KNOWLEDGE AND REPORTING BEHAVIORS IN COLLEGIATE ATHLETES

Major Field: Health and Human Performance—Athletic Training

Biographical:

Education:

Completed the requirements for the Master of Science in Health and Human Performance—Athletic Training at Oklahoma State University, Stillwater, Oklahoma in May, 2014.

Completed the requirements for the Bachelor of Science in Kinesiology—Athletic Training at San Diego State University, San Diego, California in 2012.

Experience:

Athletic Trainer Certified Ortho Oklahoma, PC	09/2013 to Current Stillwater, OK
Graduate Research Assistant Oklahoma State University	03/2013 to Current Stillwater, OK
Graduate Teaching Assistant Oklahoma State University	01/2013 to 05/2013 Stillwater, OK
Student Athletic Trainer San Diego Mesa College	08/2011 to 06/2012 San Diego, CA
Student Athletic Trainer University of San Diego	08/2010 to 06/2011 San Diego, CA

Professional Memberships:

National Athletic Trainers' Association	06/2010 to Current