STUDENT CONCUSSION TREATMENT IN THE UNIVERSITY SETTING

CONSENSUS RECOMMENDATIONS of the Florida Academic Healthcare Patient Safety Organization's Student Concussion Task Force

Consensus Recommendations of the Florida Academic Healthcare Patient Safety Organization Student Concussion Integration Task Force

These Consensus Recommendations, developed by the Florida Academic Healthcare Patient Safety Organization (FAH PSO) Student Concussion Task Force, are for informational purposes only and should not be construed or relied upon as the legal standards of care or a clinical practice guideline. The applicable standards for any particular patient is determined by many factors, including the patient-specific clinical data available and is subject to change given developments in scientific knowledge, technological advances, and the evolution of healthcare. The determination of appropriate medical care for any individual patient is subject to the clinical examination by the individual healthcare provider in light of all the information and clinical data available at that time. The ultimate decision regarding the appropriateness of any treatment must be made by each healthcare provider in light of all circumstances prevailing in the individual situation and in accordance with the laws of the jurisdiction in which the care is rendered.

The FAH PSO recommends institutions review these guidelines and accept, modify, or reject these recommendations based on their own institutional resources and patient populations. Any decision not to implement any of the recommendations herein, either fully or partially, should not be construed as evidence of negligence. Adherence to or adoption of the consensus recommendations referenced in this publication does not guarantee a successful outcome. Any recommendations or templates of proposed policies or documents contained herein are solely illustrative. Treatment of the individual patient will depend on that patient's clinical presentation and the evaluation and clinical judgment of the involved health care provider(s). Additionally, institutions should continue to review and modify these recommendations as the science continues to evolve. It is anticipated that these recommendations will require updating as the scientific information regarding concussion evolves.

Participants

The following healthcare providers participated in the development of these consensus recommendations. This publication does not necessarily reflect the views or opinions of any particular healthcare provider, university institution, or healthcare organization. Again, these recommendations do not intend to create nor should they be construed as the legal standard or care or a clinical practice guideline. None of the participants has any affiliations or financial involvement that conflicts with the material presented in this report.

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About the Florida Academic Healthcare Patient Safety Organization

In 2005, Congress developed and enacted the Patient Safety and Quality Improvement Act (PSQIA) with the intent of cultivating a culture of safety and improving healthcare, by providing federal privilege and confidentiality protections for information that is reported to a Patient Safety Organization (PSO), developed by a PSO, or which represents the analyses and deliberations of patient safety events, for the conduct of patient safety activities. The PSQIA promotes the sharing of knowledge gleaned from these patient safety activities and the sharing of best practices and recommendations that seek to improve the quality of healthcare.

The Florida Academic Healthcare Patient Safety Organization (FAH PSO), listed by the Agency for Healthcare Research and Quality on April 22, 2014, represents a significant step toward improving patient safety in the third most populous state in the United States. The PSQIA and the associated federal confidentiality protections provide the required framework to allow the sharing of sensitive patient safety information among medical providers located at the six different State of Florida medical universities training the next generation of healthcare providers. The FAH PSO represents Florida Atlantic University, Florida International University, Florida State University, the University of Central Florida, the University of Florida, the University of South Florida, and the respective institutions' healthcare providers working together to improve patient safety and healthcare.

Executive Summary

In 2016, at the behest of its membership, the Florida Academic Healthcare Patient Safety Organization (FAH PSO) convened a Student Concussion Task Force to arrive at expert consensus guidelines for effective identification, care, and treatment, as well as documentation of and education for concussion care for university students. This specific patient population seeks to participate in collegiate level or intramural sports and balance a challenging university curriculum; for these reasons, the FAH PSO sought to develop these recommendations supported by the literature and healthcare providers actively involved in providing these services.

This Task Force began with a review of the latest scientific evidence, guidance, and opinion statements from relevant professional societies on the appropriate and effective use of concussion care and treatment. Further insights were gathered from subject matter experts in the fields of Student Health, Sports Medicine, Neurology, Neuropsychology and Psychology. Study of the cause and effect of concussions continues to evolve. Though most concussions resolve within weeks, there remains a great deal to learn about more severe and prolonged post-concussive syndrome and chronic traumatic encephalopathy which, to date, can only be definitively diagnosed through post-mortem examination.

Over the course of a year, the Task Force generated recommendations for the identification and management of concussion care, with a focus on post-concussion management of patients and development of a supportive environment for successful treatment, and physical and cognitive recovery. While the core focus of these recommendations is concussion care and treatment, the recommendations also address several other areas critical to the treatment and monitoring of concussive symptoms, including:

- **Identification and evaluation of concussion symptoms**
- **Guidelines for the evaluation of concussive symptoms by healthcare providers and non-healthcare providers**
- **Appropriate follow up of concussive symptoms and evaluation of physical and cognitive recovery, with the goal of returning the university student to academic and physical activities**
- **Psychologic, neurologic, and academic considerations within the university setting which may affect treatment and recovery.**

The following recommendations reflect the aim, mission, and consensus opinions of the Student Concussion Task Force. These recommendations offer guidance to healthcare providers and facilities in their efforts to provide safe, effective, and evidence-based healthcare.

Within many institutions of higher learning, participation in clubs, intramural sports, and other campus recreation activities is encouraged. While eliminating sport-related injuries is not entirely possible, reducing incidence and severity may be achieved through education and comprehensive coordination of services. Resources differ for and within each institution, and the approaches for reasonable education and care will vary with each type of sport or activity; however, Student Affairs and Student Health are often among those best informed and equipped to coordinate stakeholders to ensure that university students receive concussion education and are directed to appropriate care should an injury occur.

These recommendations are supported by the literature available at the time of publication. The science of brain injury and the manifestation of injuries in the individual student continue to evolve, and therefore, individual management and practice decisions continue to rely on the clinical judgement of the healthcare provider evaluating the patient.

Scope of the Issue

Objectives

Consensus recommendations for the treatment and follow up of student health system patients presenting with concussive symptoms, with special attention to:

- Definition, diagnosis, and management of concussion
- Post-concussion management of patients across multiple campuses, including return to learn
- Concussion education for university students and university staff who are likely to encounter injured patients
- Tools to equip healthcare providers with the ability to diagnose and manage concussive symptoms
- Tools to equip non-healthcare providers with the ability to recognize possible concussive symptoms and make timely referrals to healthcare providers
- Developing a plan to foster a supportive environment for successful treatment and recovery, including psychologic, neurologic, and academic considerations
- Student concussion education, templates for the documentation of corresponding clinical evaluations, and waivers for participation in activities with a concussion risk

Scope of Issue

According to the Centers for Disease Control and Prevention, traumatic brain injury is a leading cause of death and disability in the United States, contributing to 30% of all injury deaths. In 2013, traumatic brain injury resulted in 2.8 million emergency department visits, hospitalizations, or deaths. In that same year, falls were the leading cause of traumatic brain injury among all age groups, accounting for 47% of those 2.8 million emergency department visits, hospitalizations, or deaths. In fact, in the largest concussion study to date, the NCAA estimates that there are between 1.6 million and 3.8 million recreation related concussion injuries every year. The NCAA and the Department of Defense created the Grand Alliance in 2014 to fund concussion research with the goal of leading to an improved culture of reporting and management of concussion, and to build on previous initiatives including the CARE Consortium and the Mind Matters Challenge.

One study referenced by the Centers for Disease Control indicated that, for traumatic brain injuries resulting from sports and recreation related activities, the number of emergency department visits have increased significantly since 2004 for females and since 2006 for males. This study posits that the increased number of emergency department visits may be associated with increased awareness of traumatic brain injury from media coverage and educational campaigns like Heads Up from the Centers for Disease Control and Prevention.

Notably, for people ages 15 to 24 years old, being struck by or against an object was the leading cause of TBI-related ED visits. Since 2009, almost 250,000 children age 19 or younger were treated in emergency departments for sports or recreation related concussion or TBI, and that rate has been rising since 2001 by almost 60%. Great public interest has resulted from news coverage of well-known, beloved and notorious athletes, whose deaths have been attributed, in some degree, to their history of traumatic brain injury. Many of these highly publicized incidents have also led to civil

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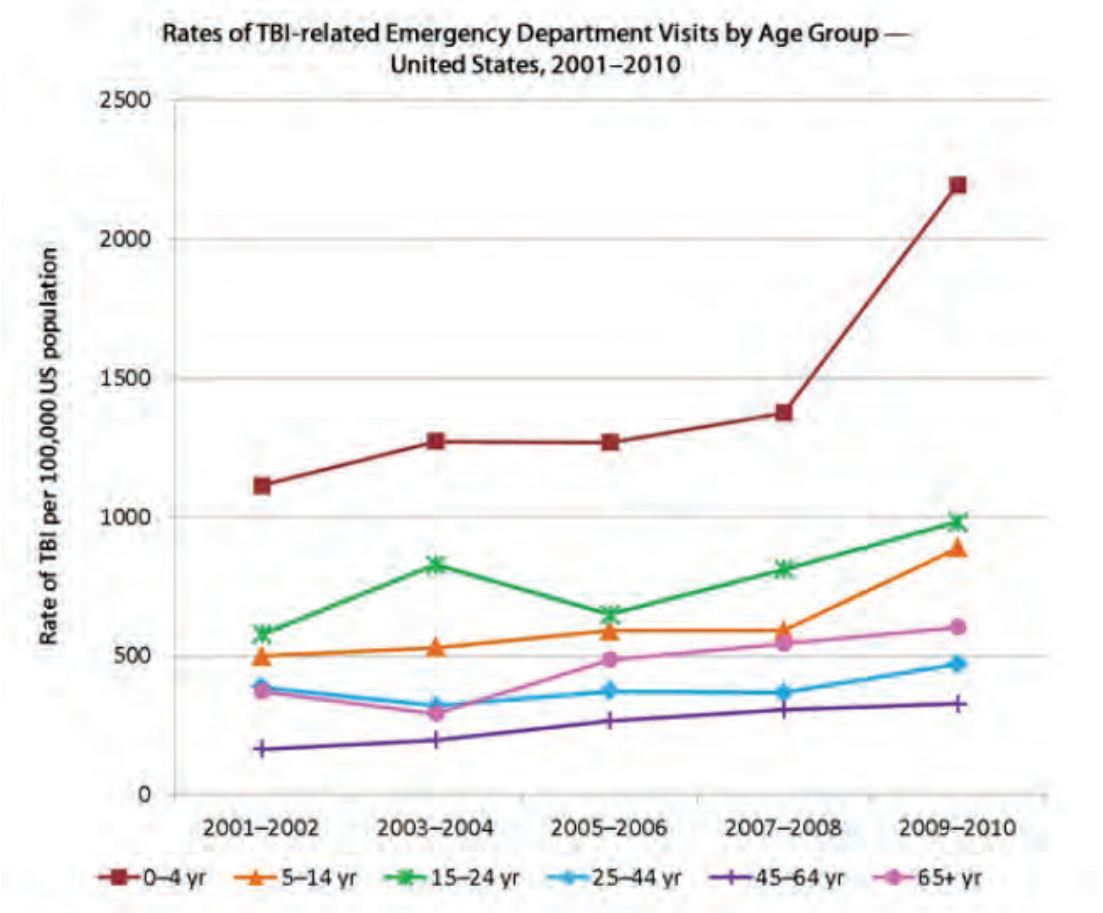
litigation in state and federal courts, against the National Football League, the National Collegiate Athletic Association, and the National Hockey League.

Though the focus of this task force is not limited to sports related concussions, the university student patient population has become more aware of the possibility of concussive injury. A leading cause of brain injury in patients ranging from 15 to 24 years of age, which includes the university student population, is motor vehicle trauma. An even higher number of brain injuries within this demographic are of unknown origin. This may result from the seasonally transient nature of this patient population, or these patients may be less likely to acknowledge or appreciate their injury. Brain injury related emergency department admissions for patients age 15 to 24 years is also on the rise. Therefore, depending on the area of the university institution and the resources available, local urgent care and emergency departments may benefit from university outreach that can help direct the patient back to the institution where resources for continued care, follow up, and academic accommodations are accessible.



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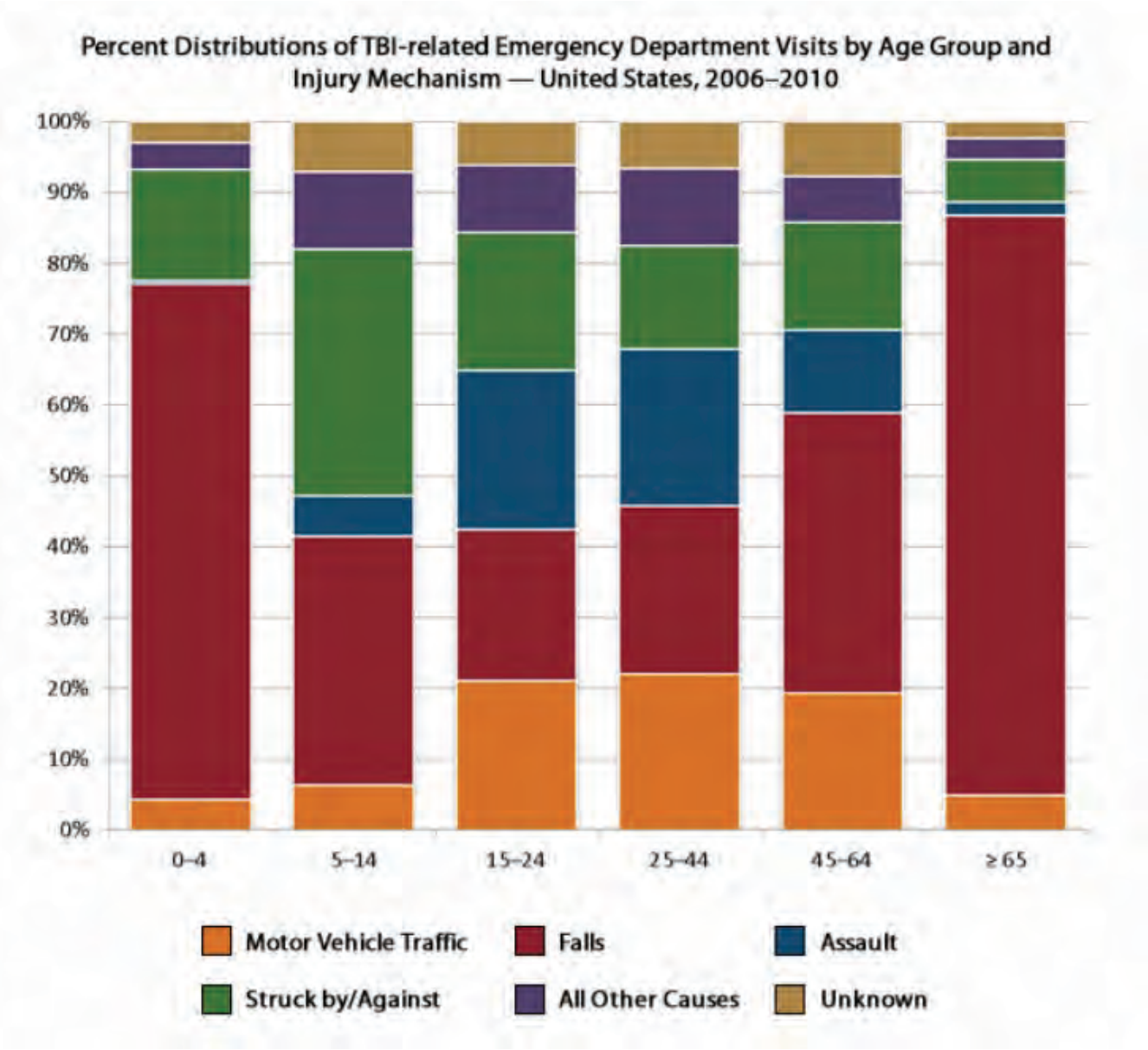

	Motor Vehicle Traffic	Falls	Assault	Struck by/Against	All Other Causes	Unknown
0–4	14,655	250,413	1,513	53,761	13,222	10,225
5–14	18,110	101,790	16,612	101,112	31,355	20,763
15–24	76,602	77,951	81,822	71,031	34,486	22,722
25–44	75,122	80,867	75,527	49,505	36,933	22,855
45–64	46,923	95,824	28,206	36,925	15,843	18,804
≥ 65	10,359	174,544	4,068	12,815	6,285	5,216

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Defining the Issue

There is presently no single consensus definition for a traumatic brain injury or its various manifestations. In fact, the NCAA estimates there are more than 42 consensus-based definitions of concussion. However, commonalities can be identified in many of these definitions, including those utilized by the Centers for Disease Control and Prevention and the National Collegiate Athletic Association.

The CDC defines a traumatic brain injury as, "a bump, blow, or jolt to the head that disrupts the normal function of the brain." The severity of this disruption may range from mild to severe. The most common type of traumatic brain injury is concussion. Concussion is a traumatic brain injury induced by biomechanical forces. Several common features that may be utilized in clinically defining the nature of a concussive head injury include:

- May be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head.
- Typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, signs and symptoms evolve over a number of minutes to hours.
- May result in neuropathological changes, but the acute clinical signs and symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies.
- Results in a range of clinical signs and symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive features typically follows a sequential course. However, in some cases symptoms may be prolonged.
- The clinical signs and symptoms cannot be explained by drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction, etc.) or other comorbidities (e.g., psychological factors or coexisting medical conditions).

The Berlin Report, which we will discuss in greater detail later in these recommendations, defines a sport related concussion as,

> "...a traumatic brain injury induced by biomechanical forces. Several common features that may be utilised in clinically defining the nature of a concussive head injury include:
>
> SRC may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head.
>
> SRC typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, signs and symptoms evolve over a number of minutes to hours.
>
> SRC may result in neuropathological changes, but the acute clinical signs and symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies.
>
> SRC results in a range of clinical signs and symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive features typically follows a sequential course. However, in some cases symptoms may be prolonged.

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The clinical signs and symptoms cannot be explained by drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction, etc) or other comorbidities (eg, psychological factors or coexisting medical conditions)."

A patient may also suffer a **sub-concussive impact** to the head, which does not result in those symptoms generally seen in a concussion (or any symptoms at all) and, therefore, does not result in a diagnosis of concussion. These events require greater study, as it is unclear what effect repeated but milder head impacts may have on a developing brain.

Post-concussion syndrome (PCS) refers to a set of lingering cognitive symptoms that manifest days after the initial head injury. Although these symptoms usually resolve within 3 months, they can persist longer. Patients whose symptoms persist for less than 3 months are referred to as having experienced post-concussion symptoms, while those with symptoms persisting for longer than 3 months are diagnosed with PCS.

The first step toward developing an effective treatment is to understand the pathophysiology and anatomical basis of the development of PCS and establish dependable biomarkers of the syndrome. Diagnosing PCS depends solely on clinical criteria, the judgment of the physician or healthcare professional, the patient's self-reporting of symptoms, and the diagnostic assessment selected. The severity of the concussion or traumatic brain injury plays no role in the likelihood of developing PCS.

No single treatment exists for post-concussion syndrome. Instead, an appropriate healthcare provider should treat the symptoms specific to the patient and, if applicable, refer the patient to a mental health provider for treatment of anxiety and depression, or cognitive rehabilitation for attention and memory issues.

On the most severe end of the spectrum of brain injury manifestations, **Chronic Traumatic Encephalopathy** (CTE) is a rare progressive neurodegenerative disease caused by total brain trauma, but is not limited to sports or recreation related activities with reported concussions. The incidence and prevalence is unknown, but the condition has been widely publicized in relation to the deaths of a number of professional athletes. Again, multiple consensus definitions are in use, but most agree CTE is the result of repetitive brain trauma. It is diagnosed only after death by distinctive immunoreactive stains of the brain for the Tau protein and is presently considered to be incurable.

To emphasize the evolving nature of this research, and the need for further scientific inquiry into this condition, a recent study evaluated the brains of deceased football players with CTE and compared those to the brains of individuals with Alzheimer's disease, and others that were not athletes. Those brains with CTE had significantly higher amounts of CCL11. CCL11 is a protein commonly associated with inflammation. Increased amounts of CCL11 are associated with age-related cognitive decline and appear to be significantly increased in subjects affected by CTE, as compared to those with Alzheimer's Disease. In addition, in this recent study of deceased football players, the longer they played, the higher the level of CCL11. This study may be a first step toward diagnosing CTE in living patients and, possibly, the discovery of treatments for the condition and its symptoms.

Typical signs and symptoms include a decline of recent memory and executive function, mood and behavioral disturbances (especially depression, impulsivity, aggressiveness, anger, irritability, suicidal behavior and eventual progression to dementia). However, initial signs and symptoms do not typically manifest until decades after the trauma is received (ages 40-50).

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Though unlikely to ever manifest in the university healthcare setting, CTE has been the source of great discourse and misunderstanding related to concussion. The possibility of CTE is one of many reasons institutional policies regarding waivers for all campus recreation, intramural sports, and sports clubs, and policies for retaining those waivers should be reviewed, as allegations of failure to warn of the risk or to provide education can arise decades later.

The Berlin Report

"The Berlin Report," formally known as the 2017 Concussion in Sport Group (CISG) consensus statement, is often referenced in the discussion of concussion and is intended to build on the four previously released consensus statements developed at the international conferences on concussion in sport. The Berlin Report was developed for healthcare providers involved in all levels of athlete care, and is intended to guide clinical practice while recognizing the science of sports-related concussion is evolving.

The Berlin Report also recognizes the research to date includes a relatively small number of studies, small sample sizes, and lack of consistency in study designs and methods. The future use of advanced neuroimaging, fluid biomarkers and genetic testing is anticipated to play a role in the greater understanding of the factors that influence the risk of concussion. Recommendations of the Berlin Report include: enrollment of larger sample sizes across all sports, particularly studies involving youth; and adoption of standard injury criteria, time frames for standard assessment, and multidimensional measures for outcome and recovery.

Defining the Participants

Outside of conference practice and competitions, sport-related injuries can occur in connection with club sports, intramural sports, and other activities in which students (residing on or off campus), staff, faculty, community members, visitors from other institutions, and others may participate.

Varsity sports at each of the FAH PSO universities include the most competitive and regulated sports on each campus. These are usually managed by the Athletics Association or Department on each campus, with dedicated team physicians, training facilities, and often, separate healthcare facilities for acute and even extended care of injuries. Varsity sports are also regulated, in part, by the policies and regulations of the NCAA. Among these regulations are required Concussion Safety Protocols. In January 2015, the NCAA initiated the Concussion Safety Protocol Review Process after the five Division I conferences passed concussion safety protocol legislation. The legislation required that each school submit a concussion safety protocol to the Concussion Safety Protocol Committee for review, consistent with the Interassociation Consensus: Diagnosis and Management of Sport-Related Concussion Best Practices. Several of our FAH PSO universities have submitted their concussion protocols to the NCAA. These consensus recommendations, however, are distinguished from those required for varsity sports. Of note, many of these varsity sports may have access to additional resources and technology that may prove useful to club sports, recreation, and intramural sports.

Club Sports are student-run organizations, often open to university students, faculty, staff and spouses of any skill level, which offer the opportunity to compete with other colleges throughout the state, region and nation. The Club Sports programs emphasize leadership, education and service and are often housed within the Department of Recreational

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Sports and funded with activities fees through Student Affairs. Each Club Sport may have its own national governing body, or a governing body that regulates several sports like the National Intramural Recreational Sports Association. At each institution, the Club Sport may be staffed and supervised by employees of the Department of Recreational Sports, including graduate and program assistants. They may monitor competitions and practice, and likely also ensure compliance with any applicable policies and serve to ensure safety. The Department of Recreational Sports may also employ Athletic Trainers for acute care, follow up care, or training advice. Athletic Trainers may be present for competitions if the sport is deemed a high or medium risk sport.

Intramural Sports are similar to Club Sports in the opportunities provided, but maintain a less structured format. The sports may be competitive or recreational and are inclusive of a wider range of participants that are often asked to purchase a limited recreational sports membership in order to participate.

Recreational Activities encompass a broad range of activities that take place on university property and/or are sponsored by the university. University students frequently engage in various recreational activities throughout their educational career, and these types of activities include, but are not limited to, community service, performing arts, advocacy, special interests, and networking events. These events are often supervised by the university faculty and staff, who monitor to ensure compliance with any applicable policies and safety standards. However, students engaging in these recreational activities seldom receive additional concussion education or medical supervision.

Measuring the Issue

There is presently no national systematic collection of traumatic brain injury data for non-scholarship athletes in the university setting. The largest and most comprehensive study of concussion in the university setting was launched in May 2014 in a joint initiative between the NCAA and the U.S. Department of Defense. This study, however, focuses on NCAA student athletes and military service members. The NCAA estimates that there are currently 480,000 student athletes and that this population has suffered an average of 10,500 concussions in the past five years. This study also estimated that between 1.6 million and 3.8 million recreation-related concussions occur annually nationwide.

By comparison, a total of approximately 293,000 students are enrolled in the participating FAH PSO universities. The National Intramural-Recreational Sports Association (NIRSA) estimates that 75% of students use on-campus recreation center facilities, programs, and services. This estimate translates to more than 200,000 students participating in on-campus recreation activities at the FAH PSO universities. Of those participants, 80% participate in campus recreations programs and/or activities at least once per week. Given these considerable concussion figures for scholarship athletes, and the exposure of non-scholarship athletes to risk prone activities, it is likely that a number of non-scholarship athletes on our university campuses have suffered concussions or sub-concussive injuries that have gone undetected and untreated. In fact, NIRSA has recently created a Concussion Advisory Council and has surveyed its membership on current practices in concussion assessment, awareness, and return-to-play policies.

It is recommended that a central registry be established identifying those patients that are at risk of traumatic brain injury and the stakeholders responsible for those activities. In fact, a number of studies have recommended that the CDC place a high priority on developing state-based data systems that can help link people with TBI to much needed

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information and services. However, for purposes of these recommendations, the creation of a central registry of patients with any form of traumatic brain injury at FAH PSO participating universities would enhance the development of TBI research and corresponding programs for all Florida academic institutions. For example, the Florida Brain and Spinal Cord Injury Program (FBSCIP) supports a TBI and Spinal Cord Injury (SCI) registry that identifies moderately to severely injured people with TBI while they are still in the hospital. The program focuses on case management to facilitate coordination and payment for rehabilitation services needed for their return to the community. A similar registry for university settings may assist in gathering data for further TBI research as well as for the request of additional resources to educate those experiencing symptoms and provide timely referrals to federal, state, and community resources.

It is further recommended that each institution track the number and severity of traumatic brain injuries reported by University patients. Information regarding the location where the traumatic brain injury was suffered as well as the activity in which the patient was participating, if consistently gathered, may be documented. The retention of this data may be beneficial not only to the distribution of resources within Student Health Services, but may also assist risk management and insurance services with the identification of vulnerable areas that may benefit from further education or process changes.

Ideally, a centralized database collecting information on concussion injury will emerge. A standardized minimum assessment for concussion injury and a template common format for the documentation of this assessment is a next step. This will allow for benchmarking amongst the university participants, with the hope that such a centralized database may be adopted by other universities nationwide and serve to improve concussion recognition and care for all students. This may be accomplished through the identification of a “champion” or opinion leader at each campus that is accepted by the university community, and can serve as a resource and recipient of campus-wide information, thereby creating the nexus for traumatic brain injury information. University “champions” may include:

- Dean’s Office
- Student Health
- Housing and Residence Coordinators
- Campus Recreation
- Intramural Sports
- Sports Clubs
- University Risk Managers
- University General Counsel
- Professional Liability Insurance Entities

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Consideration should be given to the creation of a committee of directors or designees of each of these areas in order to develop a network of educational resources and ensure that, for example, Campus Recreation has access to the most current evidence-based research on the identification and management of traumatic brain injury. In addition, establishing a network that includes the Dean's Office may assist in obtaining referrals to Student Health through academic sources and also develop traumatic brain injury education geared toward academic counseling.

Further, relationships with local urgent care and emergency healthcare facilities are important. Brain injury related admissions for patients age 15 to 24 years to the emergency department is on the rise. Therefore, depending on the area of the institution and the resources available, local urgent care and emergency facilities may benefit from university outreach that can help direct the patient back to the institution where those resources exist. This would also assist in encouraging continuity of care.

The Berlin Report relies greatly on expert consensus and calls for the collection of additional data and research. Standardization of evaluations across the university setting will allow for greater and better collection of data. The wealth of data available in the Florida university setting will allow for the collection of standardized data in the years to come and will serve to inform long term studies of this population. There is currently no national systematic collection of data for non-scholarship athletes in the university setting.

Risk Stratification

Though we tend to think of football or soccer as having an increased risk of traumatic brain injury, a number of other non-contact recreational activities, like swimming, present a risk. Each university may consider creating a document containing all of the activities on campus, likely those conducted through Student Affairs, the number of students participating in each, and a risk stratification for reach of those activities based on the risk for traumatic brain injury. This would assist with the provision of resources and concussion education.

In one recent study of sports related concussion, the NCAA Injury Surveillance Program gathered data during the 2009-2010 to 2013-2014 academic years and analyzed the incidence of concussion in specific sports. The estimated number of nationally reported sports related concussions has increased within specific sports. However, it is unknown whether these increases are attributable to increased reporting or frequency of concussions. Many sports report more sports related concussions in practice than in competition, although competition rates are higher.

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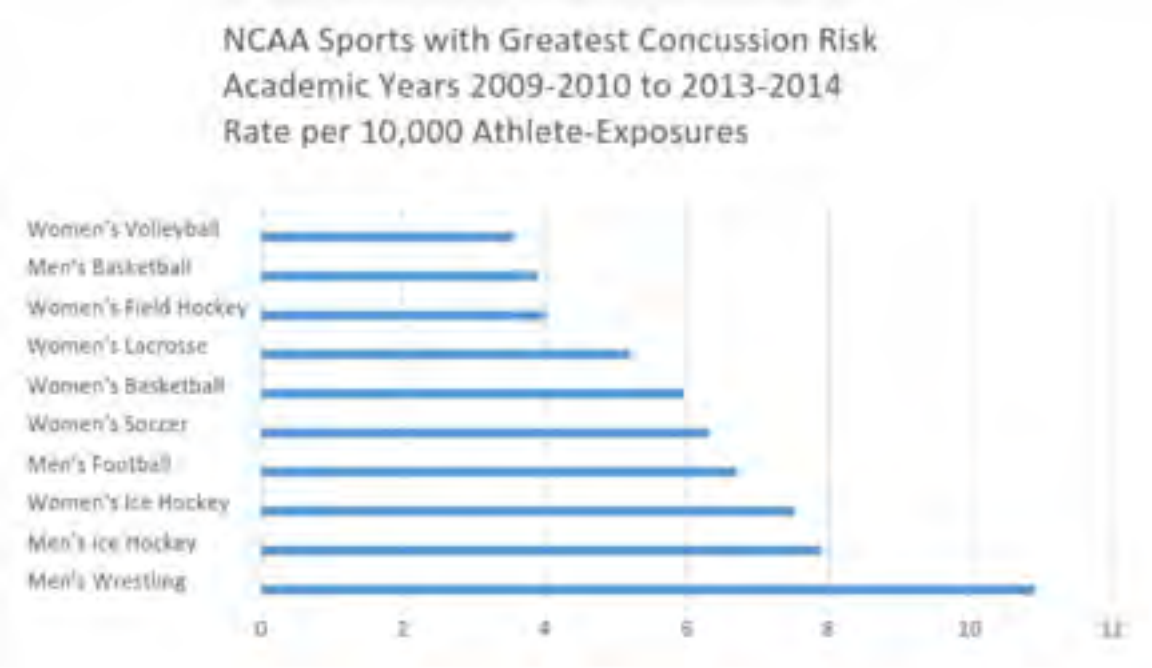

With this information and the use of subject matter experts like coaches, athletic trainers, sports medicine physicians, an initial risk stratification of university sports and recreations can be created until additional data can be gathered. The use of this risk stratification tool can direct the use of sports specific concussion waivers and education to participants.

Measuring Concussion in the Student Health Setting

Institutions with more robust Sports Medicine involvement, whether they have healthcare providers specializing in this area of medicine or are caring for athletes in the Student Health setting, may have access to additional resources in the treatment of potentially concussive injuries. However, it is important to establish a standardized assessment tool for all providers, regardless of location or resources, and particularly for those that offer primary care and do not regularly evaluate or treat patients with concussive symptoms.

Concussion identification and management can often begin long before the patient arrives at Student Health. For example, with the participation of Athletic Trainers at Intramural Sports and Club Sports activities, or event those where there is student administrator or program assistant, there is an opportunity to recognize the possibility of concussion and immediately remove the participant from play. This intervention can reduce the risk of further injury, including suffering another impact. There are a number of concussion checklists available from reliable resources such as the American Academy of Neurology and the Centers for Disease Control.

Scope of the Issue

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The **Concussion Recognition Tool 5 (CRT5)** is one such tool for standardized assessment of a potentially concussive injury. This most recent revision of the Pocket Sport Concussion Assessment Tool 2, endorsed by the Berlin Report, was initially introduced by the Concussion in Sport Group in 2005. The CRT5 is designed to assist non-medically trained individuals to recognize the signs and symptoms of possible sport-related concussion and provides guidance for removing an athlete from play or sport and to seek medical attention. Healthcare providers are often not present at a majority of events which may result in brain injury, particularly recreational sports. This tool may be especially beneficial for those patients who suffer an injury while participating in university endorsed activities, given that education may be provided to the coordinators or supervisors of the event through Student Affairs. There has been very little research conducted on the utility of this tool in detecting brain injury, but may be useful to laymen in performing an initial assessment and referring to a healthcare provider for a full assessment. It is the stated goal of the authors that it be disseminated with the goal of fostering research to determine its utility.

The **Sport Concussion Assessment Tool, 5th Edition (SCAT5)** is a standardized tool for evaluating concussions designed for use by physicians and licensed healthcare professionals. If the evaluator of the potential concussion is not a physician or licensed healthcare professional, a more appropriate evaluation tool for use is the CRT5 referenced above. It should be noted that the SCAT5 is to be used for evaluating patients aged 13 years and older and that for children aged 12 years or younger, the Child SCAT5 should be used.

Use of the SCAT5, and its recommended assessments, in this practice setting is recommended by this task force as a minimum standard of evaluation of concussive symptoms by a healthcare provider. However, the SCAT5 is an assessment that is limited to approximately the first 3 to 5 days following a concussion. Therefore, there are limitations in relying solely on the SCAT5 for a thorough patient assessment. Should the patient's concussion symptoms continue and evolve past this time period, a different level of assessment and involvement may be necessary and is dependent upon the evaluation and clinical judgment of the health care provider treating that patient.

It is recognized that cognitive baseline tests may be highly variable, and therefore, can be altered by a number of factors. They may be but one of the tools utilized by the healthcare provider who will continue to care for them. These tools are utilized to inform the neurological exam and the clinical diagnosis made by the healthcare provider.

Scope of the Issue
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Screening for Acute Concussion

The diagnosis of a concussion is a clinical diagnosis based on the healthcare providers' evaluation of the patient's history and physical examination. Although different screening tools may be used to evaluate a patient with a suspected concussion, there is no single screening tool that may provide a conclusive concussion diagnosis.

Generally, physicians with expertise in concussion will not be present when the student suffers a concussion, and the initial assessment of an injured student will be performed, if at all, by a non-healthcare provider with little to no experience with concussion. Use of screening tools, like the CRT5, will assist non-healthcare providers in forming an initial opinion on the severity of the injury suffered and will increase the likelihood of having those patients referred to a healthcare provider for conclusive evaluation and treatment. Healthcare providers are formally trained to perform neurologic and general medical assessments and to recognize the signs and symptoms of concussion and traumatic brain injury.

Along with the use of the SCAT5, healthcare providers will also evaluate the patient for some or all of the following, depending on the patient's presentation:

- **Review history for prior TBI**
- **Review for history of headaches**
- **Developmental history i.e. learning disabilities, ADHD, etc.**
- **Psychiatric history, i.e. anxiety, depression, sleep disorders, etc.**

No specific imaging parameters are currently recommended to aid in diagnosis of a concussion. If a patient presents with loss of consciousness, persistent vomiting and/or an abnormal neurological exam, referral to the emergency department for emergent evaluation and CT scan may be warranted. CT scans can diagnose acute issues such as edema and hematomas which would require urgent treatment.

A patient who has experienced a traumatic brain injury may not exhibit clinical symptoms of that injury, and any existing clinical symptoms may not be due to traumatic brain injury. Traumatic brain injury, including concussion, is not focal but a network injury that may affect different areas of the brain differently and with varying effects among individuals with the same type and intensity of injury.

Discharge instructions and documentation typically includes a statement that the patient has the capacity to safely transfer themselves home and that the healthcare provider has offered to explore transportation alternatives should they lack capacity. If the patient lacks capacity to transfer themselves safely home, the healthcare provider should document the manner of transfer and with whom. Consideration should be given to providing widely accepted concussion education materials and documenting the provision of this information to the patient.

Scope of the Issue

(continued)

Follow Up of Diagnosed Concussion

Per the Berlin report, the SCAT5 currently represents the "most well-established and rigorously developed instrument available" for assessment. It is most useful immediately after an injury, but appears to decrease in utility 3 to 5 days after the initial injury. The symptom checklist remains useful in tracking the patient's recovery. Baseline testing is not necessary, but serial testing may be useful if those same conditions can be recreated by the same healthcare provider. This is ultimately only one of many tools to be utilized by the healthcare provider that will be caring for the patient to inform their diagnosis and tracking of the patient's condition.

Where there is a diagnosis of concussion, the patient is encouraged to return to Student Health Services, to that same provider whenever possible, in 1 week and every following week until they are symptom free. If symptoms persist or worsen, based on the healthcare provider's clinical evaluation, the patient may be referred for additional neuropsychological assessments. The healthcare provider may also consider involving the sport and other activities in the evaluation. Due consideration is given to "unplugged syndrome" (encouraging the patient to disconnect from mobile and electronic devices), or cognitive rest, and the worsening of the patient's concussive symptoms by failing to take part in any activity. Because the use of electronic devices can be visually taxing and provoke those symptoms associated with concussion, health care providers may recommend limiting time and exposure on these devices. It is unlikely that patients will adhere to a complete restriction of the use of electronic devices. Therefore, instead of recommending complete restriction of their electronic devices, the discussion with the patient should seek to decrease their use of the electronic devices. If there is any increase in symptoms while using the electronic devices, then the patient should be advised to discontinue use immediately.

It should also be noted that often the physical recovery of the patient following a concussion occurs at a faster rate than the cognitive recovery. This may depend on the type and severity of the injury, as well as a number of underlying factors related to the health of the patient prior to suffering the concussion. Therefore, the follow up evaluations remain multifactorial and the patient should not be released to all activities if symptoms and corresponding limitations persist for physical or cognitive recovery.

If the patient's cognitive or neurocognitive symptoms persist after three weeks, then the patient is often referred to a neuropsychologist where available. If, however, after two weeks the patient has evidenced and continues to have significant deficits, then the patient may be referred to a neuropsychologist sooner to address possible learning deficit strategies. There may also be other domains that would require referral of the patient. For example, referral for ocular, motor, or cervical domains of care and expertise may be provided through resources in the community or within your own university health system. Though likely to have already developed these resources and referrals, these should be re-examined, re-developed, and encouraged in anticipation of future need. There are also concussion centers that may provide assistance to other universities without those resources.

Scope of the Issue
(continued)

Return to Play and Return to Learn

Following a concussion, symptoms may be associated with ongoing cognitive dysfunction and slowed reaction time. This cognitive delay may result in not only a decreased ability to play safely and successfully, but may also place the patient at greater risk of additional injury or concussion. In order to reduce the risk of a subsequent injury, healthcare providers and those non-healthcare providers that may be supervising students, prohibit them from returning to play (which is defined as including practice, actual competition, or any other activity with risk of contact injury) until a healthcare provider has deemed the concussion to have resolved. Because the determination that a concussion has resolved is a clinical determination, based on a healthcare provider's neurologic and cognitive assessment of the patient, a non-healthcare provider does not make the determination as to whether the patient is cleared to return to play. A clinical determination of clearance to return to play should be performed by a qualified healthcare provider, which includes a medical doctor or doctor of osteopathic medicine with knowledge of the concussion after appropriate consults are considered, at the discretion of the qualified healthcare provider. The healthcare provider may also consider a neuropsychological evaluation, for supplemental evaluation, prior to the return to play if, for example, the patient continues to have persistent (over 7 days) concussion symptoms.

There is presently limited data regarding implementation of a graded physical activity program designed to assist with recovery from a concussion. Although rest is recommended in most consensus statements, and is a widely utilized intervention, there is insufficient evidence to show that complete rest will promote recovery. Preliminary evidence suggests that following rest during the acute phase following a concussion, a staged return to moderate activity, while remaining below that patient's thresholds for cognitive and physical activity, is possibly associated with normalizing of physical, cognitive, and academic function. Despite the lack of concrete evidence supporting a graduated return to sport, it is generally accepted that engaging in any activity that exacerbates underlying symptoms or cognitive impairments be avoided.

Table 1 Graduated return-to-sport (RTS) strategy

Stage	Aim	Activity	Goal of each step
1	Symptom-limited activity	Daily activities that do not provoke symptoms	Gradual reintroduction of work/school activities
2	Light aerobic exercise	Walking or stationary cycling at slow to medium pace. No resistance training	Increase heart rate
3	Sport-specific exercise	Running or skating drills. No head impact activities	Add movement
4	Non-contact training drills	Harder training drills, eg, passing drills. May start progressive resistance training	Exercise, coordination and increased thinking
5	Full contact practice	Following medical clearance, participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6	Return to sport	Normal game play	

NOTE: An initial period of 24–48 hours of both relative physical rest and cognitive rest is recommended before beginning the RTS progression.
There should be at least 24 hours (or longer) for each step of the progression. If any symptoms worsen during exercise, the athlete should go back to the previous step.
Resistance training should be added only in the later stages (stage 3 or 4 at the earliest). If symptoms are persistent (eg, more than 10–14 days in adults or more than 1 month in children), the athlete should be referred to a healthcare professional who is an expert in the management of concussion.

Scope of the Issue
(continued)

In addition, each University may consider making evaluation and medical release by a healthcare provider a condition of return to play with Campus Recreation, Intramural Sports, and Sports Clubs. Such language may also be incorporated into the waiver executed by each student prior to taking part in these activities.

Return to learn may involve a number of accommodations recommended by the healthcare provider following their continued examination and follow up with the patient, and in conjunction with their academic department or advisors. In particularly severe or persistent cases of traumatic brain injury, the healthcare provider may recommend and provide documentation for a "Medical Drop" of some classes in order to decrease the burden on the patient.

Table 2 Graduated return-to-school strategy

Stage	Aim	Activity	Goal of each step
1	Daily activities at home that do not give the child symptoms	Typical activities of the child during the day as long as they do not increase symptoms (eg, reading, texting, screen time). Start with 5–15 min at a time and gradually build up	Gradual return to typical activities
2	School activities	Homework, reading or other cognitive activities outside of the classroom	Increase tolerance to cognitive work
3	Return to school part-time	Gradual introduction of schoolwork. May need to start with a partial school day or with increased breaks during the day	Increase academic activities
4	Return to school full time	Gradually progress school activities until a full day can be tolerated	Return to full academic activities and catch up on missed work

Return to Learn Accommodations

- Permission to attend and observe class without active participation
- Extensions on assignments
- Permission to leave class briefly on occasion
- Preferential seating if necessary
- Option of rescheduling exams if multiple exams are scheduled on one day
- Option of rescheduling exams held at night
- Option of written instructions in place of oral instructions
- Extended time for quizzes and exams
- Distraction-reduced exam space
- Dropping classes

The decision to have a patient return to academic endeavors may include coordination among a multidisciplinary team which may include student health services, the dean's office, and academic counseling, among others.

Scope of the Issue
(continued)

Multidisciplinary Team for Return to Learn

- Student Health Services Healthcare Providers
- Psychologist/Mental Health Counselor
- Academic Counselors
- Course Instructor
- Dean of Students
- Office of Disability Services

At these follow up appointments, the healthcare provider may reassess the patient's ability to return to learn and/or return to play until such time as the healthcare provider has deemed these symptoms to have resolved completely. Because traumatic brain injury is unique to each patient, and resulting neurological injury may result in a wide spectrum of clinical symptoms, the restrictions placed on the patient remain at the sole discretion of the healthcare provider. These restrictions may involve graduated exertion for both return to learn and/or return to play as in some cases, the patient may not evidence clinical symptoms for several days.

Use and Return of Waivers

A waiver is a contract in this case, between the student and the institution. The waiver allows the student to release the institution from liability even if there is some finding of negligence by a third party. As a contract, there must be the exchange of something of value. The student is releasing the institution from liability for the benefit and privilege of being permitted to participate in Campus Recreation, Intramural Sports, and/or Sports Clubs. In most states, courts will uphold a waiver agreement provided that the waiver is properly constructed and is not in violation of any public policy. Most states demand that the language used in the waiver is clear and unambiguous as to its intent. The intent in this instance is to ensure that the student taking part in the activities is aware of the risks associated with the sports and that they will release the institution from any liability should they become injured. The purpose of these requirements is to ensure the waiver agreement is easy to read and comprehend so that the individual signing the waiver is given explicit notice of the rights they are forfeiting in exchange for their participation.

These waivers include language stating that participation in these activities is entirely voluntary. The waiver sets forth the acknowledgment that these activities intrinsically involve risks of physical injury greater than those encountered in daily life, and by taking part in these activities, participants acknowledge and assume the risks inherent therein. Further, waivers often have notice and acknowledgment that the institution does not carry accident or injury insurance to cover the participants of those activities. Institutions often utilize the same waiver agreement or waiver language for activities that take place in Campus Recreation, Intramural Sports, and Sports Clubs to allow for consistency and ease of use.

Once a determination is made regarding which activities will require a waiver, education occurs for those who are supervising the activities regarding the need for the waiver, and appropriate routing and retention. For example, it is recommended that if there is a regular orientation of those who are coaching or supervising activities, that processes

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(continued)

and education be made part of their formal orientation. This often includes a general overview of concussions, signs and symptoms to be cognizant of, and when to involve urgent or emergent medical services. If at all possible, an electronic format with electronic signatures assists with obtaining and retaining waivers, and remove entirely the need for paper records. Depending on the structure of the institution, the collection and retention of the waivers may be performed through the office of the Dean of Students or the Athletic Department, depending on whether the activities being discussed reside under the Campus Recreation, Intramural Sports, or Sports Clubs departments.

After the waiver agreements are collected, it is recommended that institutions store the waivers consistent with state laws. Given that a patient's seemingly related symptoms may manifest or be acknowledged years or even decades later, ideally any executed waivers should be retained indefinitely. Many universities and schools assign their risk management department with the task of managing all waiver agreements, including athletic waivers. This can be highly effective, however, not all institutions have risk management departments dedicated to this function or to athletic departments or campus recreation, for example. To maintain the efficient collection and processing of waiver agreements, institutions may decide to commit administrative staff and support to manage the waiver process.
A number of computer programs and applications currently exist to manage the collection and retention of these waivers. Institutions have many options available to them for the storage of waiver agreements. If the institutions wish to maintain the waivers electronically, they may decide to keep the waivers indefinitely. This approach is most effective in combating claims that may extend well past the statutory time limit to bring claims against the institutions. Schools must assess their records management system's effectiveness and capacity, and make balanced risk choice accordingly. Waiver agreements, if correctly constructed and properly stored, have the potential to be very useful in litigation.

Scope of the Issue
(continued)

Additional Waiver Considerations

Though each institution should consider utilizing the same waiver agreement or waiver language for activities that take place in the areas of Campus Recreation, Intramural Sports, and Sports Clubs to allow for consistency and ease of use, some consideration should be given to the creation of sport or activity specific waivers. Depending on the types of activities involved, and the ability to track a number of different waivers, the institution's counsel may prefer to have individual waivers for specific activities, to include the specific risks of that activity. For example, if there is a club that involves water sports, consideration should be given to including the risk of drowning. Or, depending on the weather of a specific region, there may be additional risks. For example, for those outside activities taking place in the heat of summer of Florida, the risk of heat stroke may be included. Institutions may also consider requiring its participants to complete an additional waiver if they have a pre-existing serious health condition, or develop a health condition or serious injury during their participation that may place them at a greater risk for serious health injury.

Pre-Participation Education

The use of pre-participation of education and waivers will serve to educate and inform students of the risks they are assuming in electing to participate in these activities, but more importantly, will also educate the student as to the symptoms of concussion leading to earlier identification and treatment of those symptoms. The implementation of pre-participation education and waivers will also serve to inform and educate non-healthcare providers on the risks associated with these activities and provide them with a tools to identify a possible concussion and promptly refer the student to a healthcare provider. School-based professionals who are non-healthcare providers should be educated by experienced healthcare professionals designated by each institution, prior to their supervision of these activities, so that they may also understand the signs and symptoms of a concussion so that they may provide accurate information to students and provide a timely referral when appropriate.

Recently, there has been a growing trend to increase the educational resources available to individuals who wish to engage in athletics. The focus of much of this literature is on actively avoiding, recognizing, and treating potential brain injuries in youth and young adults. Various athletic groups, like the NCAA, distribute sport-specific posters that provide key information to further reduce the likelihood of an injury and how to recognize when an injury has occurred. Institutions affiliated with the NCAA distribute fact sheets to student-athletes and coaches prior to the start of the season to further increase awareness on sport-specific injuries.

Moreover, one of the major groups advocating awareness and recognition of concussion and other serious brain injuries that may occur during sports is the Centers for Disease Control through their program Heads Up. Heads Up is a series of educational initiatives designed by the CDC to increase awareness, recognition, prevention, and responsiveness to a serious brain injury. The CDC hopes that through this campaign they can better safeguard youth and young adults from significant head trauma that may occur as a result of playing sports. With all of these educational efforts taking place with a strong emphasis on improving brain injury treatment and prevention, it can be valuable to incorporate information about the institution's own concussion management plan into general educational materials and programs.

The decision to provide concussion education and counseling may be based on a risk stratification of the activities offered by Campus Recreation, Intramural Sports, and Sports Clubs. For example, team contact sports such as football, wrestling, lacrosse, and soccer have a greater concussion risk than other non-contact sports. A risk stratification of these activities may help allocate resources and education to those areas that have the greater need, as well as to those students and those non-healthcare providers who may be supervising their activities.

Scope of the Issue

(continued)

Injury Report Forms

Consideration should also be given to the creation and use of an injury report form. If for example, a participant is injured during Club Sports or Intramural Sports activities, and certainly if receiving acute care or evaluation by an Athletic Trainer in that context, one may consider completing an injury report form documenting the injury, that care or an evaluation was administered, and noting that the injured participant has been referred to a physician for continuing care, when indicated. For any injury, but particularly when a concussion is suspected, there should be some statement regarding the participant's assumption of responsibility for future injury should they elect to continue their participation. Each university may offer to provide a copy of this injury report form to the participant to provide to their healthcare provider for continuity of care. In addition, if the participant is provided care by an Athletic Trainer or other healthcare provider on the field, there ideally may be a system for documenting this healthcare into a medical record system, which will also assist with continuity of care and appropriate referral. Any such injury report should also contain a statement making that participant responsible for ensuring that they have been cleared to return to play by a qualified healthcare professional before resuming participation in any of the sports or recreational activities. Depending on the type and breadth of services provided, the creation of an injury report form may be impractical or difficult to implement and be accompanied by a host of logistical issues. Without a unified supervisory system for Athletic Trainers that allows standardized reporting that is also monitored by entity that oversees the Athletic Trainers, appropriate reporting and follow up will be difficult to accomplish.

Scope of the Issue
(continued)

Implementing the Plan

The concussion management plan is intended to serve as a tool for groups and organizations in the course of installing or operating their plan. However, the work of this team does not end with development of the written plan or protocol. Managing the implementation of this plan is just as critical to the success of the plan and of optimal care for our university students. There are various issues and areas that a committee may want to address specifically when crafting a concussion management plan or protocol. For instance, the following questions may assist the evolution of the concussion management plan:

- **Is there "off-the-shelf" training already available, or is there a customized training regimen that is better suited to fit our needs?**
- **Is there a need to develop institution-specific training?**
- **How will the training information and practices be delivered to our student, and what platforms will be best utilized to deliver such information?**
- **When will training be delivered?**
- **If there will be "face-to-face" training, what process will be used to identify or develop quality trainers?**
- **Are there types of training that are mandatory for student-athletes, and are there types of training that are auxiliary?**

While committees consider the numerous needs for their student athletes, it is important to distinguish that no concussion management plan is perfect. Each plan should be tailored to the specific institutions they serve and address the different issues each encounters. Development of a plan or protocol must take special note of any part of the plan that involves "hand-offs" between different departments or units. These "hand-offs" can be the source of several problems, and one of the many reasons why there exists the need for a clear line of authority. For example, and as previously referenced with regard to Athletic Trainers, the organizational structure of responsible departments may vary by institution, and information may not easily be shared. While this authority can rest with one individual or be a collaborative effort, it is imperative that the authority for decision-making is understood in order to reduce any possibility of ambiguities. Organizations may want to consider adding concussion management to the job descriptions of coaches, athletic trainers and other relevant personnel who are in frequent contact with the students in order to cast a wide net in identifying and responding to concussions.

Along with a distinguished source of authority, the implementation of an effective concussion management plan requires efficient communication, accountability, and encouragement from all parties involved. This strategy differs from training in that the content is more general and disseminated more widely. There may be some desire to have certain communications targeted to specific audiences to support active reporting of symptoms, such as:

- Students
- Coaches
- Families of the students
- Athletic trainers
- Athletic medical staff
- Student health services
- Team Captains
- Faculty
- Disability services
- Administrators

Scope of the Issue
(continued)

Improved Communication Ideas

For an improved chain of communication regarding injuries, consider a checklist for suspicion of concussion by Athletic Trainer following an activity that utilizes the player roster. A quick review of the roster where there is no injury will not trigger any care. However, it may help to serve as a reminder that there was a possible injury and trigger further care by the MD or DO.

The Florida Academic Healthcare Patient Safety Organization is committed to patient safety and quality improvements, made possible by the members of the PSO and for the benefit of the patients. Through continued collaboration of subject matter experts and sharing of lessons learned by our healthcare providers, we hope to move toward a consensus that continuously improves the service to patients.

Resources

TRAUMATIC BRAIN INJURY

National Collegiate Athletic Association (NCAA):

ncaa.org/about/resources/media-center/news/ncaa-dod-launch-concussion-study

ncaa.org/health-and-safety/medical-conditions/concussion

ncaa.org/sites/default/files/SSI_ConcussionProtocolCheckList_20180213.pdf

American Academy of Neurology:

aan.com/practice/sports-concussion-toolkit

Congressionally Directed Medical Research Programs (CDMRP): http://cdmrp.army.mil

NIH National Institute for Neurological Disorders and Stroke (NINDS):

Traumatic Brain Injury Information: ninds.nih.gov/disorders/tbi/tbi.htm

Brain Trauma Foundation: braintrauma.org

National Neurotrauma Society: neurotraumasociety.org

Center for Disease Control and Prevention (CDC), HEADS UP Program:

cdc.gov/headsup/index.html

Traumatic Brain Injury: http://www.medicine.iu.edu/research/areas-of-expertise/traumatic-brain-injury

CDC Injury Prevention & Control: Traumatic Brain Injury:

cdc.gov/traumaticbraininjury/basics.html

Vestibular/Ocular-Motor Screening (VOMS) for Concussion:

physiotherapyalberta.ca/files/vomstool.pdf

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http://www.ncaa.org/sport-science-institute/topics/care-consortium

http://www.ncaa.org/sport-science-institute/topics/mind-matters-challenge

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https://www.cdc.gov/traumaticbraininjury/data/rates_ed_byage.html

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https://www.cdc.gov/headsup/basics/concussion_whatis.html

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Role of advanced neuroimaging, fluid biomarkers and genetic testing in the assessment of sport-related concussion: a systematic review

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ABSTRACT

Objective To conduct a systematic review of published literature on advanced neuroimaging, fluid biomarkers and genetic testing in the assessment of sport-related concussion (SRC).

Data sources Computerised searches of Medline, PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycINFO, Scopus and Cochrane Library from 1 January 2000 to 31 December 2016 were done. There were 3222 articles identified.

Study selection In addition to medical subject heading terms, a study was included if (1) published in English, (2) represented original research, (3) involved human research, (4) pertained to SRC and (5) involved data from neuroimaging, fluid biomarkers or genetic testing collected within 6 months of injury. Ninety-eight studies qualified for review (76 neuroimaging, 16 biomarkers and 6 genetic testing).

Data extraction Separate reviews were conducted for neuroimaging, biomarkers and genetic testing. A standardised data extraction tool was used to document study design, population, tests employed and key findings. Reviewers used a modified quality assessment of studies of diagnostic accuracy studies (QUADAS-2) tool to rate the risk of bias, and a modified Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system to rate the overall level of evidence for each search.

Data synthesis Results from the three respective reviews are compiled in separate tables and an interpretive summary of the findings is provided.

Conclusions Advanced neuroimaging, fluid biomarkers and genetic testing are important research tools, but require further validation to determine their ultimate clinical utility in the evaluation of SRC. Future research efforts should address current gaps that limit clinical translation. Ultimately, research on neurobiological and genetic aspects of SRC is predicted to have major translational significance to evidence-based approaches to clinical management of SRC, much like applied clinical research has had over the past 20 years.

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INTRODUCTION

Over the past decade, there has been major progress in the methods for evaluation of sport-related concussion (SRC) and in determining the natural history of *clinical* recovery after injury.[1–4] Critical questions remain, however, about the acute *neurobiological* effects of SRC on brain structure and function, and the eventual time course of *physiological recovery* after injury.

Studies using advanced neuroimaging techniques have demonstrated that concussion is associated with metabolic and physiological changes in the brain, which correlate with postconcussive symptoms and performance on neurocognitive testing during the acute postinjury phase.[5–12] In parallel, the assessment of novel and selective blood biomarkers and genetic testing for traumatic brain injury (TBI) has rapidly expanded, but with limited application to the study of SRC. Extending from the broader TBI literature, there is also increasing interest in the role of genetics in predicting risk of injury, prolonged recovery and long-term neurological health problems associated with SRC and repetitive head impact exposure in athletes.[13]

Clinically, there is a need for diagnostic biomarkers as a more objective means to assess the presence/severity of concussion in athletes. Beyond the potential diagnostic utility, there is also keen interest in the development of prognostic biomarkers of recovery after SRC. Emerging data suggest that physiological abnormalities may persist beyond the typical window of clinical recovery after mild traumatic brain injury (mTBI), which raises concerns about risks associated with repeat injury during the acute recovery phase.[14 15] Most concerning is that a *window of cerebral vulnerability* may extend beyond the point of clinical recovery, when the brain remains physiologically compromised and athletes are at heightened risk of repetitive injury. Imaging and blood biomarkers that reliably reflect the extent of neuronal, axonal and glial damage and/or microscopic pathology could conceivably diagnose and predict clinical recovery outcome after SRC.

We conducted a systematic review of the existing literature on the utility of advanced imaging, fluid biomarkers and genetic testing in the assessment of SRC.

METHODS

Systematic review methodology[16] was employed to address the following core questions for the 5th International Consensus Conference on Concussion in Sport:

- *What advanced or novel tests can assist in the assessment of SRC?*
- *What is the role for advanced neuroimaging?*
- *What is the role for cerebral spinal fluid (CSF), blood, and urine and saliva biomarkers?*
- *What is the role for genetic or epigenetic testing?*

Table 1 Medical subject heading terms and key words used for electronic database searches

	(Concussion OR concuss* OR brain injuries OR head injuries OR ((head OR brain) AND injur*) OR Post-Concussion Syndrome OR postconcussion* OR Mild traumatic brain injury OR MTBI OR acquired brain injury OR blunt head trauma OR Craniocerebral Trauma OR (('mild traumatic' OR acquired) AND brain injur*)) AND (athletes OR sports OR sport OR sporting OR athleti* OR athlete* OR recreation OR recreat* OR baseball OR bicycling OR boxing OR cycling OR diving OR equestrian OR equine OR football OR Head Protective Devices OR helmet* OR hockey OR lacrosse OR martial arts OR karate OR judo OR tae kwon do OR aikido OR mountaineering OR racquet sports OR rugby OR skating OR skiing OR snow sports OR soccer OR wrestling)		
Head injury and relevant sports.	**Neuroimaging search**	**Biomarkers search**	**Genetics search**
Advanced or novel tests	(Neuroimaging OR radiological OR neuroradiological OR brain imaging OR Positron-Emission Tomography OR ((PET OR MRI) AND (scan OR scans)) OR Magnetic Resonance Imaging OR ((structural OR Functional) AND MRI) OR spectroscopy OR Magnetic Resonance Spectroscopy OR Diffusion Tensor Imaging OR Arterial Spin Labeling OR Electroencephalography OR EEG OR Diagnostic Techniques, Neurological OR Magnetoencephalography OR Fluid-attenuated inversion recovery OR Diagnostic imaging OR Quantitative EEG OR QEEG OR event-related potentials OR 'event related potential*' OR 'evoked potential*' OR ERP OR scanning OR fMRI OR 'resting-state' OR 'resting state')	(Biomarkers OR biomarker OR neuroendocrine OR pituitary OR hormone* OR cortisol OR hydrocortisone OR gonadal steroid hormones OR growth hormone OR thyroid OR SIADH OR Inappropriate ADH Syndrome OR ((Cerebrospinal OR 'cerebro spinal') AND fluid*) OR CSF OR Serum OR urine OR saliva OR neuronal OR glial OR neuroglia OR axonal OR (Marker* AND (immunologic OR laboratory OR clinical OR biochemical OR immune OR immunologic OR biological OR biologic)))	(Epigenetic* OR Epigenomics OR 'copy number' OR 'rare variant*' OR Genetic Variation OR 'genetic diversit*' OR genotype OR genogroup* OR genotype* OR genetics OR genetic* OR mitochondria OR mitochond* OR Intracellular signaling peptides and proteins OR Polymorphism, Genetic OR DNA Copy Number Variations OR 'DNA polymorphism' OR 'genotype environment interaction' OR Polymorphism, Single Nucleotide OR 'Intracellular signaling' OR genome OR OR genomics OR genom* OR allele OR allel* OR chromosomes OR chromosom* OR 'genetic testing')

Three separate systematic literature searches (neuroimaging, biomarkers and genetics) were conducted to address each of the outlined questions above. The stepwise approach and workflow for our systematic searches were registered with an international prospective register of systematic reviews[17] (see online supplementary appendices 1–3). Prior reviews have separately evaluated the state of the science on imaging, biomarkers and genetics in the broader spectrum of TBI or SRC,[18–22] but this is the first integrated review of the most up-to-date evidence on these novel technologies specific to SRC.

Databases and search terms

Our literature search used PubMed/Medline, Scopus, Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycINFO and Cochrane Library. Given the focus of this systematic review on the evolution of emerging technologies, our search was limited to the published literature from 1 January 2000 to 31 December 2016. The decision to include published literature dating back to 2000 was based on the relevance of modern technologies to our specific review question; this approach is further supported by the finding that the earliest publication of articles meeting our inclusion criteria was 2004 for MRI, 2013 for biomarkers and 2015 for genetics. The search strategy was developed in conjunction with an expert medical librarian, who also conducted an independent peer review of the strategy. Table 1 summarises the combination of key words and medical subject headings (MeSH) terms used for the three respective searches. A common group of search terms for head injury and sport was used for all three searches, then combined with the specific terms for searches related to neuroimaging, biomarkers and genetics.

Study selection criteria

In addition to meeting the MeSH term criteria, the basic requirements for a study to be included in our search were that the article (1) was published in English, (2) represented original research, (3) involved human research, (4) pertained only to SRC (ie, not non-sports TBI), (5) included data from studies involving neuroimaging (including electrophysiological testing), fluid biomarkers or genetic testing in the assessment of SRC, and (6) had at least one data collection point within 6 months of injury. Two reviewers collaboratively screened articles for inclusion. Titles and abstracts were reviewed first, and duplicates and irrelevant articles were excluded, followed by full-text screenings. A third reviewer was consulted to resolve discrepancies about article inclusion.

Data extraction and analysis

Members of the author group extracted relevant data from included studies to populate the data extraction tool for each search. The author group then conducted reviews relevant to each search based on their respective area of subject matter expertise (neuroimaging, biomarkers and genetics). For the included studies, a standardised data extraction method was used (see tables 2-4 for the data extraction tools for the neuroimaging, biomarker and genetic searches). Articles are listed in chronological order based on publication year to illustrate the pattern and evolution of research over time. Two subject matter experts from our working group independently examined all retrieved citations to determine eligibility for inclusion.

Assessment of risk of bias and level of evidence

As recommended by the Cochrane Collaboration, a modified version of the QUADAS-2 was used to assess the risk of bias for identified diagnostic accuracy studies[23] (see online supplementary appendix 1). Generalisability was assessed based on the degree of representativeness across age, gender and sport. Two primary reviewers for each study independently assessed the risk of bias in identified studies. Using the modified QUADAS-2 tool, the overall risk of bias was assessed (low, moderate and high) for each included study. Discrepancies were resolved by consensus after consulting with an independent third rater.

A rating for the overall level of evidence was assigned for each search area (neuroimaging, biomarkers and genetics) based on a simple hierarchical 'level of evidence' grading system, modified

Table 2 Data extraction tool for studies using neuroimaging

	Study design		Participants					Review of evidence
First author, year	Study type	Modality	Sport	Age/level (mean ± SD, range)	Gender (M/F)	n (control description)	Time from injury to examination	Risk of bias
Chen JK, 2004[11]	PCS	T-fMRI	WR, IH, OT	Control: 27.6±5.2 years; concussed: 26.9±7.2 years	M	16 C+, 8 C- (age-matched males)	1–14 months (mean 4.7 months)	High
Jantzen KJ, 2004[6]	PCS	T-fMRI	FB	20 years; 19–23 years	M	4 C+, 4 C-	Three athletes examined within 1 week postinjury, 1 at end of season	Moderate
Cimatti M, 2006[26]	CS	MRS	BX, OT	UNK	UNK	6 C+	24–48 hours postinjury	High
Gosselin N, 2006[91]	PCS	EEG	IH, FB SCR	Asymptomatic: 26.1±6.1 years; symptomatic: 25.7±7.0 years; control: 22.0±1.8 years	M/F	20 C+, 10 C-	Asymptomatic 5.3±3.1 weeks; symptomatic 15.1±16.6 weeks postinjury	Moderate
Chen JK, 2007[49]	PCS	T-fMRI	Any	Low PCS: 26.9±5.6 years; moderate PCS: 30.8±5.8 years; control: 21.9±1.6 years	M	18 C+, 10 C-	5±6.4 months postinjury	High
Lovell MR, 2007[5]	PCS	T-fMRI	Any	16.6±2.4; 13–24 years	M/F	28 C+, 13 C- (age-matched athletes)	6.6±4.7 days and 33.3±33.8 days postinjury	Moderate
Chen JK, 2008[50]	PCS	T-fMRI	Any	Control: 20±1.2 years; C+ no depression: 26±5.6 years; C+ mild depression: 29±6.7 years; C+ moderate depression: 30±7.4 years	M	40 C+, 16 C- (IH and FB controls)	4.9–7.3 months depending on group	Moderate
Vagnozzi R, 2008[32]	PCS	MRS	RB, BX, OT	27±4.8 years, 21–35 years	M/F	14 C+, 5 C- (age-matched controls)	3, 15 and 30 days postinjury	Moderate
Slobounov S, 2009[63]	PCS	EEG	RB, FB, IH, SCR	Male: 21.3 years; female: 20.8 years; 18–25 years	M/F	21 C+	7, 14 and 21 days postinjury	Moderate
Cao C, 2010[61]	PCS	EEG	RB, FB, IH	Male: 20.9 years; female: 21.4 years; 18–25 years	M/F	29 C+	BL, and 7 days postinjury	Moderate
Henry LC, 2010[27]	PCS	MRS	Any	Control: 23±0.71 years; concussed: 22.1±0.77 years	M	12 C+, 12 C-	Within 6 days postinjury (81.9±46.7 hours)	Moderate
Livingston SC, 2010[92]	PCS	TMS	Any	20.4±1.3 years	M/F	9 C+, 9 C- (age, gender, sport, position, concussion history and LD/ADHD matched)	1, 3, 5 and 10 days postinjury	Moderate
McCrea M, 2010[4]	PCS	qEEG	FB	Col/HS	M	28 C+, 28 C- (age, years of education, GPA and BL performance matched)	BL, day of injury, 8 days and 45 days postinjury	Moderate
Pardini JE, 2010[93]	PCS	T-fMRI	Any	16.3 years, 14–23 years	M/F	16 C+	3–12 days postinjury; median: 6.5 days postinjury	Moderate
Slobounov SM, 2010[53]	PCS	T-fMRI	RB, IH, SCR	Control: 21.3 years; concussed: 20.8 years	M/F	15 C+, 15 C- (age-matched athlete controls)	≤30 days postinjury	Moderate
Vagnozzi R, 2010[30]	PCS	MRS	RB, SCR, BX, OT	Control: 27.6±3.6 years; concussed: 26.5±5.5 years; 16–35 years	M/F	40 C+, 30 C-	3, 15, 22 and 30 days postinjury	Moderate
Zhang K, 2010[48]	PCS	T-fMRI/DTI	RB, IH, SCR	Control: 21.3±1.5 years; concussed: 20.8±1.7 years	M/F	15 C+, 15 C- (age-matched athlete controls)	30±2 days postinjury	Moderate
Cao C, 2011[62]	PCS	EEG	RB, FB, IH, SCR	Male: 21.3 years; female: 20.8 years; range: 18–25 years	M/F	30 C+, 30 C- (age and sex matched athletes from same group without history of concussion)	BL, 30±3 days postinjury	Moderate
Cubon VA, 2011[10]	PCS	DTI	Any	Control: 20.4±1.8 years; concussed: 19.7±1.6 years	M/F	10 C+, 10 C- (sex and age matched non-contact controls)	At least 1 month postinjury mean: 115±104 days	Moderate
Henry LC, 2011[40]	PCS	DTI	FB	Control: 22.8±1.5 years; concussed: 22.1±1.7 years	M	16 C+, 8 C- (FB controls without concussion history)	5 days (mean: 81.9±46.7 hours) and 6 months (mean: 6.4±0.4 months) postinjury	Moderate
Henry LC, 2011[33]	PCS	MRS	FB	22.5 years	M	10 C+, 10 C- (athlete controls without concussion history)	5 days (mean: 81.9±46.7 hours) and 6 months (mean: 6.4±0.4 months) postinjury	Moderate
Len TK, 2011[68]	PCS	CVR	IH, OT	21.4±1.7 years, 16–25 years	M/F	10 C+, 21 C-	4.5±1.1 days postinjury	Moderate
Slobounov SM, 2011[60]	PCS	R-fMRI	RB, IH, SCR	Control: 21.3±1.5 years; concussed: 20.8±1.7 years	M/F	17 C+, 17 C-	10±2 days postinjury	Moderate

Continued

Table 2 Continued

	Study design		Participants					Review of evidence
First author, year	Study type	Modality	Sport	Age/level (mean ± SD, range)	Gender (M/F)	n (control description)	Time from injury to examination	Risk of bias
Slobounov S, 2011[94]	PCS	EEG	RB, FB, IH, LX, OT	Control: 21.3±1.5 years; concussed: 20.8±1.7 years	M/F	14 C+, 15 C- (student-athletes without history of concussion)	15 days postinjury and within 24 hours of symptom resolution	Moderate
Baillargeon A, 2012[95]	PCS	EEG	SCR, IH, RB, FB	Control: 9–12 years (11±1.2 years), 13–16 years (14.8±1.1 years), adults (23.3±3.3 years); concussed 9–12 years (10.5.±1.2 years), 13–16 years (14.2±1.0 years), adults (23.4±2.1 years)	M	48 C+, 48 C-	6 months postinjury	Moderate
Barr WB, 2012[96]	PCS	EEG	FB	Col/HS	M	59 C+, 31 C- (age, years of education, GPA and BL performance matched)	Day of injury, 8 days and 45 days postinjury	Moderate
Breedlove EL, 2012[97]	PCS	T-fMRI	FB	Season 1: 17.0 years, 15–18 years; Season 2: 16.8 years, 14–18 years	M	7 C+	Preseason and in-season follow-up for concussed athletes	High
Chamard E, 2012[36]	PCS	MRS	IH	20.21 years, 18–37.2 years	M/F	45 C+	72 hours, 14 days and 2 months postinjury	Moderate
Johnson B, 2012[28]	PCS	MRS	Any	Control: 20.2±0.8 years; concussed: 20.3±1.5 years	M/F	28 C+, 20 C- (athlete controls)	≤24 hours of symptom resolution, placed into three groups; subjects recovered within 1 week, 2 weeks or 3+ weeks postinjury	Moderate
Johnson B, 2012[56]	PCS	R-fMRI	Any	Control: 20.4±0.8 years; concussed 20.6±1.2 years; additional concussed: 19.9±1.5 years	M/F	23 C+, 15 C- (athlete controls)	14 scanned within 24 hours of symptom resolution (10±2 days postinjury); 9 scanned outside of 24 hours of symptom resolution (10±4 days postinjury)	Moderate
Johnson B, 2012[29]	PCS	MRS	Any	Control: 20.4±0.8 years; concussed: 20.6±1.2 years	M/F	15 C+, 15 C- (athlete controls)	≤24 hours of symptom resolution	Moderate
Livingston SC, 2012[98]	PCS	TMS	Any	20.4±1.3 years	M/F	9 C+, 9 C- (age, gender, sport, position, concussion history and LD/ADHD matched)	1, 3, 5 and 10 days postinjury	Moderate
Maugans TA, 2012[37]	PCS	DTI, MRS, ASL	FB, SCR, WR	11–15 years	M/F	12 C+, 12 C- (age and gender matched)	≤72 hours, 14 days and 30 days postinjury	Moderate
McAllister TW, 2012[99]	PCS	DTI	FB, IH	Col/HS	M	10 C+	Preseason, ≤10 days of injury	Moderate
Slobounov S, 2012[64]	PCS	EEG	RB, FB, IH, SCR	Male: 21.8 years; female: 20.1 years; 18–25 years	M/F	49 C+, 383 C- (athletes evaluated at BL)	BL, 7 days, 15 days, 30 days, 6 months and 12 months postinjury	Moderate
Zhang K, 2012[100]	PCS	R-fMRI	RB, FB, IH, SCR	Control: 20.9±1.1 years; concussed: 20.8±1.5 years	M/F	14 C+, 17 C-	≤24 hours of symptom resolution 10±2 days postinjury	Moderate
Borich M, 2013[38]	PCS	DTI	IH	Control: 15.7±0.9; concussed: 15.5±1.2 years	M/F	12 C+, 10 C- (age, gender and physical activity matched controls)	35.6±15.0 days postinjury	High
Hammeke TA, 2013[101]	PCS	T-fMRI	FB	Control: 16.5±0.52 years; concussed: 16.5±0.52 years	M	12 C+, 12 C- (uninjured teammate; age, education and preseason symptom matched)	13 hours and 7 weeks postinjury	Moderate
Len TK, 2013[67]	PCS	CVR	IH, OT	19.7±3.3 years	M/F	20 C+	BL, 2, 4 and 7 days postinjury, and end of season	Moderate
Prichep LS, 2013[65]	PCS	EEG	FB	17.9 years, 15.1–23.2 years	M	65 C+	≤24 hours, 8 and 45 days postinjury	Moderate
Vagnozzi R, 2013[31]	PCS	MRS	Any	Control: 25.9±5.7 years; concussed: 24.6±6.4 years; 16–35 years	M/F	11 C+, 11 C- (sex and age matched)	3, 15, 30 and 45 days postinjury	Moderate
Virji-Babul N, 2013[44]	PCS	DTI	IH, RB, OT	14–17 years	M/F	12 C+, 10 C-	≤2 months postinjury	High
Bartnik-Olson BL, 2014[25]	PCS	ASL, DTI, MRS	FB, OT	8–17 years	M/F	15 C+, 15 C- (age, gender and BMI matched controls)	Mean: 5.8±4.8 months postinjury	Moderate

Continued

Table 2 Continued

	Study design		Participants					Review of evidence
First author, year	Study type	Modality	Sport	Age/level (mean ± SD, range)	Gender (M/F)	n (control description)	Time from injury to examination	Risk of bias
Chamard E, 2014[35]	PCS	MRS	Any	Control: 21.1 years; concussed: 21.4 years	F	11 C+, 10 C- (athletes without history of concussion)	9.4±4.3 days and 181.9±14.6 days postinjury	Moderate
Dettwiler A, 2014[47]	PCS	T-fMRI	Any	19.8±0.9 years	M/F	15 C+, 15 C- (age and sex matched normal controls)	≤2 days, 2 weeks and 2 months postinjury	Moderate
Helmer KG, 2014[102]	PCS	SWI	IH	Male: 23±2 years; female: 21±4 years	M/F	11 C+, 45 C- includes same subjects at BL	BL, 72 hours, 2 weeks, 2 months, and end of season	High
Keightley ML, 2014[51]	PCS	T-fMRI	Any	Control: 14±2.3 years; concussed: 14.5±2.3 years	M/F	15 C+, 15 C- (age-matched controls)	Range of 9–90 days postinjury	Moderate
Kontos AP, 2014[104]	PCS	fNIRS	Any	Control: 22±0.3 years; concussed: 22.7±1.3 years	M/F	9 C+, 5 C- (age-matched healthy controls)	Range of 15–45 days postinjury, while still symptomatic	High
Murugavel M, 2014[45]	PCS	DTI	Any	Control: 19.9±1.7 years; concussed: 20.2±1.0 years; 18–22 years	M	21 C+, 16 C- (age and sex matched healthy non-contact controls)	2 days, 2 weeks and 2 months postinjury	Moderate
Pasternak O, 2014[42]	PCS	DTI	IH	17–26 years	M/F	11 C+ (7 with usable postinjury scan)	BL, 72 hours postinjury	Moderate
Powers KC, 2014[105]	PCS	TMS	FB	Control: 20.3±1.5 years; concussed: 20.2±1.2 years	M	8 C+, 8 C- (age and position matched with healthy teammate controls)	1–4 weeks postinjury (on symptom resolution)	Moderate
Sasaki T, 2014[43]	PCS	DTI	IH	Control: 21.3±1.8 years; concussed: 21.7±1.5 years	M/F	16 C+, 18 C- (teammates)	Preseason and postseason, mean time to scan: 95±45 days (range: 42–161 days)	Moderate
Sinopoli KJ, 2014[52]	PCS	T-fMRI	IH, OT	Control: 12.6±1.6 years; concussed: 12.6±1.6 years; 9–15 years	M	13 C+, 14 C-	3–6 months postinjury	Moderate
Teel EF, 2014[106]	PCS	EEG	Any	Control: 21±1 years; concussed: 21±1 years	M/F	7 C+, 12 C-	≤8 days (mean: 5±1)	Moderate
[107]Virji-Babul N, 2014[107]	PCS	EEG	IH, SCR	Control: 15.8±1.3 years; concussed: 16±0.9 years	M	9 C+, 33 C- (soccer player controls)	≤3 months postinjury	High
Balkan O, 2015[108]	PCS	EEG	Any	Control: 16 years; concussed: 16.5 years	M	21 C+, 33 C- (soccer players)	≤3 months postinjury	Moderate
Borich M, 2015[55]	PCS	R-fMRI	IH	Control: 15.7±0.9 years; concussed: 15.5±1.2 years	M/F	12 C+, 10 C- (age, gender and physical activity matched controls)	35.7±15 days postinjury	High
Czerniak SM, 2015[58]	PCS	R-fMRI	Any	Control: 20±0.4 years; concussed: 20.3±0.4 years; 18–22 years	M/F	9 C+, 12 C-	≤6 months postinjury (mean: 112±22 days postinjury)	Moderate
Gay M, 2015[109]	PCS	EEG	Any	CoI	UNK	9 C+, 9 C- (age-matched student athletes)	During return-to-play protocol	High
Jing M, 2015[103]		DTI	FB	19–23 years (median: 20 years)	M	3 C+, 8 C-	Within 24 hours postinjury	High
Johnson B, 2015[54]	PCS	T-fMRI	Any	20–22 years	M/F	9 C+, 9 C- (age and sex matched normal volunteers)	Within 7 days postinjury	Moderate
Meier TB, 2015[66]	PCS	ASL	FB	Control: 20.7±1.4 years; concussed: 20.6±1.2 years	M	17 C+, 27 C- (healthy football players)	1 day, 1 week and 1 month postinjury	Moderate
Sikoglu EM, 2015[34]	PCS	MRS	Any	Control: 20.2±0.4 years; concussed: 20.1±0.3 years; 18–22 years	M/F	14 C+, 13 C-	76.45±19.3 (mean ± SE) days postinjury (6–185 days)	Moderate
Yuan W, 2015[110]	PCS	DTI	Any (17/23 sports injury)	11–16.7 years	M/F	23 C+, 20 C- (orthopaedically injured controls)	≤96 hours postinjury	Moderate
Zhu DC, 2015[46]	PCS	R-fMRI, DTI	FB	Control: 20.5±1.8 years; concussed: 20±1.3 years	M	8 C+, 11 C- (college students of comparable age and physical activity)	1, 7 and 30 days postinjury	Moderate

Continued

Table 2 Continued

	Study design		Participants					Review of evidence
First author, year	Study type	Modality	Sport	Age/level (mean ± SD, range)	Gender (M/F)	n (control description)	Time from injury to examination	Risk of bias
Broglio SP, 2016[111]	PC[112]S	EEG	Any	Control: 17.1±2.9 years; concussed: 16.3±2.2 years	M/F	24 C+, 21 C-	While symptomatic, at time of self-reported symptom resolution, at return to play and at 1 month postasymptomatic	Moderate
Chamard E, 2016[39]	PCS	DTI	IH, SCR, OT	Control: 21±1.4 years; concussed: 21.4±1.7 years	F	10 C+, 8 C- (female athletes without history of concussion)	6 months postinjury	High
Jarrett M, 2016[112]	PCS	SWI	IH	Control: 22.9±2.3 years; concussed: 21.2±3.1 years	M/F	11 C+, 15 C- (college students)	72 hours, 2 weeks and 2 months postinjury	Moderate
Kontos AP, 2016[113]	PCS	EEG	Any	Control: 18.3±2.2 years; PTM: 16.5±1.5 years; NO-PTM 16.5±2.3 years; 18–22 years	M/F	15 PTM, 22 NO-PTM, 20 C- (healthyhealthy age, sex, and concussion history matched)	1, 2, 3 and 4 weeks postinjury	Moderate
Lancaster MA, 2016[15]	PCS	DTI	FB	Control: 18.0±1.5 years; concussed: 17.6±1.5 years	M	27 C+, 26 C- (age, sex and sport matched controls)	24 hours and 8 days postinjury	Moderate
Meier TB, 2016[59]	PCS	R-fMRI	FB, SCR, OT	Control: 20.3±1.4 years; concussed: 20.3±1.3 years	M/F	43 C+, 51 C- (healthy contact-sport athletes)	24 hours, 1 week and 1months postinjury	Moderate
Meier TB, 2016[41]	PCS	DTI	FB, SCR, OT	Control: 20.3±1.5 years; concussed: 20.1±1.4 years	M/F	40 C+, 46 C- (healthy contact-sport athletes)	24 hours, 1 week and 1 months postinjury	Moderate
Militana AR, 2016[57]	PCS	ASL, T-fMRI, R-fMRI, CVR	SCR, OT	Control: 20±1.6 years; concussed: 19.7±1.2 years	M/F	7 C+, 11 C- (healthy controls without history of concussion	3–6 days postinjury	Moderate
Mutch AC, 2016[69]	PCS	CVR	SCR, IH, FB, OT	Control: 18.5 years; concussed: 15.7 years	M/F	6 C+, 24 C- (normal control atlas)	Between 7 and 279 days postinjury	Moderate
Wang Y, 2016[14]	PCS	ASL	FB	Control: 18±1.76 years; concussed: 17.7±1.5 years	M	18 C+, 19 C- (age, gender, sport and academic achievement matched controls)	24 hours and 8 days postinjury	Moderate
Wright AD, 2016[114]	PCS	DTI	IH	21.2±3.1 years	M/F	11 C+, 34 C-	72 hours, 2 weeks and 2 months postinjury	Moderate

Definitions and coding table 3.
Author indicates last name of first author. Year refers to year of publication. Study type coded as follows: CS, clinical series; PCS, prospective cohort study.
Modality refers to specific form(s) of neuroimaging used in the study: ASL, arterial spin labelling; CVR, cerebrovascular reactivity; DTI/DKI, diffusion tensor/kurtosis imaging; MRS, magnetic resonance spectroscopy; R-fMRI, resting-state functional MRI; T-fMRI, task-related functional MRI; SWI, susceptibility weighted imaging.
Electrophysiological testing: EEG, electroencephalogram;qEEG, quantitative electroencephalogram; ERP, event-related potential; TMS, transcranial magnetic stimulation.
Other: fNIRS, functional near-infrared spectroscopy; SPECT, single photon emission computed tomography.
Sports coded as follows: BX, boxing; FB, football; FH, field hockey; IH, ice hockey; LX, LaCrosse; OT, other; RB, rugby; SCR, soccer; WR, wrestling.
Age/Level coded as follows: Col, college; HS, high school; P, professional; O, other; Y, youth.F/M indicates gender: F, female; M, male; list both if it applies.
Misc: BL, baseline; LD, learning disability; ADHD attention-deficit/hyperactivity disorder; GPA, grade point average; BMI, body mass index; PTM/NO-PTM, post-traumatic migrain. Risk of bias: overall risk of bias rated as low, moderate, high or unclear, based on modified QUADAS-2 critical appraisal tool (see online supplementary appendix 2).

Table 3 Data extraction tool for studies using fluid biomarkers

	Study design		Participants					Review of evidence
First author, year	**Study type**	**Modality**	**Sport**	**Age/level (mean ± SD, range)**	**Gender (M/F)**	**n (control description)**	**Time from injury to examination**	**Risk of bias**
Dambinova SA, 2013[70]	PCS	AMPAR	RB, SCR, LX, OT	Control: 21.0±3.3 years; concussed: 21.0±3.0 years	M/F	33 C+, 91 C-	BL and two follow-up time points within 6 months	High
Kiechle K, 2014[71]	PCS	S100B	FB, SCR, OT	25.4±5.5 years	M/F	17 C+, 46 C- (at BL)	BL, ≤3 hours, 2 days, 3 days and 7 days postinjury	Moderate
Shahim P, 2014[72]	PCS	S100B, tau, NSE	IH	28 years, 19–38 years	M	28 C+, 47 C- at BL (preseason)	BL, 1 hour, 12 hours, 36 hours, 144 hours postinjury, and day of return to play	Moderate
Oliver J, 2015[75]	PCS	MBG	FB	Col	M	6 C+, 110 C- at BL (preseason)	BL, 24 hours, 48 hours, 72 hours, 96 hours and 2 weeks postinjury	High
Pham N, 2015[76]	PCS	PrPC, GFAP	IH, FB, SCR, WR, OT	21.2±2.9 years, 18–30 years	M/F	6 C+, 27 C- non-athletes, 76 C- athletes at BL	BL and 1–7 days postinjury	Moderate
Schulte S, 2015[77]	PCS	S100B, NSE	FB	21 years, 18–26 years	M	11 C+	BL, 1 day, return-to-play, end-of-play	High
Shahim P, 2015[74]	PCS	VILIP-1, tau, S100B, NSE	IH	Preseason: 27.6 years; concussed: 27.2 years	M	28 C+, 45 C- at BL (preseason)	BL, 1 hour, 12 hours, 36 hours, 144 hours postinjury, and day of return to play	Moderate
Siman R, 2015[78]	PCS	SNTF	IH	Preseason: 27.6 years; concussed: 27.2 years	M	28 C+, 45 C- at BL (preseason)	BL, 1 hour, 12 hours, 36 hours, 144 hours postinjury, and day of return to play	Moderate
Singh R, 2016[83]	PCS	QUIN, 3HK, KYNA	FB	Control: 20.4±1.5 years; concussed: 20.3±1.1 years	M	18 C+, 18 C- (FB teammates)	1 day, 1 week and 1 month postinjury	Moderate
Bouvier D, 2016[73]	PCS	S100B	RB	28.6±3.98 years	M	5 C+, 27 C-	Before competition, immediately postmatch and 36 hours postmatch	Moderate
Daley M, 2016[80]	PCS	Multiple metabolites	IH	Control: 12.9±1.0 years; concussed: 13.4±2.3 years	M	12 C+, 17 C- (age, sex and sport matched controls)	2.3±0.7 days postinjury	High
Hutchison MG, 2016[82]	PCS	Cortisol	FB, SCR, IH, LX, OT	21.0±2.5 years	M/F	26 C+, 26 C- (age, sex and sport matched controls)	Within 1 week, after symptom resolution and 1 week after return to play	Moderate
La Fountaine MF, 2016[84]	CS	PRL	Any	20±1 years	M	4 C+	Within 48 hours, 7 days and 14 days postinjury	High
Meier TB, 2016[41]	PCS	Tau	FB, SCR, OT	Control: 20.3±1.5 years; concussed: 20.1±1.4 years	M/F	40 C+, 46 C- (collegiate contact-sport controls)	1 day, 1 week and 1 month postinjury	High
Shahim P, 2016[79]	PCS	Tau	IH	P	M	28 C+	BL, 1 hour, 12 hours, 36 hours, 144 hours postinjury and the day the athlete returned to play	Moderate
Shahim P, 2016[81]	PCS	Tau, NF-L, GFAP, amyloid β, NG	IH	Control: median 25 years; concussed: median 31 years	M	16 C+, 15 C-	Median time from injury to examination was 4 months	Moderate

Definitions and coding for Table 3: Author indicates last name of first author. Year refers to year of publication.
Study type coded as follows: CS, clinical series; PCS, prospective cohort study.
Modality refers to specific fluid biomarker(s) used in the study: AMPAR, α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid receptor peptide; S100B, S100 calcium binding protein B; NSE, neuron specific enolase; MBG, marinobufagenin; PrPC, plasma soluble cellular prion protein; GFAP, glial fibrillary acidic protein; VILIP-1, Visinin-like protein-1; SNTF, calpain-derived αII-spectrin N-terminal fragment; QUIN, quinolinic acid; 3HK, 3-hydroxykynurenine; KYNA, kynurenic acid; PRL, prolactin; NF-L, neurofilament light; NG, neurogranin.
Sports coded as follows: BX, boxing; FB, football; FH, field hockey; IH, ice hockey; LX, LaCrosse; OT, other; RB, rugby; SCR, soccer; WR, wrestling.
Age/Level coded as follows: Col, college; HS, high school; P, professional; O, other; Y, youth.F/M indicates gender: F, female; M, male; list both if it applies.Misc: BL, baseline.
Risk of bias: overall risk of bias rated as low, moderate, high or unclear, based on modified QUADAS-2 critical appraisal tool (see online supplementary appendix 2).

Table 4 Data extraction tool for studies using genetic testing

	Study design		Participants					Review of evidence
First author, year	Study type	Modality	Sport	Age/level (mean ± SD, range)	Gender (M/F)	n (control description)	Time from injury to examination	Risk of bias
McDevitt J, 2015[87]	PCS	VNTR/GRIN2A	Any	19.5±6.0 years	M/F	87 C+	Recovery followed prospectively; ≤60 days postinjury	High
Gill J, 2016[85]	PCS	RNA	Any	Control: 18.5±0.4 years; concussed: 19.4±1.5 years	M/F	15 C+, 16 C-	BL, within 6 hours and 7 days postinjury	Moderate
Madura SA, 2016[90]	PCS	SLC17A7	Any	20.0±6.3 years	M/F	40 C+	Recovery followed prospectively; ≤20 days postinjury	High
Merchant-Borna K, 2016[86]	PCS	mRNA	FB, IH, SCR, LX	Control: 18.5±0.4 years; concussed: 19.4±1.5 years	M/F	16 C+, 16 C- teammate controls (253 C- at BL including C+ athletes)	BL, within 6 hours, and 7 days postinjury	Moderate
Merritt VC, 2016[89]	PCS	APOE	Any	19.3±1.5 years	M/F	45 C+, 43 C-	10.0±14.3 days postinjury	Moderate
Merritt VC, 2016[88]	CS	APOE	Any	Positive ε4 allele group 19.9±1.4 years; negative ε4 allele group 20±1.6 years	M/F	42 C+	9.8±14.6 days postinjury (range of 0–72 days)	Moderate

Definitions and coding for Table 4: Author indicates last name of first author. Year refers to year of publication.
Study type coded as follows: CS, clinical series; PCS, prospective cohort study.
Modality refers to specific genetic marker(s) studied: VNTR, variable number tandem repeats; GRIN2A, N-methyl-D-aspartate receptor 2A; APOE, Apolipoprotein e; SLC17A7, Solute Carrier Family 17 Member 7.
Sports coded as follows: BX, boxing; FB, football; FH, field hockey; IH, ice hockey; LX, LaCrosse; OT, other; RB, rugby; SCR, soccer; WR, wrestling.
Age/Level coded as follows: Col, college; HS, high school; O, other; P, professional; Y, youth.
F/M indicates gender: F, female; M, male; list both if it applies.
Misc: BL, baseline.
Risk of bias: overall risk of bias rated as low, moderate, high or unclear, based on modified QUADAS-2 critical appraisal tool (see online supplementary appendix 2).

from that established by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) Working Group (see table 5).[24] In cases of uncertainty, the full article was obtained and any disagreement resolved through discussion and consultation with a third reviewer. Finally, a qualitative synthesis of the overall level of evidence from each of the three searches was conducted by the subject matter experts and reported in each results section.

RESULTS

The electronic literature database search identified 3222 articles. After applying additional requirements and eliminating duplicate articles, a total of 98 qualified for further review (76 neuroimaging, 16 biomarkers and 6 genetic testing). Tables 2–4 provide a summary of key findings from studies in each domain (neuroimaging, biomarkers and genetic testing).

Neuroimaging studies

Seventy-six studies using neuroimaging and electrophysiological measures revealed significant effects of SRC by each of the modalities assessed in this review. These included diffusion tensor imaging (DTI) (n=18), task-based functional MRI (fMRI) (n=15), electroencephalogram (EEG)/quantitative-EEG (qEEG:n=16), magnetic resonance spectroscopy (MRS) (n=13), and resting-state fMRI (n=8), as well as fewer studies that used measures of cerebrovascular reactivity (CVR) (n=4), arterial spin labelling (n=5), transcranial magnetic stimulation (TMS) (n=3), susceptibility weighted imaging (n=2) and functional near-infrared spectroscopy (n=1). Although EEG and TMS were not explicitly referenced in our assigned review questions, the decision was made to include them in the neuroimaging section of the review based on published reports using these technologies in the study of SRC. The limited number of studies for any specific marker, the varying time frames, the lack of standardisation and the different analyses employed make the determination of consistent patterns difficult.

Nevertheless, some consistent patterns do emerge. With MRS there is a reduction of N-acetylaspartate (NAA; relative to creatine and/or choline) predominately in white matter,[25–32] with some evidence of acute reduction with subsequent recovery by 30 days postinjury.[30 32] Others, however, have reported decreased NAA levels more chronically.[25 33] Fewer studies have observed the effects of SRC on other metabolites,[27 31 33–35] although null results have also been reported.[36 37]

The majority of DTI work reports a decrease in mean diffusivity and/or an increase in fractional anisotropy in white matter within 6 months postinjury,[15 38–44] although opposite patterns or null results have been reported.[10 37 45 46] In addition, most observed a reduction in radial diffusivity,[38 39 42 43] whereas both increases and decreases in axial diffusivity have been described.[39 40 42 43]

The results from task-fMRI studies are more variable. The majority used a working memory paradigm leading to varying and seemingly contradictory findings, with reports of increased[47 48] and decreased activity in task-related networks (eg, dorsolateral prefrontal cortex).[11 49–51] Multiple studies, however, have reported additional activity outside of the core task regions following SRC in a variety of tasks.[11 49 50 52–54] Time since injury, task variables and symptom presentation are likely modifying factors. In addition, although most studies investigated working memory, the type and number of stimuli used (ie, low vs high working memory 'load') varied largely, which may explain apparent discordance in hypoactivation versus hyperactivation results reported.

Findings from the resting-state fMRI literature also vary, likely because methodologies differ. Nevertheless, the default mode network (DMN) is the most extensively studied network in the SRC literature. Results have varied across studies, however, as

both increases and decreases in connectivity between DMN regions have been reported across and within studies.[46 55–57] Altered functional connectivity has also been observed relative to executive function, visual and motor networks.[55 58–60]

Several studies have demonstrated the effects of SRC on EEG/qEEG at rest or during different task conditions. Importantly, multiple studies assessed electrophysiological changes following injury relative to a preinjury baseline measure.[4 61–64] For example, Cao and Slobounov have reported differences in several EEG metrics postinjury relative to baseline.[61 62] Measures from qEEG have also been shown to be altered at 8 days post-SRC relative to baseline,[4] and have been associated with concussion severity, underlining the potential of electrophysiological measurements in the assessment of SRC.[65]

Consistent findings across the other modalities are difficult to assess due to the limited number of studies. However, four of five studies that investigated cerebral blood flow following SRC reported reductions at the acute and subacute phases (days to weeks),[14 37 66] and even at more chronic time points (~5 months).[25] An additional study reported no differences in resting cerebral blood flow,[57] although it did report an increase in CVR, consistent with others that showed impaired CVR.[67–69]

The majority of neuroimaging studies, although of high quality and informative, had at least a moderate risk of bias based on the scoring criteria outlined in the modified QUADAS-2 tool. Most common was the lack of generalisability due to the inclusion of limited age ranges, male athletes focus and/or limited sample sizes. Additional factors included a lack of appropriate control groups, lack of preinjury enrolment and potential for measurement bias due to limited information regarding the definition/diagnosis of mTBI/SRC. Also, publication bias that limits reporting null results should be acknowledged, although this issue is not unique to the current literature.

Given the above, it is our opinion that the level of evidence for the role of these neuroimaging and electrophysiological measures in the *clinical assessment* of SRC is low (see table 5) because the most studies reviewed were not designed to specifically assess clinical potential. Rather, they aimed to assess the effects of SRC using that marker. Therefore, for the purposes of this review, we make a distinction between the level of evidence for the utilisation of these markers for clinical assessment of SRC and their use to characterise the pathophysiology involved. It is our opinion that there is a significant role for neuroimaging and electrophysiological measures in characterising the pathophysiology of SRC.

Table 5 Quality of evidence grades

Grade	Definition
High	High level of confidence in the strength of the existing findings demonstrating reliability, validity and clinical utility of the tool(s) for use in the assessment of SRC.
Moderate	Moderate level of confidence in the strength of the existing findings demonstrating reliability, validity and clinical utility of the tool(s) for use in the assessment of SRC.
Low	Low level of confidence in the strength of the existing findings demonstrating reliability, validity and clinical utility of the tool(s) for use in the assessment of SRC.
Very low	Very Low level of confidence in the strength of the existing findings demonstrating reliability, validity and clinical utility of the tool(s) for use in the assessment of SRC.

Quality of evidence is a continuum; any discrete categorisation involves some degree of arbitrariness. Nevertheless, advantages of simplicity, transparency and vividness outweigh these limitations.
SRC, sport-related concussion.

Fluid biomarker studies

Sixteen papers met our inclusion/exclusion criteria relevant to diagnosis or prognosis following sport concussion using fluid biomarkers (see table 3). Fourteen papers analysed blood (plasma or serum) biomarkers, one paper analysed salivary cortisol, and one paper analysed CSF. Eleven papers found significant alterations in one or more of the following blood biomarkers that could potentially aid in the diagnosis of SRC: α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid receptor peptide (AMPAR),[70] S100 calcium binding protein B (s100B),[71–74] total tau,[72] marinobufagenin,[75] plasma soluble cellular prion protein,[76] glial fibrillary acidic protein,[76] neuron-specific enolase (NSE),[77] calpain-derived αII-spectrin N-terminal fragment (SNTF),[78] tau-C[79] and metabolomics profiling.[80] In contrast, NSE,[72] visinin-like protein-1,[74] total tau,[41 74 81] tau-A[79] and salivary cortisol[82] did not distinguish concussed athletes from non-concussed athletes. Several serum biomarkers such as SNTF,[78] quinolinic acid,[83] prolactin[84] and tau-A[79] showed early evidence in predicting outcomes following sport concussion. Finally, decreased levels of amyloid-beta-42 and increased neurofilament light in CSF were observed in athletes with postconcussion syndrome, although these results were largely driven by athletes with postconcussion syndrome duration of more than 1 year.[81]

Overall risk of bias rating for the fluid biomarker papers ranged from moderate to high. High risk of bias occurred most commonly due to limited external validity and poor generalisability in terms of gender (males only), age (collegiate athletes) and sport (most often football or ice hockey). Other factors contributing to moderate to high risk included small sample sizes, no control subjects and lack of preseason assessment. Based on our review of the existing literature, the overall level of evidence for use of fluid biomarkers in the *clinical assessment* of SRC is considered low (see table 5). Early but limited evidence does indicate, however, that fluid biomarkers may inform our scientific understanding of the underlying pathophysiology of concussion in humans.

Genetic testing studies

Outcome after SRC is variable and unpredictable, suggesting that factors other than injury severity, such as host genotype, are important modulators. Emerging literature on genetic predictors of TBI highlights their relevance,[13] and suggests four broad contexts in which genetic variation could modulate outcome: (1) modulation of the impact of a given neurotrauma 'dose' in terms of injury extent, (2) modulation of repair mechanisms, thus impacting trajectory of recovery and ultimate functional outcome, (3) modulation of preinjury traits (eg, resilience) or cognition (cognitive reserve), and (4) interactions between genetic vulnerabilities to neurobehavioural disorders and neurotrauma (ie, role of comorbidities).

Our search strategy identified six papers specifically addressing genetic factors in SRC. Of these, two (from the same group) studied gene expression acutely (within 6 hours) and subacutely (within 7 days) after concussion in essentially the same cohort of collegiate athletes.[85 86] Comparison of preseason baseline and postinjury samples in this cohort of college athletes showed differential expression of genes driving immune and inflammatory pathways acutely, and hypothalamic–adrenal–pituitary axis function subacutely.

The other four papers tested hypotheses related to specific candidate genes. McDevitt *et al* (2015)[87] studied the role of variable number tandem repeat (VNTR) alleles in the promoter region of GRIN2A (a gene coding an NMDA glutamate receptor

subunit) in a cohort of 87 concussed athletes. Recovery times over 60 days were associated with the long variant of the allele. Two studies from Merritt and colleagues[88 89] found an association of the APOEe4 allele with total symptom score, cognitive and physical symptoms, and the presence and severity of headache in a cohort of concussed collegiate athletes assessed a mean of 10 days after injury. Another study in a cohort of 40 concussed collegiate athletes examined the rs74174284 polymorphism in the promoter region of the SLC17A7 gene, and found that the C allele was associated with prolonged recovery times and poorer motor performance.[90]

Overall, the risk of bias in reviewed studies was moderate to high (related to small sample size, inadequate representation across age/gender/sport, poorly defined diagnostic methods for concussion, referral bias and failure to include non-concussed teammates exposed to repetitive head impacts as controls). The overall level of evidence for clinical application was determined as low (see table 5), prohibiting endorsement of genetic testing for clinical evaluation or management of SRC. However, the available studies provide 'proof of concept' that genetic assessment might identify those at risk for poor outcomes from SRC, even before injury. Although genetic assessment cannot yet be endorsed as a clinical tool in SRC management, it certainly warrants future research.

DISCUSSION

Over the past 20 years, there has been significant progress in our understanding of the underlying neurobiology and pathophysiology of mTBI and concussion from both basic animal models and human studies. Collectively, the fact that nearly 100 studies included in our systematic review have employed advanced technologies specifically in the study of SRC over the past 15 years is a clear indication of how research in this arena has progressed. That said, the current state of this work is limited by several factors, including the relatively small number of studies investigating each modality, small sample sizes across studies, varied study design, outcome measures and analytic methods, and lack of consistency in the timing of postinjury data collection points, and risk of bias due to very limited generalisability across studies.

The collective body included in our systematic review was considered to have at least moderate risk of bias based on our assessment. *The risk of bias rating was clearly affected more by limited generalisability than by any inherent or created bias in the traditional sense associated with investigator conflicts, research design, outside influence, etc*. Generalisability was limited largely by the size and scope of the study sample (eg, restricted to single gender or sport) in several studies. This will be an important consideration for future research efforts to overcome.

Ultimately, determining the utility of these advanced technologies likely divides into two parallel discussions: (1) their use as research tools to study changes in brain structure and function associated with SRC, and (2) their clinical application as diagnostic and prognostic markers of injury and recovery to assist in the assessment and management of athletes with SRC, over and above our current clinical tools. In terms of their current readiness for *clinical application*, our systematic review rated the level of evidence as low for advanced neuroimaging, low for fluid biomarkers and low for genetic testing (see table 5). At the same time, however, our systematic review generally supports the utility of advanced neuroimaging, fluid and genetic biomarkers in studies aimed at identifying the neurobiological effects of concussion and the natural history of neurobiological recovery after injury.

Our rating of the neuroimaging evidence is consistent with a recently published position statement from the Radiologic Society for North America on the use of advanced neuroimaging modalities in the assessment of TBI. Advanced neuroimaging is sure to play a critical role in the future study of SRC. Similarly, the use of fluid biomarkers has advanced our understanding of the pathophysiology of SRC, but the validation of these markers is in the preliminary stages. Clinically, blood biomarkers require hours of analysis and access to a basic science laboratory, which is not currently practical for assessing acute SRC in the competitive sports setting. Future studies with larger samples sizes, standardised protocols, and more stringent study designs that include baseline testing, appropriate controls, blinded analysis and real-life outcome measures, are needed before these markers are translated from 'bench to bedside'.

Further research is critical to determine whether the time course of neurobiological recovery is 'coupled' with clinical or subjective recovery (eg, resolutions of signs, symptoms and functional impairments), or the extent to which the tail of neurobiological recovery extends beyond the observed endpoint of clinical recovery. In a research setting, this work is a critical next step towards understanding the pathophysiology of concussion in humans. From a clinical perspective, discoveries along these lines also have translational significance to determining when athletes achieve full recovery and are fit to safely return to activity without elevated risk or vulnerability to additional injury. Further, the novel technologies may enable researchers to better determine the effects of repetitive head impact exposure on brain structure and function, even in the absence of frank concussion.

It should be acknowledged that genetic testing is not intended for use in the diagnosis of concussion, but has importance in determining the factors that influence risk of injury and recovery after SRC. Data from genetic studies may provide intriguing insights about the host response to concussion, although the absence of data on how such differential gene expression affects outcome limits inferences about whether these changes constitute a contributory disease mechanism or a reparative host response. There is a clear need for large-scale research efforts to determine the role that genetics plays in the broader space of TBI and with specific relevance to athletes with SRC.

Given the complex pathophysiology of concussion, it is considered unlikely that a singular diagnostic and prognostic biomarker solution will prevail. Rather, an integrated combination of specific imaging, fluid and genetic biomarkers is predicted to have the greatest utility to clinical care. Ultimately, research on neurobiological and genetic aspects of SRC is predicted to have major translational significance to evidence-based approaches to clinical management of athletes with SRC, much like applied clinical research has had over the past 20 years.

RECOMMENDATIONS FOR FUTURE RESEARCH DIRECTIONS

We offer the following recommendations in order to further accelerate the field's understanding of the pathophysiology of SRC and to determine the potential of these advanced technologies for the clinical assessment of SRC:

1. Enrolment of larger sample sizes with greater representation across sport, age and sex, particularly studies involving youth and female athletes.
2. Preinjury enrolment of athletes to allow truly prospective recruitment of consecutive injuries. Although often impractical for neuroimaging, collecting biomarkers at preinjury would represent an ideal study design.
3. Studies driven by a priori hypotheses based on current evidence on neuropathophysiology of concussion from preclinical models and non-sport head injury. Exploratory

(hypothesis-generating) research may also lead to important breakthroughs.
4. Careful consideration regarding the control groups used (eg, controlling for head impact exposure vs concussive injury) in order to advance our understanding of the effects of both concussion and repetitive head impact exposure (without concussion) on brain structure and function.
5. Adopt standard injury criteria, time frames of assessment and multidimensional measures of outcome and recovery, as well as metrics and processing strategies within modalities/metrics to allow comparison across studies (eg, National Institute of Neurological Disorders and Stroke TBI Common Data Elements, Canadian Pediatric mTBI Common Data Elements).
6. Simultaneous assessment of multiple biomarkers to determine the additive value of each marker in the clinical assessment of SRC.
7. Rather than simply showing associations between measurements and diagnosis or outcome, it is important to demonstrate additional benefit of novel biomarkers over current approaches.
8. Clinical utility is more likely to derive from biomarker combinations rather than individual biomarkers; we recommend the exploration of biomarker panels, both within and across techniques.

Several limitations of our systematic search and review warrant consideration. First, we recognise that the scope of our assigned systematic review was purposefully broad in order to inform the 5th International Consensus Conference on Concussion in Sport, but still rendered a relatively small number of qualifying studies, particularly with respect to fluid biomarkers and genetics. In addition to the aforementioned methodological limitations that impact the quality of evidence from reviewed studies, we also acknowledge the potential for publication bias (eg, public reporting of positive findings only) affecting our results of the systematic review. Further, articles included for review were limited to those published in English language, raising the prospect that studies published in other languages are not represented here.

CONCLUSION

Our results indicate that advanced neuroimaging, fluid biomarkers and genetic testing show significant promise as research tools in the study of SRC, but require considerable further research to determine their ultimate utility in a clinical setting. Future research efforts should address current gaps to help guide and accelerate clinical translation.

What are the findings?

- Over the past two decades, there has been a major expansion of research on the neurobiology of SRC, marked by the increase in number of studies that have employed advanced neuroimaging and fluid biomarkers to measure the acute effects of SRC on brain structure and function.
- These technologies show significant promise as research tools, but require considerable further research to determine their ultimate clinical utility.
- Future research efforts should address current gaps that limit clinical translation, including greater consistency across the most advanced technology platforms, larger and more representative study samples (across age, gender, sport, etc), and more rigorous analytic methods across studies.

How might it impact on clinical practice in the future?

- Ultimately, this line of research on neurobiological and genetic aspects of SRC is predicted to have major translational significance to evidence-based approaches to clinical management of athletes with SRC, much like applied clinical research has had over the past 20 years.

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Role of advanced neuroimaging, fluid biomarkers and genetic testing in the assessment of sport-related concussion: a systematic review

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CONCUSSION RECOGNITION TOOL 5 ©

To help identify concussion in children, adolescents and adults

Supported by

RECOGNISE & REMOVE

Head impacts can be associated with serious and potentially fatal brain injuries. The Concussion Recognition Tool 5 (CRT5) is to be used for the identification of suspected concussion. It is not designed to diagnose concussion.

STEP 1: RED FLAGS — CALL AN AMBULANCE

If there is concern after an injury including whether ANY of the following signs are observed or complaints are reported then the player should be safely and immediately removed from play/game/activity. If no licensed healthcare professional is available, call an ambulance for urgent medical assessment:

- **Neck pain or tenderness**
- **Double vision**
- **Weakness or tingling/ burning in arms or legs**
- **Severe or increasing headache**
- **Seizure or convulsion**
- **Loss of consciousness**
- **Deteriorating conscious state**
- **Vomiting**
- **Increasingly restless, agitated or combative**

Remember:

- In all cases, the basic principles of first aid (danger, response, airway, breathing, circulation) should be followed.
- Assessment for a spinal cord injury is critical.
- Do not attempt to move the player (other than required for airway support) unless trained to so do.
- Do not remove a helmet or any other equipment unless trained to do so safely.

If there are no Red Flags, identification of possible concussion should proceed to the following steps:

STEP 2: OBSERVABLE SIGNS

Visual clues that suggest possible concussion include:

- Lying motionless on the playing surface
- Slow to get up after a direct or indirect hit to the head
- Disorientation or confusion, or an inability to respond appropriately to questions
- Blank or vacant look
- Balance, gait difficulties, motor incoordination, stumbling, slow laboured movements
- Facial injury after head trauma

STEP 3: SYMPTOMS

- Headache
- "Pressure in head"
- Balance problems
- Nausea or vomiting
- Drowsiness
- Dizziness
- Blurred vision
- Sensitivity to light
- Sensitivity to noise
- Fatigue or low energy
- "Don't feel right"
- More emotional
- More Irritable
- Sadness
- Nervous or anxious
- Neck Pain
- Difficulty concentrating
- Difficulty remembering
- Feeling slowed down
- Feeling like "in a fog"

STEP 4: MEMORY ASSESSMENT

(IN ATHLETES OLDER THAN 12 YEARS)

Failure to answer any of these questions (modified appropriately for each sport) correctly may suggest a concussion:

- "What venue are we at today?"
- "Which half is it now?"
- "Who scored last in this game?"
- "What team did you play last week/game?"
- "Did your team win the last game?"

Athletes with suspected concussion should:

- Not be left alone initially (at least for the first 1-2 hours).
- Not drink alcohol.
- Not use recreational/ prescription drugs.
- Not be sent home by themselves. They need to be with a responsible adult.
- Not drive a motor vehicle until cleared to do so by a healthcare professional.

ANY ATHLETE WITH A SUSPECTED CONCUSSION SHOULD BE IMMEDIATELY REMOVED FROM PRACTICE OR PLAY AND SHOULD NOT RETURN TO ACTIVITY UNTIL ASSESSED MEDICALLY, EVEN IF THE SYMPTOMS RESOLVE

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University Concussion Return to Play Form

This form is adapted from the Acute Concussion Evaluation (ACE) care plan on the U.S. Centers for Disease Control web site www.cdc.gov/injury. All medical providers are encouraged to review this site if they have questions regarding the latest information on the evaluation and care of the athlete following a concussion injury. **Providers, please initial any recommendations that you select.**

Athlete's Name _____ Date of Birth: _____

School: _____ Team / Sport: _____

HISTORY OF INJURY Person Completing Form (*Circle One*): Athletic Trainer | First Responder | Coach | Parent | Student

Date of Injury: _____ ☐ Please see attached information ☐ Please see further history on back of this form

Did the athlete have:	(Circle one)	Duration / Resolution
Loss of consciousness or unresponsiveness?	YES | NO	Duration: _____
Seizure or convulsive activity?	YES | NO	Duration: _____
Balance problem / unsteadiness?	YES | NO	IF YES, HAS THIS RESOLVED? YES | NO
Dizziness?	YES | NO	IF YES, HAS THIS RESOLVED? YES | NO
Headache?	YES | NO	IF YES, HAS THIS RESOLVED? YES | NO
Nausea?	YES | NO	IF YES, HAS THIS RESOLVED? YES | NO
Emotional instability (abnormal laughing, crying, smiling, anger)?	YES | NO	IF YES, HAS THIS RESOLVED? YES | NO
Confusion?	YES | NO	IF YES, HAS THIS RESOLVED? YES | NO
Difficulty concentrating?	YES | NO	IF YES, HAS THIS RESOLVED? YES | NO
Vision Problems?	YES | NO	IF YES, HAS THIS RESOLVED? YES | NO
Other: _____	YES | NO	IF YES, HAS THIS RESOLVED? YES | NO

Signature: _____ Date: _____

PHYSICIAN RECOMMENDATIONS This return to play plan is based on today's evaluation.

RETURN TO SPORTS

PLEASE NOTE:

1. **Athletes must not return to practice or play the same day that their suspected concussion occurred.**
2. **Athletes should never return to play or practice if they still have ANY symptoms of concussion.**
3. Athletes, be sure your coach/athletic trainer are aware of your injury & symptoms, and have contact information for treating physician.

The following are the return to sports recommendations at the present time:

SCHOOL (ACADEMICS): ___ May return to school now. ___ May return to school on _____. ___Out of school until follow-up visit

PHYSICAL EDUCATION: ___ Do NOT return to PE class at this time. ___ May Return to PE class.

SPORTS: ___ Do not return to sports practice or competition at this time.

___ May gradually return to sports practice under supervision of the health care provider for your team or sport.

___ May be advanced back to competition after phone conversation with attending physician.

___ Must return to Physician for final clearance to return to competition.

- OR - ___ FULL CLEARANCE: May return to full participation in ALL activities (PE and Sports).

Return to this office on (date/time) _____ ☐ No follow-up needed.

Additional Comments: _____ ☐ See further follow-up information on back.

Medical Office Information **(Please Print/Stamp)**

Physician' Name (please print) _____

Physician's Phone _____

Office Address _____

_____

(Circle One)

Physician's Signature (required) _____, M.D. | D.O

Date _____

- All students must have an MD or DO signature to return to play
- More than one evaluation is typically necessary for medical clearance for concussion as symptoms may not fully be present for days. Due to the need to monitor concussions for recurrence of signs & symptoms with cognitive or physical stress. **Emergency Room and urgent Care physicians typically do not make clearance decisions at the time of first visit.**
- Physician signing this form is licensed and has training in concussion management.

A physician may delegate aspects of the Return to play process to a licensed athletic trainer, nurse practitioner or physician assistant, and may work in collaboration with a licensed neuropsychologist in compliance for RTP clearance.

Medical Provider Name (please print) _____

NP, PA-C, LAT, Neuropsychologist (please circle one)

Office Address _____

_____

Phone Number _____

Signature (required) _____

Date _____

Name and contact information of supervising/collaborating physician

_____

_____

Return to Learn

You have been diagnosed with a concussion, a type of brain injury caused by a sudden impact to your head. It can also be caused by sudden movement of your brain inside your head, such as from forceful shaking. Some concussions are mild, and most patients have a full recovery. Others are severe. Early care and monitoring are important to prevent long-term complications.

What to Expect at Home

Healing from a concussion takes days to weeks or even months. You (or your child's) condition will slowly improve.

When You (or your child) First Go (Goes) Home

You may use acetaminophen (Tylenol) for a headache. ***DO NOT use aspirin, ibuprofen (Motrin®, Advil®, Naproxen), or other non-steroidal anti-inflammatory drugs, or NSAIDS.*** If you have a headache, try placing a cold, damp cloth on your forehead.

Make sure to eat foods that are easy to digest. Light activity around the home is okay. Rest is extremely important; however, this does not mean to stay in bed. It is very important that abstain for any activity that may result in another, or similar, head injury.

Don't drink alcohol or use any recreational drugs.

Be wary of activities that need concentration, such as reading, homework, and complex tasks.

Ask a friend or family member to stay with you for a few days. You should not be alone until you know how the injury has affected you.

Tell your caregiver to wake you every 2 to 3 hours during the first night. **Your caregiver should call 911 if he or she can't wake you, or if you are confused.**

Returning to School

As long as you display symptoms, you should avoid sports, strenuous exercise, being overly active, and physical education class. Ask the doctor when you can return to your normal activities.

Make sure your teachers, physical education teacher, coaches, and school nurse are aware of the recent injury.

Talk to teachers about helping you catch up on school work. Also, ask about timing of tests or major projects. Teachers should also understand that you may be more tired, withdrawn, easily upset, or confused. You may also have a hard time with tasks that require remembering or concentrating. You may experience mild headaches and be less tolerant of noise. If you experience symptoms in school, you may want to stay home until the symptoms are alleviated.

Concussion Awareness and Dangers of Concussion *(continued)*

Discuss with your teachers about:

- Reducing the amount of homework or class work you may need to complete
- Allowing you to turn assignments in late as needed
- Providing extra time to study and complete tests
- Being patient with your conduct and behaviors as you recover

Based on how bad the head injury was, you may need to wait 1 to 3 months before doing the following activities.

Ask your primary health care physician about:

- Playing contact sports, such as football, hockey, and soccer
- Riding a bicycle, motorcycle, or off-road vehicle
- Driving a car (if they are old enough and licensed)
- Skiing, snowboarding, skating, skateboarding, gymnastics, or martial arts
- Participating in any activity where there is a risk of hitting the head or of a jolt to the head

Some organizations recommend that you stay away from sports activities that could produce a similar head injury, for the rest of the season.

When to Seek Medical Attention

Your caregiver should call 911 right away if you have fallen asleep, cannot be awakened, or you are confused.

If symptoms do not go away or are not significantly improving after 2 or 3 weeks, follow-up with your primary healthcare physician.

Call the doctor if you are experiencing any of the following symptoms:

- A stiff neck
- Fluid or blood leaking from the nose or ears
- Any change in awareness, a hard time waking up, or has become more sleepy
- A headache that is getting worse, lasts a long time, or is not relieved by acetaminophen (Tylenol)
- Fever
- Vomiting more than 3 times
- Problems walking or talking
- Changes in speech (slurred, difficult to understand, does not make sense)
- Problems thinking straight
- Seizures (jerking arms or legs without control)
- Changes in behavior or unusual behavior
- Double vision
- Changes in eating patterns

Gradual Return to Play Plan

Return to play should occur in gradual steps beginning with light aerobic exercise only to increase your heart rate (e.g. stationary cycle); moving to increasing your heart rate with movement (e.g. running); then adding controlled contact if appropriate; and finally return to sports competition.

Pay careful attention to your symptoms and your thinking and concentration skills at each stage or activity. After completion of each step without recurrence of symptoms, you can move to the next level of activity the next day. ***Move to the next level of activity only if you do not experience any symptoms at the present level***, if your symptoms return, let your health care provider know, return to the first level and restart the program gradually.

Stage	Exercise	Date	Completed/Comments	Supervised By
1	20-30 minutes of cardio activity: walking, stationary bike. Weightlifting at light intensity (no benching or squatting): low weight, high reps. **Goal: 30-40% of maximum heart rate.**			
2	30 minutes of cardio activity: jogging at medium pace. Sit-ups, push-ups, lunge walks x 25 each. Weightlifting at moderate intensity. **Goal: 40-60% of maximum heart rate.**			
3	30 minutes of cardio activity: running at fast pace. Sit-ups, push-ups, lunge walks x 50 each. Sport-specific agility drills in three planes of movement. Resume regular weightlifting routine. **Goal: 60-80% of maximum heart rate.**			
4*	Participate in non-contact practice drills. Warm-up and stretch x 10 minutes. Intense, non-contact sport-specific agility drills x 60 minutes. **Goal: 80-100% of maximum heart rate.**			
5	Participate in controlled contact practice.			
6	Resume full participation in competition.			

Pocket CONCUSSION RECOGNITION TOOL™

To help identify concussion in children, youth and adults

RECOGNIZE & REMOVE

Concussion should be suspected **if one or more** of the following visible clues, signs, symptoms or errors in memory questions are present.

1. Visible clues of suspected concussion

Any one or more of the following visual clues can indicate a possible concussion:

Loss of consciousness or responsiveness
Lying motionless on ground/Slow to get up
Unsteady on feet / Balance problems or falling over/Incoordination
Grabbing/Clutching of head
Dazed, blank or vacant look
Confused/Not aware of plays or events

2. Signs and symptoms of suspected concussion

Presence of any one or more of the following signs & symptoms may suggest a concussion:

- Loss of consciousness
- Seizure or convulsion
- Balance problems
- Nausea or vomiting
- Drowsiness
- More emotional
- Irritability
- Sadness
- Fatigue or low energy
- Nervous or anxious
- "Don't feel right"
- Difficulty remembering
- Headache
- Dizziness
- Confusion
- Feeling slowed down
- "Pressure in head"
- Blurred vision
- Sensitivity to light
- Amnesia
- Feeling like "in a fog"
- Neck Pain
- Sensitivity to noise
- Difficulty concentrating

3. Memory function

Failure to answer any of these questions correctly may suggest a concussion.

"What venue are we at today?"
"Which half is it now?"
"Who scored last in this game?"
"What team did you play last week/game?"
"Did your team win the last game?"

Any athlete with a suspected concussion should be IMMEDIATELY REMOVED FROM PLAY, and should not be returned to activity until they are assessed medically. Athletes with a suspected concussion should not be left alone and should not drive a motor vehicle.

It is recommended that, in all cases of suspected concussion, the player is referred to a medical professional for diagnosis and guidance as well as return to play decisions, even if the symptoms resolve.

RED FLAGS

If ANY of the following are reported then the player should be safely and immediately removed from the field. If no qualified medical professional is available, consider transporting by ambulance for urgent medical assessment:

- Athlete complains of neck pain
- Increasing confusion or irritability
- Repeated vomiting
- Seizure or convulsion
- Weakness or tingling/burning in arms or legs
- Deteriorating conscious state
- Severe or increasing headache
- Unusual behaviour change
- Double vision

Remember:

- In all cases, the basic principles of first aid (danger, response, airway, breathing, circulation) should be followed.
- Do not attempt to move the player (other than required for airway support) unless trained to so do
- Do not remove helmet (if present) unless trained to do so.

from McCrory et. al, Consensus Statement on Concussion in Sport. Br J Sports Med 47 (5), 2013

Concussion Protocol

Education

Concussion is a common consequence of trauma to the head, and can occur in a variety of sports. Among people aged 15-24 years, sports are now second only to motor vehicle accidents as the leading cause of traumatic brain injury. The majority of concussions are self-limited injuries; however catastrophic results can occur and the long-term effects of multiple concussions are unknown.

All concussions are serious, and all athletes with a suspected concussion should not return to play until they have been seen and cleared by a qualified physician. Returning to play prematurely after a concussion can lead to another concussion or even death. Athletes with a history of concussion may be more likely to experience another concussion than an athlete with no history of concussion.

Every concussion is different. Some symptoms may appear right away, while others may not show up for days or weeks after the initial injury. Occasionally an athlete may receive a blow that results in a stunned confused feeling that goes away within minutes. This is still considered a concussion, although short in duration.

Part 2: Recognition/Evaluation

When a student-athlete shows any signs, symptoms or behaviors consistent with a concussion, the athlete shall be immediately removed from athletic participation until a thorough sideline head injury assessment can be performed by the Certified Athletic Trainer (ATC). The sideline head injury assessment to determine the presence of a concussion will include:

- Head Injury Initial Evaluation Form
- Sport Concussion Assessment Tool (SCAT5)

Signs & Symptoms

Signs:

- Difficulty concentrating
- Inappropriate playing behavior
- Decreased playing ability
- Inability to perform daily activities
- Reduced attention
- Cognitive and memory dysfunction
- Sleep disturbances
- Vacant stare
- Loss of bowel and/or bladder control
- Personality change
- Unsteadiness of gait
- Slurred/incoherent speech
- Loss of consciousness

Symptoms:

- Nausea/vomiting
- Dizziness
- Confusion
- Fatigue
- Light headedness
- Headaches
- Irritability
- Disorientation
- Seeing bright lights/stars
- Feeling of being stunned
- Depression
- Ringing in the ears

Concussion Protocol

(continued)

Due to the serious nature of this injury and potential dangerous results of returning to activity, concussions need to be recognized and diagnosed as soon as possible. It is required that student-athletes be truthful about injuries they have sustained to RWC staff. Athletes should inform an RWC ATC as soon as any abnormal signs or symptoms are present. If an ATC determines an athlete has a concussion, the athlete will be placed on the **No-Play list, and they must complete the following steps:

- Stay in contact with the athletic trainer by reporting signs and symptoms
- Stop participation in all activities.
- Once symptom free for 24 hours, the athlete may contact an RWC athletic trainer to begin the Return to Play Protocol
- Complete the Return to Play protocol while remaining symptom free
- Obtain final clearance for return to play by a qualified physician

**When the athlete is placed on the no-play list, they will be suspended from use of the Recreation and Wellness Center, including participating in intramurals and/or club sports, until they have completed the Return to Play protocol and have received final clearance from a qualified physician. The athlete must return a note from the evaluating physician to the Athletic Training Coordinator to be removed from suspension.

Recovery

How fast people recover from a concussion varies from person to person.

Although most people have a good recovery, how quickly depends on many factors. These factors include how severe the concussion was, what part of the brain was injured, their age, and how healthy they were before the concussion.

Rest is very important after a concussion because it helps the brain to heal. The student-athlete will need to be extremely patient because healing takes time. As the days go by, they can expect to gradually feel better. While they are healing, they should be very careful to avoid doing anything that could cause a blow to your head. On rare occasions, receiving another blow before a concussion has healed can be fatal.

Here are some tips for healing:

- Get plenty of sleep at night and rest during the day
- Return to activities gradually, not all at once
- Avoid activities that could lead to a second brain injury until cleared by a Doctor
- Take only those drugs that your Doctor has approved

Concussion Protocol

(continued)

Student Resources & Contact Info

Be sure to utilize the RWC certified athletic trainers. If a student-athlete is interested in meeting with an athletic trainer during open clinic hours, all they need to do is come to the RWC Athletic Training room between 2:00 pm and 5:00 pm Mon. - Fri.

Students should also use resources such as the Student Health Services. This resource is included in student fees and is free for current students. The sports medicine staff is led by Dr. _____ and his/her staff can direct you to further testing and provide further medical assistance. The Student Health Services' doctors can also set students up with academic services if the injury is preventing someone from getting to class.

If you have any other questions, please feel free to contact us here at the RWC.

SCAT3™

Sport Concussion Assessment Tool – 3rd Edition

For use by medical professionals only

Name

Date/Time of Injury:
Date of Assessment:

Examiner:

What is the SCAT3?[1]

The SCAT3 is a standardized tool for evaluating injured athletes for concussion and can be used in athletes aged from 13 years and older. It supersedes the original SCAT and the SCAT2 published in 2005 and 2009, respectively[2]. For younger persons, ages 12 and under, please use the Child SCAT3. The SCAT3 is designed for use by medical professionals. If you are not qualified, please use the Sport Concussion Recognition Tool[1]. Preseason baseline testing with the SCAT3 can be helpful for interpreting post-injury test scores.

Specific instructions for use of the SCAT3 are provided on page 3. If you are not familiar with the SCAT3, please read through these instructions carefully. This tool may be freely copied in its current form for distribution to individuals, teams, groups and organizations. Any revision or any reproduction in a digital form requires approval by the Concussion in Sport Group.

NOTE: The diagnosis of a concussion is a clinical judgment, ideally made by a medical professional. The SCAT3 should not be used solely to make, or exclude, the diagnosis of concussion in the absence of clinical judgement. An athlete may have a concussion even if their SCAT3 is "normal".

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific signs and/or symptoms (some examples listed below) and most often does not involve loss of consciousness. Concussion should be suspected in the presence of **any one or more** of the following:

- Symptoms (e.g., headache), or
- Physical signs (e.g., unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour (e.g., change in personality).

SIDELINE ASSESSMENT

Indications for Emergency Management

NOTE: A hit to the head can sometimes be associated with a more serious brain injury. Any of the following warrants consideration of activating emergency procedures and urgent transportation to the nearest hospital:

- Glasgow Coma score less than 15
- Deteriorating mental status
- Potential spinal injury
- Progressive, worsening symptoms or new neurologic signs

Potential signs of concussion?

If any of the following signs are observed after a direct or indirect blow to the head, the athlete should stop participation, be evaluated by a medical professional and **should not be permitted to return to sport the same day** if a concussion is suspected.

Any loss of consciousness?	☐ Y ☐ N
"If so, how long?"	
Balance or motor incoordination (stumbles, slow/laboured movements, etc.)?	☐ Y ☐ N
Disorientation or confusion (inability to respond appropriately to questions)?	☐ Y ☐ N
Loss of memory:	☐ Y ☐ N
"If so, how long?"	
"Before or after the injury?"	
Blank or vacant look:	☐ Y ☐ N
Visible facial injury in combination with any of the above:	☐ Y ☐ N

1 Glasgow coma scale (GCS)

Best eye response (E)	
No eye opening	1
Eye opening in response to pain	2
Eye opening to speech	3
Eyes opening spontaneously	4
Best verbal response (V)	
No verbal response	1
Incomprehensible sounds	2
Inappropriate words	3
Confused	4
Oriented	5
Best motor response (M)	
No motor response	1
Extension to pain	2
Abnormal flexion to pain	3
Flexion/Withdrawal to pain	4
Localizes to pain	5
Obeys commands	6
Glasgow Coma score (E + V + M)	of 15

GCS should be recorded for all athletes in case of subsequent deterioration.

2 Maddocks Score[3]

"I am going to ask you a few questions, please listen carefully and give your best effort."

Modified Maddocks questions (1 point for each correct answer)

What venue are we at today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week/game?	0	1
Did your team win the last game?	0	1
Maddocks score		of 5

Maddocks score is validated for sideline diagnosis of concussion only and is not used for serial testing.

Notes: Mechanism of Injury ("tell me what happened"?):

Any athlete with a suspected concussion should be REMOVED FROM PLAY, medically assessed, monitored for deterioration (i.e., should not be left alone) and should not drive a motor vehicle until cleared to do so by a medical professional. No athlete diagnosed with concussion should be returned to sports participation on the day of Injury.

BACKGROUND

Name: _____ Date: _____

Examiner: _____

Sport/team/school: _____ Date/time of injury: _____

Age: _____ Gender: ☐ M ☐ F

Years of education completed: _____

Dominant hand: ☐ right ☐ left ☐ neither

How many concussions do you think you have had in the past? _____

When was the most recent concussion? _____

How long was your recovery from the most recent concussion? _____

Have you ever been hospitalized or had medical imaging done for a head injury? ☐ Y ☐ N

Have you ever been diagnosed with headaches or migraines? ☐ Y ☐ N

Do you have a learning disability, dyslexia, ADD/ADHD? ☐ Y ☐ N

Have you ever been diagnosed with depression, anxiety or other psychiatric disorder? ☐ Y ☐ N

Has anyone in your family ever been diagnosed with any of these problems? ☐ Y ☐ N

Are you on any medications? If yes, please list: ☐ Y ☐ N

_____

SCAT3 to be done in resting state. Best done 10 or more minutes post excercise.

SYMPTOM EVALUATION

3 How do you feel?

"You should score yourself on the following symptoms, based on how you feel now".

	none	mild			moderate		severe
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22) _____

Symptom severity score (Maximum possible 132) _____

Do the symptoms get worse with physical activity? ☐ Y ☐ N

Do the symptoms get worse with mental activity? ☐ Y ☐ N

☐ self rated ☐ self rated and clinician monitored

☐ clinician interview ☐ self rated with parent input

Overall rating: If you know the athlete well prior to the injury, how different is the athlete acting compared to his/her usual self?

Please circle one response:

no different	very different	unsure	N/A

Scoring on the SCAT3 should not be used as a stand-alone method to diagnose concussion, measure recovery or make decisions about an athlete's readiness to return to competition after concussion. Since signs and symptoms may evolve over time, it is important to consider repeat evaluation in the acute assessment of concussion.

COGNITIVE & PHYSICAL EVALUATION

4 Cognitive assessment

Standardized Assessment of Concussion (SAC)[4]

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score		of 5

Immediate memory

List	Trial 1		Trial 2		Trial 3		Alternative word list		
elbow	0	1	0	1	0	1	candle	baby	finger
apple	0	1	0	1	0	1	paper	monkey	penny
carpet	0	1	0	1	0	1	sugar	perfume	blanket
saddle	0	1	0	1	0	1	sandwich	sunset	lemon
bubble	0	1	0	1	0	1	wagon	iron	insect
Total									

Immediate memory score total of 15

Concentration: Digits Backward

List	Trial 1		Alternative digit list		
4-9-3	0	1	6-2-9	5-2-6	4-1-5
3-8-1-4	0	1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0	1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0	1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6
Total of 4					

Concentration: Month in Reverse Order (1 pt. for entire sequence correct)

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan	0	1
Concentration score		of 5

5 Neck Examination:

Range of motion Tenderness Upper and lower limb sensation & strength

Findings: _____

6 Balance examination

Do one or both of the following tests.

Footwear (shoes, barefoot, braces, tape, etc.) _____

Modified Balance Error Scoring System (BESS) testing[5]

Which foot was tested (i.e. which is the **non-dominant** foot) ☐ Left ☐ Right

Testing surface (hard floor, field, etc.) _____

Condition

Double leg stance:	Errors
Single leg stance (non-dominant foot):	Errors
Tandem stance (non-dominant foot at back):	Errors

And / Or

Tandem gait[6,7]

Time (best of 4 trials): _____ seconds

7 Coordination examination

Upper limb coordination

Which arm was tested: ☐ Left ☐ Right

Coordination score of 1

8 SAC Delayed Recall[4]

Delayed recall score of 5

INSTRUCTIONS

Words in *Italics* throughout the SCAT3 are the instructions given to the athlete by the tester.

Symptom Scale

"You should score yourself on the following symptoms, based on how you feel now".

To be completed by the athlete. In situations where the symptom scale is being completed after exercise, it should still be done in a resting state, at least 10 minutes post exercise.

For total number of symptoms, maximum possible is 22.

For Symptom severity score, add all scores in table, maximum possible is 22 x 6 = 132.

SAC[4]

Immediate Memory

"I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order."

Trials 2 & 3:

"I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before."

Complete all 3 trials regardless of score on trial 1 & 2. Read the words at a rate of one per second. **Score 1 pt. for each correct response.** Total score equals sum across all 3 trials. Do not inform the athlete that delayed recall will be tested.

Concentration

Digits backward

"I am going to read you a string of numbers and when I am done, you repeat them back to me backwards, in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7."

If correct, go to next string length. If incorrect, read trial 2. **One point possible for each string length**. Stop after incorrect on both trials. The digits should be read at the rate of one per second.

Months in reverse order

"Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November … Go ahead"

1 pt. for entire sequence correct

Delayed Recall

The delayed recall should be performed after completion of the Balance and Coordination Examination.

"Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order."

Score 1 pt. for each correct response

Balance Examination

Modified Balance Error Scoring System (BESS) testing[5]

This balance testing is based on a modified version of the Balance Error Scoring System (BESS)[5]. A stopwatch or watch with a second hand is required for this testing.

"I am now going to test your balance. Please take your shoes off, roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable). This test will consist of three twenty second tests with different stances."

(a) Double leg stance:

"The first stance is standing with your feet together with your hands on your hips and with your eyes closed. You should try to maintain stability in that position for 20 seconds. I will be counting the number of times you move out of this position. I will start timing when you are set and have closed your eyes."

(b) Single leg stance:

"If you were to kick a ball, which foot would you use? [This will be the dominant foot] Now stand on your non-dominant foot. The dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."

(c) Tandem stance:

"Now stand heel-to-toe with your non-dominant foot in back. Your weight should be evenly distributed across both feet. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."

Balance testing – types of errors

1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into > 30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position > 5 sec

Each of the 20-second trials is scored by counting the errors, or deviations from the proper stance, accumulated by the athlete. The examiner will begin counting errors only after the individual has assumed the proper start position. **The modified BESS is calculated by adding one error point for each error during the three 20-second tests. The maximum total number of errors for any single condition is 10.** If a athlete commits multiple errors simultaneously, only one error is recorded but the athlete should quickly return to the testing position, and counting should resume once subject is set. Subjects that are unable to maintain the testing procedure for a minimum of **five seconds** at the start are assigned the highest possible score, ten, for that testing condition.

OPTION: For further assessment, the same 3 stances can be performed on a surface of medium density foam (e.g., approximately 50 cm x 40 cm x 6 cm).

Tandem Gait[6,7]

Participants are instructed to stand with their feet together behind a starting line (the test is best done with footwear removed). Then, they walk in a forward direction as quickly and as accurately as possible along a 38mm wide (sports tape), 3 meter line with an alternate foot heel-to-toe gait ensuring that they approximate their heel and toe on each step. Once they cross the end of the 3m line, they turn 180 degrees and return to the starting point using the same gait. A total of 4 trials are done and the best time is retained. Athletes should complete the test in 14 seconds. Athletes fail the test if they step off the line, have a separation between their heel and toe, or if they touch or grab the examiner or an object. In this case, the time is not recorded and the trial repeated, if appropriate.

Coordination Examination

Upper limb coordination

Finger-to-nose (FTN) task:

"I am going to test your coordination now. Please sit comfortably on the chair with your eyes open and your arm (either right or left) outstretched (shoulder flexed to 90 degrees and elbow and fingers extended), pointing in front of you. When I give a start signal, I would like you to perform five successive finger to nose repetitions using your index finger to touch the tip of the nose, and then return to the starting position, as quickly and as accurately as possible."

Scoring: 5 correct repetitions in < 4 seconds = 1

Note for testers: Athletes fail the test if they do not touch their nose, do not fully extend their elbow or do not perform five repetitions. **Failure should be scored as 0.**

References & Footnotes

1. This tool has been developed by a group of international experts at the 4th International Consensus meeting on Concussion in Sport held in Zurich, Switzerland in November 2012. The full details of the conference outcomes and the authors of the tool are published in The BJSM Injury Prevention and Health Protection, 2013, Volume 47, Issue 5. The outcome paper will also be simultaneously co-published in other leading biomedical journals with the copyright held by the Concussion in Sport Group, to allow unrestricted distribution, providing no alterations are made.

2. McCrory P et al., Consensus Statement on Concussion in Sport – the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. British Journal of Sports Medicine 2009; 43: i76-89.

3. Maddocks, DL; Dicker, GD; Saling, MM. The assessment of orientation following concussion in athletes. Clinical Journal of Sport Medicine. 1995; 5(1): 32–3.

4. McCrea M. Standardized mental status testing of acute concussion. Clinical Journal of Sport Medicine. 2001; 11: 176–181.

5. Guskiewicz KM. Assessment of postural stability following sport-related concussion. Current Sports Medicine Reports. 2003; 2: 24–30.

6. Schneiders, A.G., Sullivan, S.J., Gray, A., Hammond-Tooke, G. & McCrory, P. Normative values for 16-37 year old subjects for three clinical measures of motor performance used in the assessment of sports concussions. Journal of Science and Medicine in Sport. 2010; 13(2): 196–201.

7. Schneiders, A.G., Sullivan, S.J., Kvarnstrom. J.K., Olsson, M., Yden. T. & Marshall, S.W. The effect of footwear and sports-surface on dynamic neurological screening in sport-related concussion. Journal of Science and Medicine in Sport. 2010; 13(4): 382–386

ATHLETE INFORMATION

Any athlete suspected of having a concussion should be removed from play, and then seek medical evaluation.

Signs to watch for

Problems could arise over the first 24–48 hours. The athlete should not be left alone and must go to a hospital at once if they:

- Have a headache that gets worse
- Are very drowsy or can't be awakened
- Can't recognize people or places
- Have repeated vomiting
- Behave unusually or seem confused; are very irritable
- Have seizures (arms and legs jerk uncontrollably)
- Have weak or numb arms or legs
- Are unsteady on their feet; have slurred speech

Remember, it is better to be safe.
Consult your doctor after a suspected concussion.

Return to play

Athletes should not be returned to play the same day of injury.
When returning athletes to play, they should be **medically cleared and then follow a stepwise supervised program,** with stages of progression.

For example:

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
No activity	Physical and cognitive rest	Recovery
Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity, 70 % maximum predicted heart rate. No resistance training	Increase heart rate
Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
Non-contact training drills	Progression to more complex training drills, eg passing drills in football and ice hockey. May start progressive resistance training	Exercise, coordination, and cognitive load
Full contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
Return to play	Normal game play	

There should be at least 24 hours (or longer) for each stage and if symptoms recur the athlete should rest until they resolve once again and then resume the program at the previous asymptomatic stage. Resistance training should only be added in the later stages.

If the athlete is symptomatic for more than 10 days, then consultation by a medical practitioner who is expert in the management of concussion, is recommended.

Medical clearance should be given before return to play.

Scoring Summary:

Test Domain	Score		
	Date:	Date:	Date:
Number of Symptoms of 22			
Symptom Severity Score of 132			
Orientation of 5			
Immediate Memory of 15			
Concentration of 5			
Delayed Recall of 5			
SAC Total			
BESS (total errors)			
Tandem Gait (seconds)			
Coordination of 1			

Notes:

CONCUSSION INJURY ADVICE

(To be given to the **person monitoring** the concussed athlete)

This patient has received an injury to the head. A careful medical examination has been carried out and no sign of any serious complications has been found. Recovery time is variable across individuals and the patient will need monitoring for a further period by a responsible adult. Your treating physician will provide guidance as to this timeframe.

If you notice any change in behaviour, vomiting, dizziness, worsening headache, double vision or excessive drowsiness, please contact your doctor or the nearest hospital emergency department immediately.

Other important points:

- Rest (physically and mentally), including training or playing sports until symptoms resolve and you are medically cleared
- No alcohol
- No prescription or non-prescription drugs without medical supervision. Specifically:
  - No sleeping tablets
  - Do not use aspirin, anti-inflammatory medication or sedating pain killers
- Do not drive until medically cleared
- Do not train or play sport until medically cleared

Clinic phone number

Patient's name

Date/time of injury

Date/time of medical review

Treating physician

Contact details or stamp

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SCAT5©

SPORT CONCUSSION ASSESSMENT TOOL – 5TH EDITION

DEVELOPED BY THE CONCUSSION IN SPORT GROUP
FOR USE BY MEDICAL PROFESSIONALS ONLY

supported by

Patient details

Name: _____

DOB: _____

Address: _____

ID number: _____

Examiner: _____

Date of Injury: _____ Time: _____

WHAT IS THE SCAT5?

The SCAT5 is a standardized tool for evaluating concussions designed for use by physicians and licensed healthcare professionals[1]. The SCAT5 cannot be performed correctly in less than 10 minutes.

If you are not a physician or licensed healthcare professional, please use the Concussion Recognition Tool 5 (CRT5). The SCAT5 is to be used for evaluating athletes aged 13 years and older. For children aged 12 years or younger, please use the Child SCAT5.

Preseason SCAT5 baseline testing can be useful for interpreting post-injury test scores, but is not required for that purpose.Detailed instructions for use of the SCAT5 are provided on page 7. Please read through these instructions carefully before testing the athlete. Brief verbal instructions for each test are given in italics. The only equipment required for the tester is a watch or timer.

Recognise and Remove

A head impact by either a direct blow or indirect transmission of force can be associated with a serious and potentially fatal brain injury. If there are significant concerns, including any of the red flags listed in Box 1, then activation of emergency procedures and urgent transport to the nearest hospital should be arranged.

Key points

- Any athlete with suspected concussion should be REMOVED FROM PLAY, medically assessed and monitored for deterioration. No athlete diagnosed with concussion should be returned to play on the day of injury.
- If an athlete is suspected of having a concussion and medical personnel are not immediately available, the athlete should be referred to a medical facility for urgent assessment.
- Athletes with suspected concussion should not drink alcohol, use recreational drugs and should not drive a motor vehicle until cleared to do so by a medical professional.
- Concussion signs and symptoms evolve over time and it is important to consider repeat evaluation in the assessment of concussion.
- The diagnosis of a concussion is a clinical judgment, made by a medical professional. The SCAT5 should NOT be used by itself to make, or exclude, the diagnosis of concussion. An athlete may have a concussion even if their SCAT5 is "normal".

Remember:

- The basic principles of first aid (danger, response, airway, breathing, circulation) should be followed.
- Do not attempt to move the athlete (other than that required for airway management) unless trained to do so.
- Assessment for a spinal cord injury is a critical part of the initial on-field assessment.
- Do not remove a helmet or any other equipment unless trained to do so safely.

1

IMMEDIATE OR ON-FIELD ASSESSMENT

The following elements should be assessed for all athletes who are suspected of having a concussion prior to proceeding to the neurocognitive assessment and ideally should be done on-field after the first first aid / emergency care priorities are completed.

If any of the "Red Flags" or observable signs are noted after a direct or indirect blow to the head, the athlete should be immediately and safely removed from participation and evaluated by a physician or licensed healthcare professional.

Consideration of transportation to a medical facility should be at the discretion of the physician or licensed healthcare professional.

The GCS is important as a standard measure for all patients and can be done serially if necessary in the event of deterioration in conscious state. The Maddocks questions and cervical spine exam are critical steps of the immediate assessment; however, these do not need to be done serially.

STEP 1: RED FLAGS

RED FLAGS:

- **Neck pain or tenderness**
- **Double vision**
- **Weakness or tingling/ burning in arms or legs**
- **Severe or increasing headache**
- **Seizure or convulsion**
- **Loss of consciousness**
- **Deteriorating conscious state**
- **Vomiting**
- **Increasingly restless, agitated or combative**

STEP 2: OBSERVABLE SIGNS

Witnessed ☐ Observed on Video ☐

Lying motionless on the playing surface	Y	N
Balance / gait difficulties / motor incoordination: stumbling, slow / laboured movements	Y	N
Disorientation or confusion, or an inability to respond appropriately to questions	Y	N
Blank or vacant look	Y	N
Facial injury after head trauma	Y	N

STEP 3: MEMORY ASSESSMENT MADDOCKS QUESTIONS[2]

"I am going to ask you a few questions, please listen carefully and give your best effort. First, tell me what happened?"

Mark Y for correct answer / N for incorrect

What venue are we at today?	Y	N
Which half is it now?	Y	N
Who scored last in this match?	Y	N
What team did you play last week / game?	Y	N
Did your team win the last game?	Y	N

Note: Appropriate sport-specific questions may be substituted.

Name: _____

DOB: _____

Address: _____

ID number: _____

Examiner: _____

Date: _____

STEP 4: EXAMINATION GLASGOW COMA SCALE (GCS)[3]

Time of assessment			
Date of assessment			
Best eye response (E)			
No eye opening	1	1	1
Eye opening in response to pain	2	2	2
Eye opening to speech	3	3	3
Eyes opening spontaneously	4	4	4
Best verbal response (V)			
No verbal response	1	1	1
Incomprehensible sounds	2	2	2
Inappropriate words	3	3	3
Confused	4	4	4
Oriented	5	5	5
Best motor response (M)			
No motor response	1	1	1
Extension to pain	2	2	2
Abnormal flexion to pain	3	3	3
Flexion / Withdrawal to pain	4	4	4
Localizes to pain	5	5	5
Obeys commands	6	6	6
Glasgow Coma score (E + V + M)			

CERVICAL SPINE ASSESSMENT

Does the athlete report that their neck is pain free at rest?	Y	N
If there is NO neck pain at rest, does the athlete have a full range of ACTIVE pain free movement?	Y	N
Is the limb strength and sensation normal?	Y	N

In a patient who is not lucid or fully conscious, a cervical spine injury should be assumed until proven otherwise.

OFFICE OR OFF-FIELD ASSESSMENT

Please note that the neurocognitive assessment should be done in a distraction-free environment with the athlete in a resting state.

STEP 1: ATHLETE BACKGROUND

Sport / team / school: _____

Date / time of injury: _____

Years of education completed: _____

Age: _____

Gender: M / F / Other

Dominant hand: left / neither / right

How many diagnosed concussions has the athlete had in the past?: _____

When was the most recent concussion?: _____

How long was the recovery (time to being cleared to play) from the most recent concussion?: _____ (days)

Has the athlete ever been:

Hospitalized for a head injury?	Yes	No
Diagnosed / treated for headache disorder or migraines?	Yes	No
Diagnosed with a learning disability / dyslexia?	Yes	No
Diagnosed with ADD / ADHD?	Yes	No
Diagnosed with depression, anxiety or other psychiatric disorder?	Yes	No

Current medications? If yes, please list:

_____

_____

_____

_____

_____

_____

Name: _____

DOB: _____

Address: _____

ID number: _____

Examiner: _____

Date: _____

2

STEP 2: SYMPTOM EVALUATION

The athlete should be given the symptom form and asked to read this instruction paragraph out loud then complete the symptom scale. For the baseline assessment, the athlete should rate his/her symptoms based on how he/she typically feels and for the post injury assessment the athlete should rate their symptoms at this point in time.

Please Check: ☐ **Baseline** ☐ **Post-Injury**

Please hand the form to the athlete

	none	mild		moderate		severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6
Trouble falling asleep (if applicable)	0	1	2	3	4	5	6

Total number of symptoms:	of 22
Symptom severity score:	of 132
Do your symptoms get worse with physical activity?	Y N
Do your symptoms get worse with mental activity?	Y N
If 100% is feeling perfectly normal, what percent of normal do you feel?	

If not 100%, why?

_____

_____

_____

Please hand form back to examiner

3

STEP 3: COGNITIVE SCREENING

Standardised Assessment of Concussion (SAC)[4]

Name: _____

DOB: _____

Address: _____

ID number: _____

Examiner: _____

Date: _____

ORIENTATION

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score		of 5

IMMEDIATE MEMORY

The Immediate Memory component can be completed using the traditional 5-word per trial list or optionally using 10-words per trial to minimise any ceiling effect. All 3 trials must be administered irrespective of the number correct on the first trial. Administer at the rate of one word per second.

Please choose EITHER the 5 or 10 word list groups and circle the specific word list chosen for this test.

I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order. For Trials 2 & 3: I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before.

List	Alternate 5 word lists					Score (of 5) Trial 1	Trial 2	Trial 3
A	Finger	Penny	Blanket	Lemon	Insect			
B	Candle	Paper	Sugar	Sandwich	Wagon			
C	Baby	Monkey	Perfume	Sunset	Iron			
D	Elbow	Apple	Carpet	Saddle	Bubble			
E	Jacket	Arrow	Pepper	Cotton	Movie			
F	Dollar	Honey	Mirror	Saddle	Anchor			
					Immediate Memory Score			of 15
					Time that last trial was completed			

List	Alternate 10 word lists					Score (of 10) Trial 1	Trial 2	Trial 3
G	Finger Candle	Penny Paper	Blanket Sugar	Lemon Sandwich	Insect Wagon			
H	Baby Elbow	Monkey Apple	Perfume Carpet	Sunset Saddle	Iron Bubble			
I	Jacket Dollar	Arrow Honey	Pepper Mirror	Cotton Saddle	Movie Anchor			
					Immediate Memory Score			of 30
					Time that last trial was completed			

CONCENTRATION

DIGITS BACKWARDS

Please circle the Digit list chosen (A, B, C, D, E, F). Administer at the rate of one digit per second reading DOWN the selected column.

I am going to read a string of numbers and when I am done, you repeat them back to me in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7.

Concentration Number Lists (circle one)

List A	List B	List C			
4-9-3	5-2-6	1-4-2	Y	N	0
6-2-9	4-1-5	6-5-8	Y	N	1
3-8-1-4	1-7-9-5	6-8-3-1	Y	N	0
3-2-7-9	4-9-6-8	3-4-8-1	Y	N	1
6-2-9-7-1	4-8-5-2-7	4-9-1-5-3	Y	N	0
1-5-2-8-6	6-1-8-4-3	6-8-2-5-1	Y	N	1
7-1-8-4-6-2	8-3-1-9-6-4	3-7-6-5-1-9	Y	N	0
5-3-9-1-4-8	7-2-4-8-5-6	9-2-6-5-1-4	Y	N	1
List D	**List E**	**List F**			
7-8-2	3-8-2	2-7-1	Y	N	0
9-2-6	5-1-8	4-7-9	Y	N	1
4-1-8-3	2-7-9-3	1-6-8-3	Y	N	0
9-7-2-3	2-1-6-9	3-9-2-4	Y	N	1
1-7-9-2-6	4-1-8-6-9	2-4-7-5-8	Y	N	0
4-1-7-5-2	9-4-1-7-5	8-3-9-6-4	Y	N	1
2-6-4-8-1-7	6-9-7-3-8-2	5-8-6-2-4-9	Y	N	0
8-4-1-9-3-5	4-2-7-9-3-8	3-1-7-8-2-6	Y	N	1
		Digits Score:			of 4

MONTHS IN REVERSE ORDER

Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November. Go ahead.

Dec - Nov - Oct - Sept - Aug - Jul - Jun - May - Apr - Mar - Feb - Jan	0 1
Months Score	of 1
Concentration Total Score (Digits + Months)	of 5

4

STEP 4: NEUROLOGICAL SCREEN

See the instruction sheet (page 7) for details of test administration and scoring of the tests.

Can the patient read aloud (e.g. symptom check-list) and follow instructions without difficulty?	Y	N
Does the patient have a full range of pain-free PASSIVE cervical spine movement?	Y	N
Without moving their head or neck, can the patient look side-to-side and up-and-down without double vision?	Y	N
Can the patient perform the finger nose coordination test normally?	Y	N
Can the patient perform tandem gait normally?	Y	N

BALANCE EXAMINATION

Modified Balance Error Scoring System (mBESS) testing[5]

Which foot was tested (i.e. which is the non-dominant foot) ☐ Left ☐ Right

Testing surface (hard floor, field, etc.) _____

Footwear (shoes, barefoot, braces, tape, etc.) _____

Condition	Errors
Double leg stance	of 10
Single leg stance (non-dominant foot)	of 10
Tandem stance (non-dominant foot at the back)	of 10
Total Errors	of 30

Name: _____

DOB: _____

Address: _____

ID number: _____

Examiner: _____

Date: _____

5

STEP 5: DELAYED RECALL:

The delayed recall should be performed after 5 minutes have elapsed since the end of the Immediate Recall section. Score 1 pt. for each correct response.

Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order.

Time Started _____

Please record each word correctly recalled. Total score equals number of words recalled.

_____

_____

_____

Total number of words recalled accurately: of 5 or of 10

6

STEP 6: DECISION

Domain	Date & time of assessment:		
Symptom number (of 22)			
Symptom severity score (of 132)			
Orientation (of 5)			
Immediate memory	of 15 of 30	of 15 of 30	of 15 of 30
Concentration (of 5)			
Neuro exam	Normal Abnormal	Normal Abnormal	Normal Abnormal
Balance errors (of 30)			
Delayed Recall	of 5 of 10	of 5 of 10	of 5 of 10

Date and time of injury: _____

If the athlete is known to you prior to their injury, are they different from their usual self?
☐ **Yes** ☐ **No** ☐ **Unsure** ☐ **Not Applicable**
(If different, describe why in the clinical notes section)

Concussion Diagnosed?
☐ **Yes** ☐ **No** ☐ **Unsure** ☐ **Not Applicable**

If re-testing, has the athlete improved?
☐ **Yes** ☐ **No** ☐ **Unsure** ☐ **Not Applicable**

I am a physician or licensed healthcare professional and I have personally administered or supervised the administration of this SCAT5.

Signature: _____

Name: _____

Title: _____

Registration number (if applicable): _____

Date: _____

SCORING ON THE SCAT5 SHOULD NOT BE USED AS A STAND-ALONE METHOD TO DIAGNOSE CONCUSSION, MEASURE RECOVERY OR MAKE DECISIONS ABOUT AN ATHLETE'S READINESS TO RETURN TO COMPETITION AFTER CONCUSSION.

CLINICAL NOTES:

Name: _____

DOB: _____

Address: _____

ID number: _____

Examiner: _____

Date: _____

CONCUSSION INJURY ADVICE

(To be given to the person monitoring the concussed athlete)

This patient has received an injury to the head. A careful medical examination has been carried out and no sign of any serious complications has been found. Recovery time is variable across individuals and the patient will need monitoring for a further period by a responsible adult. Your treating physician will provide guidance as to this timeframe.

If you notice any change in behaviour, vomiting, worsening headache, double vision or excessive drowsiness, please telephone your doctor or the nearest hospital emergency department immediately.

Other important points:

Initial rest: Limit physical activity to routine daily activities (avoid exercise, training, sports) and limit activities such as school, work, and screen time to a level that does not worsen symptoms.

1) Avoid alcohol

2) Avoid prescription or non-prescription drugs without medical supervision. Specifically:

   a) Avoid sleeping tablets

   b) Do not use aspirin, anti-inflammatory medication or stronger pain medications such as narcotics

3) Do not drive until cleared by a healthcare professional.

4) Return to play/sport requires clearance by a healthcare professional.

Clinic phone number: _____

Patient's name: _____

Date / time of injury: _____

Date / time of medical review: _____

Healthcare Provider: _____

Contact details or stamp

INSTRUCTIONS

Words in *Italics* throughout the SCAT5 are the instructions given to the athlete by the clinician

Symptom Scale

The time frame for symptoms should be based on the type of test being administered. At baseline it is advantageous to assess how an athlete "typically" feels whereas during the acute/post-acute stage it is best to ask how the athlete feels at the time of testing.

The symptom scale should be completed by the athlete, not by the examiner. In situations where the symptom scale is being completed after exercise, it should be done in a resting state, generally by approximating his/her resting heart rate.

For total number of symptoms, maximum possible is 22 except immediately post injury, if sleep item is omitted, which then creates a maximum of 21.

For Symptom severity score, add all scores in table, maximum possible is 22 x 6 = 132, except immediately post injury if sleep item is omitted, which then creates a maximum of 21x6=126.

Immediate Memory

The Immediate Memory component can be completed using the traditional 5-word per trial list or, optionally, using 10-words per trial. The literature suggests that the Immediate Memory has a notable ceiling effect when a 5-word list is used. In settings where this ceiling is prominent, the examiner may wish to make the task more difficult by incorporating two 5–word groups for a total of 10 words per trial. In this case, the maximum score per trial is 10 with a total trial maximum of 30.

Choose one of the word lists (either 5 or 10). Then perform 3 trials of immediate memory using this list.

Complete all 3 trials regardless of score on previous trials.

"I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order." The words must be read at a rate of one word per second.

Trials 2 & 3 MUST be completed regardless of score on trial 1 & 2.

Trials 2 & 3:

"I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before."

Score 1 pt. for each correct response. Total score equals sum across all 3 trials. Do NOT inform the athlete that delayed recall will be tested.

Concentration

Digits backward

Choose one column of digits from lists A, B, C, D, E or F and administer those digits as follows:

Say: *"I am going to read a string of numbers and when I am done, you repeat them back to me in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7."*

Begin with first 3 digit string.

If correct, circle "Y" for correct and go to next string length. If incorrect, circle "N" for the first string length and read trial 2 in the same string length. One point possible for each string length. Stop after incorrect on both trials (2 N's) in a string length. The digits should be read at the rate of one per second.

Months in reverse order

"Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November ... Go ahead"

1 pt. for entire sequence correct

Delayed Recall

The delayed recall should be performed after 5 minutes have elapsed since the end of the Immediate Recall section.

"Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order."

Score 1 pt. for each correct response

Modified Balance Error Scoring System (mBESS)[5] testing

This balance testing is based on a modified version of the Balance Error Scoring System (BESS)[5]. A timing device is required for this testing.

Each of 20-second trial/stance is scored by counting the number of errors. The examiner will begin counting errors only after the athlete has assumed the proper start position. The modified BESS is calculated by adding one error point for each error during the three 20-second tests. The maximum number of errors for any single condition is 10. If the athlete commits multiple errors simultaneously, only one error is recorded but the athlete should quickly return to the testing position, and counting should resume once the athlete is set. Athletes that are unable to maintain the testing procedure for a minimum of five seconds at the start are assigned the highest possible score, ten, for that testing condition.

OPTION: For further assessment, the same 3 stances can be performed on a surface of medium density foam (e.g., approximately 50cm x 40cm x 6cm).

Balance testing – types of errors

1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into > 30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position > 5 sec

"I am now going to test your balance. Please take your shoes off (if applicable), roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable). This test will consist of three twenty second tests with different stances."

(a) Double leg stance:

"The first stance is standing with your feet together with your hands on your hips and with your eyes closed. You should try to maintain stability in that position for 20 seconds. I will be counting the number of times you move out of this position. I will start timing when you are set and have closed your eyes."

(b) Single leg stance:

"If you were to kick a ball, which foot would you use? [This will be the dominant foot] *Now stand on your non-dominant foot. The dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

(c) Tandem stance:

"Now stand heel-to-toe with your non-dominant foot in back. Your weight should be evenly distributed across both feet. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."

Tandem Gait

Participants are instructed to stand with their feet together behind a starting line (the test is best done with footwear removed). Then, they walk in a forward direction as quickly and as accurately as possible along a 38mm wide (sports tape), 3 metre line with an alternate foot heel-to-toe gait ensuring that they approximate their heel and toe on each step. Once they cross the end of the 3m line, they turn 180 degrees and return to the starting point using the same gait. Athletes fail the test if they step off the line, have a separation between their heel and toe, or if they touch or grab the examiner or an object.

Finger to Nose

"I am going to test your coordination now. Please sit comfortably on the chair with your eyes open and your arm (either right or left) outstretched (shoulder flexed to 90 degrees and elbow and fingers extended), pointing in front of you. When I give a start signal, I would like you to perform five successive finger to nose repetitions using your index finger to touch the tip of the nose, and then return to the starting position, as quickly and as accurately as possible."

References

1. McCrory et al. Consensus Statement On Concussion In Sport – The 5th International Conference On Concussion In Sport Held In Berlin, October 2016. British Journal of Sports Medicine 2017 (available at www.bjsm.bmj.com)
2. Maddocks, DL; Dicker, GD; Saling, MM. The assessment of orientation following concussion in athletes. Clinical Journal of Sport Medicine 1995; 5: 32-33
3. Jennett, B., Bond, M. Assessment of outcome after severe brain damage: a practical scale. Lancet 1975; i: 480-484
4. McCrea M. Standardized mental status testing of acute concussion. Clinical Journal of Sport Medicine. 2001; 11: 176-181
5. Guskiewicz KM. Assessment of postural stability following sport-related concussion. Current Sports Medicine Reports. 2003; 2: 24-30

CONCUSSION INFORMATION

Any athlete suspected of having a concussion should be removed from play and seek medical evaluation.

Signs to watch for

Problems could arise over the first 24-48 hours. The athlete should not be left alone and must go to a hospital at once if they experience:

- Worsening headache
- Drowsiness or inability to be awakened
- Inability to recognize people or places
- Repeated vomiting
- Unusual behaviour or confusion or irritable
- Seizures (arms and legs jerk uncontrollably)
- Weakness or numbness in arms or legs
- Unsteadiness on their feet.
- Slurred speech

Consult your physician or licensed healthcare professional after a suspected concussion. Remember, it is better to be safe.

Rest & Rehabilitation

After a concussion, the athlete should have physical rest and relative cognitive rest for a few days to allow their symptoms to improve. In most cases, after no more than a few days of rest, the athlete should gradually increase their daily activity level as long as their symptoms do not worsen. Once the athlete is able to complete their usual daily activities without concussion-related symptoms, the second step of the return to play/sport progression can be started. The athlete should not return to play/sport until their concussion-related symptoms have resolved and the athlete has successfully returned to full school/learning activities.

When returning to play/sport, the athlete should follow a stepwise, **medically managed exercise progression, with increasing amounts of exercise.** For example:

Graduated Return to Sport Strategy

Exercise step	Functional exercise at each step	Goal of each step
1. Symptom-limited activity	Daily activities that do not provoke symptoms.	Gradual reintroduction of work/school activities.
2. Light aerobic exercise	Walking or stationary cycling at slow to medium pace. No resistance training.	Increase heart rate.
3. Sport-specific exercise	Running or skating drills. No head impact activities.	Add movement.
4. Non-contact training drills	Harder training drills, e.g., passing drills. May start progressive resistance training.	Exercise, coordination, and increased thinking.
5. Full contact practice	Following medical clearance, participate in normal training activities.	Restore confidence and assess functional skills by coaching staff.
6. Return to play/sport	Normal game play.	

In this example, it would be typical to have 24 hours (or longer) for each step of the progression. If any symptoms worsen while exercising, the athlete should go back to the previous step. Resistance training should be added only in the later stages (Stage 3 or 4 at the earliest).

Written clearance should be provided by a healthcare professional before return to play/sport as directed by local laws and regulations.

Graduated Return to School Strategy

Concussion may affect the ability to learn at school. The athlete may need to miss a few days of school after a concussion. When going back to school, some athletes may need to go back gradually and may need to have some changes made to their schedule so that concussion symptoms do not get worse. If a particular activity makes symptoms worse, then the athlete should stop that activity and rest until symptoms get better. To make sure that the athlete can get back to school without problems, it is important that the healthcare provider, parents, caregivers and teachers talk to each other so that everyone knows what the plan is for the athlete to go back to school.

Note: If mental activity does not cause any symptoms, the athlete may be able to skip step 2 and return to school part-time before doing school activities at home first.

Mental Activity	Activity at each step	Goal of each step
1. Daily activities that do not give the athlete symptoms	Typical activities that the athlete does during the day as long as they do not increase symptoms (e.g. reading, texting, screen time). Start with 5-15 minutes at a time and gradually build up.	Gradual return to typical activities.
2. School activities	Homework, reading or other cognitive activities outside of the classroom.	Increase tolerance to cognitive work.
3. Return to school part-time	Gradual introduction of school-work. May need to start with a partial school day or with increased breaks during the day.	Increase academic activities.
4. Return to school full-time	Gradually progress school activities until a full day can be tolerated.	Return to full academic activities and catch up on missed work.

If the athlete continues to have symptoms with mental activity, some other accomodations that can help with return to school may include:

- Starting school later, only going for half days, or going only to certain classes
- More time to finish assignments/tests
- Quiet room to finish assignments/tests
- Not going to noisy areas like the cafeteria, assembly halls, sporting events, music class, shop class, etc.
- Taking lots of breaks during class, homework, tests
- No more than one exam/day
- Shorter assignments
- Repetition/memory cues
- Use of a student helper/tutor
- Reassurance from teachers that the child will be supported while getting better

The athlete should not go back to sports until they are back to school/learning, without symptoms getting significantly worse and no longer needing any changes to their schedule.

SPORT CLUBS PARTICIPANT WAIVER

Participants Over Eighteen (18) Years of Age

This form must be signed by **ALL** Sport Clubs participants and guests eighteen years of age or older. If you are under eighteen, please see the Recreational Sports staff for the appropriate form. Please fill out one form for each sport in which you will participate. A Sport Clubs Waiver must be completed annually. It is strongly recommended that participants purchase insurance that covers accidents which may occur during Sport Clubs activities.

Please write legibly and provide the appropriate response in all blank spaces.

Club: _____ Participant Name: _____

DOB _____/___ /_____

mm / dd / yyyy

Local Address: _____

City, State, ZIP: _____

Phone Number: _____

E-mail: _____

Biographical Information: **(please circle one)** Freshman Sophomore Junior Senior Grad Student Faculty/Staff Spouse Guest

Emergency Contact: _____ **Relationship:** _____

Phone: (_____) _____

ASSUMPTION OF THE RISK

In consideration for the benefits to be derived from my participation in a Sport Club, I hereby acknowledge the following: (1) I am aware that all Sport Clubs involve risk, and that some are violent contact sports; (2) I am aware that playing or practicing in any Sport Club will be a dangerous activity involving MANY RISKS OF INJURY; and (3) I UNDERSTAND THAT THE DANGERS AND RISKS OF PLAYING OR PRACTICING **_____ (SPORT)** INCLUDE, BUT ARE NOT LIMITED TO DEATH, SERIOUS HEAD, NECK AND SPINAL INJURIES, WHICH MAY RESULT IN COMPLETE OR PARTIAL PARALYSIS, BRAIN DAMAGE, TRAUMATIC BRAIN INJURY, POST CONCUSSIVE SYNDROME, CONCUSSION, CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE), OR OTHER NEURODEGENERATIVE DISEASE, SERIOUS INJURY TO VIRTUALLY ALL INTERNAL ORGANS, BONES, JOINTS, LIGAMENTS, MUSCLES, TENDONS, AND OTHER ASPECTS OF THE MUSCULAR SKELETAL SYSTEM AND SERIOUS INJURY OR IMPAIRMENT TO OTHER ASPECTS OF MY BODY, GENERAL HEALTH, AND WELL-BEING. I further understand and acknowledge that the dangers and risks of playing or practicing **_____ (SPORT)** may result not only in injury, but serious impairment of my future abilities to earn a living, to engage in other business, social, and recreational activities, and generally to enjoy life.

Because of the danger of participating in _____ **(SPORT)**, I acknowledge and understand the importance of following rules and regulations established by the University and/or the Department of Recreational Sports. I hereby agree to obey such rules, regulations, and instructions. I hereby acknowledge and agree that I understand the nature of the _____ **(SPORT)**; that I am qualified, in good health, and in proper physical condition to participate therein; that there are certain inherent risks and dangers associated with the _____ **(SPORT)**; and that, except as expressly set forth herein, I, knowingly and voluntarily, accept, and assume responsibility for, each of these risks and dangers, and all other risks and dangers that could arise out of, or occur during, my participation in the _____ **(SPORT)**.

I RECOGNIZE AND ACKNOWLEDGE THAT THE UNIVERSITY AND THE DEPARTMENT OF RECREATIONAL SPORTS DO NOT CARRY ANY TYPE OF ACCIDENT OR HEALTH INSURANCE POLICY ON THE PARTICIPANTS IN SPORT CLUB ACTIVITIES. I ALSO REALIZE THAT SPORTS INJURIES CAN BE CATASTROPHIC FOR THOSE WITHOUT PROPER MEDICAL COVERAGE.

RELEASE OF LIABILITY

I HEREBY RECOGNIZE AND VOLUNTARILY ASSUME ALL THE RISKS ASSOCIATED WITH MY PLAYING OR PRACTICING _____(SPORT) AND RELEASE THE UNIVERSITY BOARD OF TRUSTEES, THE UNIVERSITY DEPARTMENT OF RECREATIONAL SPORTS, THE STATE OF FLORIDA, THE FLORIDA BOARD OF GOVERNORS, THE FLORIDA DEPARTMENT OF EDUCATION AND THEIR RESPECTIVE EMPLOYEES, AGENT REPRESENTATIVES, AND VOLUNTEERS FROM ANY AND ALL OBLIGATIONS, LIABILITIES, CLAIMS, DEMANDS, COSTS, AND EXPENSES, INCLUDING ATTORNEY'S FEES, OR DEMANDS OF ANY KIND OF NATURE WHATSOEVER WHICH MAY ARISE OR IN CONNECTION WITH MY PARTICIPATION IN ANY ACTIVITIES RELATED TO _____(SPORT) CLUB. I understand that the terms hereof serve as a release and assumption of risk for me as well as my heirs, estates, executors, administrators, and assignees.

PROTECTIVE EQUIPMENT

I have been advised to wear all protective equipment that is required by the rules and regulations of the governing body for my sport. I am fully aware that the use of protective equipment, including but not limited to helmets, face shields, mouth guards, and other protective equipment do not eliminate the risk of DEATH, SERIOUS HEAD, NECK AND SPINAL INJURIES, WHICH MAY RESULT IN COMPLETE OR PARTIAL PARALYSIS, BRAIN DAMAGE, TRAUMATIC BRAIN INJURY, POST CONCUSSIVE SYNDROME, CONCUSSION, CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE), OR OTHER NEURODEGENERATIVE DISEASE, SERIOUS INJURY TO VIRTUALLY ALL INTERNAL ORGANS, BONES, JOINTS, LIGAMENTS, MUSCLES, TENDONS, AND OTHER ASPECTS OF THE MUSCULAR SKELETAL SYSTEM AND SERIOUS INJURY OR IMPAIRMENT TO OTHER ASPECTS OF MY BODY, GENERAL HEALTH, AND WELL-BEING.

SEVERABILITY

The undersigned expressly agree that the foregoing assumption of risk, release and waiver of liability and indemnity agreement is intended to be as broad and inclusive as is permitted by the law of the State of _____ and that if any portion thereof is held invalid, it is agreed that the balance shall, notwithstanding, continue in full legal force and effect.

PARTICIPANT WAIVER

In signing this agreement, **or selecting "Accept Terms & Conditions" to electronically sign this agreement** I acknowledge and represent that I have read and understand it; that I sign **or select "Accept Terms & Conditions" to electronically sign** it voluntarily and for full and adequate consideration, fully intending to be bound by the same; and that I am at least eighteen (18) years of age and fully competent.

I HAVE READ THIS AGREEMENT, UNDERSTAND THAT I AM GIVING UP SUBSTANTIAL RIGHTS BY SIGNING IT, AND AGREE TO BE BOUND BY IT.

Participant Signature _____

UFID _____ Date _____/_____/_____

Concussion Awareness and Dangers of Concussion

What is a concussion?

A concussion is a type of traumatic brain injury—or TBI—caused by a bump, blow, or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth. This sudden movement can cause the brain to bounce around or twist in the skull, creating chemical changes in the brain and sometimes stretching and damaging brain cells. Even what seems to be a mild bump or blow to the head can be serious. A concussion can also result from a fall or from players colliding with each other or with obstacles, such as a goalpost, even if they do not directly hit their head.

To help recognize a concussion, you should watch for the following:

1. A forceful blow to the head or body that results in rapid movement of the head.
2. Any change in the athlete's behavior, thinking, or physical functioning.
3. Signs and symptoms of concussion that may be reported by a coach or other observer:
    - Appears dazed or stunned
    - Is confused about assignment or position
    - Forgets sports plays
    - Is unsure of game, score or opponent
    - Moves clumsily
    - Answers questions slowly
    - Loses consciousness (even briefly)
    - Can't recall events prior to hit or fall
    - Cannot recall events after hit or fall
4. Signs and symptoms that may be reported by the player:
    - Headache or Pressure in head
    - Nausea or vomiting
    - Balance problems or dizziness
    - Double or blurry vision
    - Sensitivity to light
    - Sensitivity to noise
    - Feeling sluggish, hazy, foggy, or groggy
    - Concentration or memory problems
    - Confusion
    - Does not "feel right" or "feeling down"

Concussion Awareness and Dangers of Concussion *(continued)*

Why should an athlete report their symptoms?

If an athlete has a concussion, his/her brain needs time to heal. While an athlete's brain is healing, they are much more likely to have another concussion. Repeat concussions can increase the time it takes to recover. In rare cases, repeat concussions in athletes can result in brain swelling or permanent damage to their brain. It can even be fatal.

What should I do if I have a head injury during a game?

If you think you might have a concussion, stop playing the game right away. This will help reduce your risk of worse injury. Moderate evidence shows that checklists and screening tests can help with diagnosing concussions. If a concussion may have occurred, you should be evaluated thoroughly by a licensed health care professional. This person should be trained to diagnose and manage concussion. He or she also should be able to recognize brain injuries that are more severe.

I have been diagnosed with a concussion. When can I return to play/practice?

If you have been diagnosed with a concussion, do not return to play until:

- All symptoms have cleared up—these include symptoms you have while taking medication or, especially, after stopping it
- You have been cleared for play by a licensed health care professional trained in diagnosing and managing concussion

BE CAREFUL WHEN RETURNING TO PLAY. THIS SHOULD BE A SLOW PROCESS.

For injured athletes who continue to have symptoms:

- Moderate to strong evidence shows that they will have ongoing thinking and behavior problems and slowed reaction times
- Weak evidence shows that such athletes may be risking further injury—and even longer recovery—if they try returning to play too soon

If you have concerns about long-term risk, discuss counseling options with your health care professional. It is advised that players take the Center for Disease Control's free online concussion training at:

cdc.gov/concussion/HeadsUp/Training/HeadsUpConcussion.html

SPORT CLUBS PARTICIPANT & PARENT/LEGAL CUSTODIAN CONCUSSION STATEMENT

Sport Clubs Name: _____

Parent/Legal Custodian Name(s), if applicable: _____

Please initial that you have read *Concussion and Dangers of Concussion* and have signed the *Sports Club Participant Waiver*.

After reading the above mentioned documents, I am aware of the following information:

	Sports Club Participant Initials	Parent/Legal Custodian Initials (if applicable)
A concussion is a brain injury, which should be reported to my coach(es), a medical professional, or my parents.		
A concussion can affect the ability to perform everyday activities such as the ability to think, balance, and classroom performance.		
I am fully aware and understand the dangers and risks of concussions as listed in the *Sport Clubs Participant Waiver*.		
I will tell my parents, my coach, and/or a medical professional about my injuries and illnesses.		N/A
I will not return to play in a game or practice if a hit to my head or body causes any concussion-related symptoms.		N/A
I will/my child will need written permission from a medical professional trained in concussion management to return to play or practice after a concussion.		
I understand that most concussions take days or weeks to get better. A concussion may not go away right away. I realize that resolution from this injury is a process and may require more than one medical evaluation.		
I realize that ER/Urgent Care physicians will not provide clearance if seen right away after the injury.		
After a concussion, the brain needs time to heal. I understand that I am/my child is much more likely to have another concussion or more serious brain injury if return to play or practice occurs before concussion symptoms go away.		
I have been advised to wear all protective equipment that is required by the rules and regulations of the governing body for my sport.		
I am fully aware that the use of protective equipment, including but not limited to helmets, face shields, mouth guards, and other protective equipment do not eliminate the risk of DEATH, SERIOUS HEAD, NECK AND SPINAL INJURIES, WHICH MAY RESULT IN COMPLETE OR PARTIAL PARALYSIS, BRAIN DAMAGE, TRAUMATIC BRAIN INJURY, POST CONCUSSIVE SYNDROME, CONCUSSION, CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE), OR OTHER NEURODEGENERATIVE DISEASE, SERIOUS INJURY TO VIRTUALLY ALL INTERNAL ORGANS, BONES, JOINTS, LIGAMENTS, MUSCLES, TENDONS, AND OTHER ASPECTS OF THE MUSCULAR SKELETAL SYSTEM AND SERIOUS INJURY OR IMPAIRMENT TO OTHER ASPECTS OF MY BODY, GENERAL HEALTH, AND WELL-BEING.		

_____ _____

Signature of Sports Club Participant Date

_____ _____

Signature of Parent/Legal Custodian (if applicable) Date

University Student Health Services

UID: 1234-5678

Age: 18 Gender: Male Birthdate: 1/2/2000 Encounter Date: 2/23/18 9:02 AM

Allergies

Allergen	Reactions

- Medication and Allergy lists were not updated and reviewed at this visit.

Patient's Current Medication

New Prescriptions

No medications on file

Previous Medications

No medications on file

Modified Medications

No medications on file

Discontinued Medications

No medications on file

Provider Notes:

Chief Complaint: follow up for concussion
Duration of symptoms seen last on 2/16/18

History

Chief Complaint

Patient presents with

- Follow up for Concussion

Past Medical History

Diagnosis	Date

- Seasonal allergies

Subjective:

Established patient
New problem

CC: I have a concussion

Concerned about concussion

Incident: The patient is playing a friendly soccer game at University Fields when he was struck with a kickball directly in the left temporal and occipital scalp area with immediate concussion symptoms but continued to play and not take himself out of the game.

He is slightly better but still unable to attend class secondary to increasing headache and mental fogginess.

LOC	None
Education:	Undergrad
Dominant Hand:	Right
Date of Event:	02/16/18
Prior Concussions:	Denies
Headaches/migraines:	No
ADD/ADHD	No
Depression/Anxiety:	Yes with prior treatment but off all medications at present
Medications	None

PMHx: reviewed and updated
PSHx: reviewed and updated

SocHx: reviewed and updated

He continues to be significantly symptomatic today having difficulty completing routine tasks and having difficulty with his academic work.

Chronic Problems

Description	Note
• Concussion without loss of consciousness, initial encounter	Concussion #1; age 17 soccer related kick in the head. Out of school 5 days. Concussion #2; age 18. Soccer ball vs left-temporo-occipital blow from kick ball. Feb 2018.

Active Problems

Description	Note
• Anxiety disorder, unspecified	

Physical Exam

Encountered By: Johnson

BP	**120/80 mmHg**
Pulse	**67**
Resp	**18**
Temp	**36.6 °C (97.9 °F)**
Temp src	**Oral**
Height	**1.829 m (6' 0.01")**
Weight	**86.183 kg (190 lb)**
SpO2	**97 %**
BMI (Calculated)	**25.82**

BP 120/80 | Pulse 67 | Temp 36.6 °C (97.9 °F) (Oral) | Resp 18 | Ht 1.829 m (6' 0.01") | Wt 86.183 kg (190 lb) | BMI 25.76 kg/m2 | SpO2 97%

Objective

Constitutional
Vital Signs noted
Well Nourished
Well Hydrated

Head: nc Trauma

Eyes: no sclera icterus, perrl eomi

Neck: FROM, but has pain on range of motion
No adenopathy
2+ carotids

Normal Contours

Abdomen: BS+
Soft
Non tender
No hepatomegaly
No splenomegaly palpable

CVAT none
Back: no scoliosis noted
No spasm or tenderness

Neuro: normal gait
No focal deficits
Speech diction and speed are within normal limits

Skin: Warm and dry
No open lesions

Psyche: mood/affect appropriate
Alert, oriented

SCAT 3 DATA
GCS 15/15
Maddocks 5/5

Symptom Evaluation

#	**12 – 17 / 21**
Severity Score	**40 – 65 / 132**
Physical Activity	**Worsens symptoms**
Mental Activity	**Worsens symptoms**

Cognitive	
Orientation	5/5
Immediate Memory	**4/5/5 of 15**
Digits Backwards	**2 of 4**
BESS	
Non-dominant Foot	
Hard surface	
Tandem Stance	**0**
Coordination	
Upper limb	**1/1**
Delayed Recall	**2 -3 of 5**
Saccades	
Horizontal	**Normal**
Vertical	**Normal**
Exacerbation of symptoms	**Readily worsens symptoms**
Smooth Pursuits	
horizontal	**normal**
vertical	**normal**
Exacerbation of symptoms	**Readily worsening**

Near point coverage is 11 cm 10 cm.

Assessment

Diagnosis Code: E33.1 Concussion without loss of consciousness, initial encounter
Diagnosis Code: D06.0Z0B Anxiety disorder, unspecified Diagnosis Code: G41.8 Activity, soccer
Diagnosis Code: U92.66
Concussion rest has been reviewed.
Alarm symptoms requiring immediate evaluation include change in behavior, vomiting, dizziness, worsening, headache, double vision, or excessive drowsiness. Patient instructed to go to the emergency department should they have any worsening symptoms.

Patient was also reminded that they should participate in mental and physical rest, without being bedridden.
Patient may walk as they are able but should avoid direct sunlight or the heat of the day during his walking episodes.
Rest should not include strict bed rest but should include sitting, appropriate eating patterns, and no physically vigorous activity.
No alcohol.
The patient is on no prescription medications and may use Tylenol for headache as needed.
The patient is already driving and should limit driving if worsening headache or other symptoms.

Avoid television. This includes even casual viewing.
Avoid computer work. This would include classroom work. Patient currently much worse any activity screen exposure.

You may try short periods of computer work but should immediately stop should any worsening symptoms occur.
I will see patient back in 4 to 5 days.

Evaluation for possible neurocognitive testing recommendations for specific disability will be pending recovery trajectory over the two weeks of my evaluation.
Neuroimaging is recommend only if there are focal neurologic symptoms

Concussion: Domains
Cognitive—remains difficult for concentration
Memory—some difficult with memory
Mood/Behavioral—known history of anxiety disorder and will require careful monitoring.
Vestibular—minimally affected
Ocular—ocular has clear deficits and exacerbation of symptoms, which is not expected given the location of his trauma.
Post-Traumatic Migraine—Denies
Cervical—stiff neck is noted in the patient. Will go to physical therapy or athletic training for range of motion and immediate rehab here.

Plan

Patient Name: Smith, John DOB: 1/2/2000 DOE: 2/23/2018

The above-named student has suffered a concussion and is currently under the care of this clinic. He/she is not permitted to participate in any contact sport activity until formally cleared by this clinic.

Students recovering from a concussion have problems with memory, concentration, and thinking speed. In addition, engaging in cognitively demanding tasks can exacerbate symptoms and prolong recovery. The following academic accommodations and other recommendations will assist this student in minimizing post-concussive symptoms while continuing their academic work during the concussion recovery period:

School attendance restrictions: ___full day as tolerated; __XX__ no school until:__ re-evaluation on _02/28/18__,

Testing: __ extra time to complete tests; __ testing in a quiet environment; __XX__ eliminate or postpone tests when possible until the patient's concussion symptoms clear.

Note Taking: __XX__ allow student to obtain class notes or outlines ahead of time to aid in organization and reduce multitasking demands. Alternatively, copies of another student's notes could be provided.

Workload reduction: __XX__ allow student to have extended deadlines to turn in assignments late.

Breaks: __N/A__ take breaks as needed to control symptoms levels. If headache worsens during class, the student should be excused from class.

Physical activity: __XX__ no attendance at sports practices/P.E. class; ___ can attend but not participate in sports practices/P.E. class; ___ can leave practice early if symptoms develop; __ no participation in other strenuous physical, aerobic, or weight training activities at school or home.

Other: __XX__ limit exposure to T.V., computer, video games, movie theatres, and cell phone/texting.

At the first sign of post-concussion symptoms such as headache, the student will need to discontinue the activity in which he/she is engaged. To help alleviate the symptom or decrease the headache pain, rest until the symptom or pain subsides. As noted above, over exertion and recurrence of post-concussion symptoms can lead to a prolonged recovery.

Follow-up evaluation and revision of recommendations to occur: __02/28/2018__

Patient Status

The patient condition on admission/discharge/transfer is: Stable

Florida Academic Healthcare Patient Safety Organization
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352-273-7006

PS141483-9/4/18