21 Concussion Management in Basketball

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Fact Boxes

- The mechanical force that causes SRC can be from a direct hit to the head, or from a hit to another area of the body where the force is transmitted to the head.
- The symptoms from SRC can happen immediately or evolve over time (minutes to hours).
- There is a large range of clinical signs and symptoms, and the resolution of these is typically sequential.

- The diagnosis of SRC should be made by a licensed medical professional.
- All athletes should undergo pre-participation evaluations along with education on concussions prior to the start of the season.
- Studies have shown that delayed concussion reporting can result in a longer return-to-play time versus immediate reporting.

- Although previously thought that athletes should rest until the symptoms of concussion have resolved, new data shows that sub-symptom exercise should be incorporated after 24–48 h of rest.
- The Buffalo Concussion Treadmill Test (BCTT) is when the athlete walks on a treadmill with increasing speed and incline until concussive symptoms return—this heart rate is used to determine the target heart rate for the exercise prescription.
- Prescribing subsymptom threshold aerobic exercise within 1 week of concussion results in a reduced incidence of delayed recovery beyond 30 days.

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L. Laver et al. (eds.), *Basketball Sports Medicine and Science*,
https://doi.org/10.1007/978-3-662-61070-1_21

- Persistent post-concussive symptoms are symptoms that continue beyond the expected recovery window (more than 2 weeks in adults, more than 4 weeks in children).
- Repetitive SRC can lead to increased length of recovery, the possibility of sustaining a concussion through a less forceful injury, as well as increased severity of the concussive symptoms.
- CTE is considered a progressive neurodegenerative disease and with symptoms including behavior and mood problems and impaired cognitive function, and there is currently no direct link between it and concussions.

21.1 Introduction

Sport-related concussion (SRC) has become an important topic of concern for the public, media, and sports medicine physicians alike. Large sporting bodies are turning to medical professionals including physicians and researchers to lead the way in keeping athletes safe while participating in sport. SRC is associated more so with sports such as football or ice hockey; however, youth league through the professional-level basketball athlete is also at risk. This chapter will focus on SRC in basketball.

21.2 Description/Definition

The definition of SRC has been evolving for 50 years [1]. The separation of SRC from concussion due to other causes, such as motor vehicle collisions, has been important to both sports medicine physicians and sport governing body organizations so that appropriate guidelines for keeping athletes safe can be determined. The most recent definition as discussed at the fifth International Conference on Concussion in Sport places SRC on the spectrum of traumatic brain injury (TBI), the cause of TBI being induced by a biomechanical force [2]. This, however, does not describe what is actually known regarding what is happening in the brain. Current research is focused on the following areas of the definition including structural change, physiologic change, and grading of severity [1–3]. The current definition was founded using expert opinions, the lowest level on the hierarchical system of classifying evidence when practicing evidence-based medicine [4].

Common features have been found in the literature that can be helpful in further defining SRC. These include the following:

- The mechanical force that causes SRC can be from a direct hit to the head, or from a hit to another area of the body where the force is transmitted to the head.
- SRC has not been shown to result in a structural change on imaging studies and therefore is thought to be more of a physiological disturbance.
- The symptoms from SRC can happen immediately or evolve over time (minutes to hours).
- There is a large range of clinical signs and symptoms (could or could not involve loss of consciousness (LOC)), and the resolution of these is typically sequential.
- These signs and symptoms cannot be explained by drug, alcohol, medication use, other injuries, or other comorbid conditions [1–3].

The two main focuses of the definition are on the areas of biomechanics and clinical signs and symptoms [1–3]. Discussed in further detail in the below section on pathogenesis, most of the biomechanical data that we currently have are from studies done using helmet-based technology. Using this technology, studies are focusing on impact location, linear and rotational acceleration, and head motion [5]. Unfortunately, at the current time the data from these studies varies widely and has not been able to be used as part of the diagnostic process. At some point, this data will also have to be extrapolated to the multitude of sports where concussions occur on a frequent basis and there is no use of helmets—including basketball. The clinical signs and symptoms of a concussion are also widely variable, further complicating the ability to both define and diagnose SRC. Clinical signs typically involve physical, cognitive, and emotional symptoms that can vary both in presentation and severity. Creating a set of clinical criteria would be an important step in providing some clarity to a confusing disease process.

21.3 Epidemiology

SRC has been reported to affect about 300,000 Americans every year, the majority occurring in children and adolescents less than 20 years old [6]. This is thought to be an underestimate due to the difficulty in identifying SRC and subtle injuries. There have been studies done that show around 10% of adolescent non-athletes sustain concussions in comparison to 20% of adolescent athletes; however, this number varies depending on the source [7]. Data in the years leading up to 2011 reported around 11.6 million American children were playing the sport of basketball [6]. The number of male and female athletes participating in high school basketball has stayed fairly stable over the 10 years from 2005 to 2014, while the number of collegiate athletes has increased over this time [8].

Basketball is typically listed in the top 5 for incidence of concussion when classified by sport [9–11]. This information has been able to be obtained due to the start of Web-based sports injury surveillance programs across multiple levels including high school and the NCAA. When reviewing the current literature on concussions for high school basketball from 2005 to 2014, injury rate for practice in girls was 0.11 (injury rate/1000 AEs) and competition 0.74, whereas for boys was 0.08 and 0.33, respectively. This puts concussions at the fourth and fifth leading cause of injury in practice for both girls and boys high school basketball behind ligament sprains, muscle/tendon strains, and fractures, and the second leading cause of injury in competition behind only ligament sprain [8, 12]. In collegiate basketball from 2005 to 2014, injury rate for practice in women was 0.35 and competition 1.00, whereas for men was 0.45 and 1.26, respectively. This is similar to what is seen in high school basketball with concussion being in the top 5 leading cause of injury in practice and again second to only ligament sprain in competition [8, 12]. This data can be further divided into Collegiate by Division, practices in preseason, regular season, and postseason; however, the data remain similar across the board—concussions are consistently one of the major causes of injury to basketball players.

From 2006 to 2014, there were an average of 15 concussions per season in the National Basketball Association [13]. Data looking at athletes entering the WNBA combine from the years 2000 to 2008, of 500 professional women's basketball players 7.1% had suffered a concussion [14]. It is difficult to compare this data to that of the NBA; however, it is known that due to the longer NBA season, compared to collegiate basketball, that men's professional basketball players are more likely to experience injury [13].

21.4 Pathophysiology/ Biomechanics

The pathophysiology of concussion is not fully understood at this time. Most of the studies performed have been done using animal models; however, with the increased use of Diffusion Tensor Imaging and Functional Magnetic Resonance Imaging, more research has been able to be performed including comparison studies of imaging on animal models and humans [15]. It is currently thought to include many events such as neurometabolic changes, ionic flux and energy mismatch, cerebral blood flow changes and even pituitary dysfunction [15–17]. This cascade starts at impact, with this impact being broadly defined as being less severe than an impact that would cause cranial fracture or hemorrhage, and with the impact taking place on the head or elsewhere on the body where the force is transmitted to the head [2].

This impact delivered to the brain leads to acceleration and deceleration forces on the neuronal structures which set off a complex cascade of neurochemical and neurometabolic events: stretching of neuronal cell membranes and axons, and unregulated outflow of ions through what were once regulated ion channels. With the release of neurotransmitters such as glutamate, there is also simultaneous increase in the activity of the Na/K ATP-dependent pump to work to return to ionic balance. Unfortunately, this results in depleted energy stores with the increased use of glucose, all of which is thought to be the cause of post-concussive symptoms. Often these are self-limited, but repetitive injury could result in more prolonged deficits [15]. Along with this process, it is postulated that there is an injury-related decrease in resting cerebral blood flow which adds to the energy mismatch. This decrease in cerebral blood flow has been shown in a few studies to return to normal as the athlete is recovering from post-concussive symptoms [16, 17].

Using the proposed pathophysiologic changes discussed above, research is shifting into studies looking at biomechanics to attempt to improve the process of diagnosing concussions, staging them by severity and creating appropriate return to play protocols. Most biomechanical studies have been performed in sports in which athletes are wearing helmets because of the use of helmet-based technology and sensor systems. These studies look at the location of impact on the head, frequency, and the motion of the head after impact. Even when looking at large meta-analysis studies of linear and rotational forces exerted by certain impacts, there was difficulty in showing that impacts above a certain force always resulted in a concussion. There were many instances in which extreme forces resulted in no diagnosis, and lower forces resulted in a concussion diagnosis. Other factors that played into these studies include the differences in forces when looking at males versus females, as well as forces affecting the pediatric versus the adult population. When looking at the epidemiologic data reported on concussions in basketball, there are many ways that these concussions take place including player to player contact as well as player to floor contact. The most common cause found in recent studies is player to player contact, frequently being elbow-to-head contact during rebounding [5, 18]. Unfortunately, there are not a lot of biomechanical studies on player to player contact in basketball to look at forces, impact location, and motion after impact due to players not wearing helmets. Some studies have looked into mouthguard technology as well as using human head modeling to begin to gather data that could be better extrapolated to sports without helmets. Still yet are studies in the early stages of examining blood biomarkers [2, 3].

It is unlikely at this current time that we are able to use this data in a meaningful way to help with diagnosis, staging severity, predicting outcomes, or determining appropriate return to play. Much more work is needed to be able to use this data in the clinical setting, and especially in sports not involving helmets, athletes of both sexes, and athletes of all ages, such as basketball.

21.5 Diagnosis

As discussed when examining the definition of SRC, it is a complicated injury in which there is no "one size fits all" group of symptoms athletes present with, level of impact force is not black and white, and there are also no proven diagnostic tests including imaging scans or blood work to make a final diagnosis. In this section, we will discuss how to recognize and make the diagnosis of concussion from the sideline and in the office, appropriate physical exam techniques and helpful tools that can be used to aid your clinical judgment.

The diagnosis of SRC happens on the court, ideally by a licensed medical professional. There are many signs and symptoms that the medical professional should be aware of observing athletes during practice and competition from the sidelines. The diagnosis of concussion is difficult and currently based on clinical assessment by the provider. There are many tools available which are unvalidated and therefore medical professionals will need to rely mostly on history and physical exam.

Before the season begins, all athletes should undergo a preparticipation physical evaluation, and part of this should include a detailed concussion history and the presence of conditions such as a learning disorder, ADHD, mood disorder, headache disorder, and what medications the athlete is currently taking as these can complicate both the diagnosis and management of SRC [2, 3, 19]. This should also include putting into place an Emergency Action Plan (EAP) should a situation arise on the court where an athlete would need immediate emergency services. There are also baseline tests that can be performed which include a symptom checklist, cognitive evaluation, and balance testing which is currently recommended by the NCAA for all athletes [19]. Baseline testing is helpful in some situations; however, it is not considered the standard of care for SRC. Part of the process of the preseason evaluation should include educating athletes on concussion including handouts with information about concussions [3]. Most athletes do not understand the risks associated with concussions and want to do whatever they can to return to the court with their teammates. Studies have shown that delayed concussion reporting can result in a longer return-to-play time versus immediate reporting [20].

After an athlete has sustained an initial injury concerning for concussion, they should be immediately evaluated for an injury that could require a higher level of care. The evaluation should focus on whether or not the athlete has lost consciousness, the development of tonic posturing, a balance disturbance, or cervical spine trauma. All of these would constitute an emergent situation where the athlete should be immediately transported to the nearest Emergency Department as outlined in your EAP. Other signs should also signal transfer to a higher level of care including a neurological deficit on your exam, recurring emesis, and worsening headache or mental status over time. It is important to remember that SRC is an evolving process, and symptoms can change over minutes to hours, highlighting the need for serial examination.

If there are no concerns for need for emergent transfer, the athlete should be evaluated by the medical professional on the sideline. Remember that this sideline evaluation should be performed with the goal of screening for a possible SRC, and not making a final diagnosis. If after the brief screening on the sideline, a concussion is no longer suspected then the medical professional can determine the appropriate timing for the athlete to return to play. As SRC is an evolving injury, serial exams can be performed prior to making official decision on returning the athlete to the activity. If the sideline screening is concerning for SRC, then a full evaluation should take place in a quiet and distraction-free environment such as the medical training room or the locker room. It is important to remember to be extremely cautious when making the decision to return to play from the sideline, keeping the athlete from returning to the game or practice if there is any slight suspicion for concussion is important [2, 3, 21, 22].

After the athlete has been removed from play, the evaluation should begin with a brief history of the event from the athlete and whether or not the athlete is experiencing symptoms such as a headache, feeling of being in a fog, or emotional symptoms (extreme anger, tearful). The athlete should be evaluated for balance or gait unsteadiness, slowed reaction times, drowsiness. Speech patterns and information processing should be inferred during this time of general assessment. A complicated aspect of the sideline diagnosis is the need to rely on the athlete to provide honest answers to symptom-based questions. It can be helpful if there is concern from the medical professional about the athlete's description of symptoms, to move the athlete to a quiet area away from the court, such as the locker room or training room, and perform a more thorough exam. Also, if the athlete is experiencing any of the previous listed clinical findings and SRC is suspected, a full concussion assessment should be performed [2, 3, 21, 23]. Other important points to remember are that if there is not a licensed medical professional at the event, and SRC is suspected, the athlete should be removed from play and not allowed to return until evaluated by a medical professional. An athlete that has been diagnosed with SRC should never return to activity on the same day as their diagnosis. This can be important in basketball where teams could be playing in multiple games, or having multiple practice sessions in the same day.

If you are evaluating the athlete for the initial encounter in an office-based setting, this should include a comprehensive history of the injury as well as initial symptoms and any change in symptoms since time of injury. The office-based physical exam should include some evaluation in the domains of neurocognition, vestibular ocular function, gait, balance, cervical spine, along with a full neurologic exam. The above evaluation should help the clinician confirm the diagnosis of SRC versus other causes from similar symptom combinations. If the athlete's symptoms have resolved, a discussion of return to learn/work as well as return to graduated activity may be implemented. If the athlete's symptoms are still present, it is important to provide guidance on symptom trajectory, early treatment interventions, and continued abstention from sport.

Many clinical tools exist to aid in the diagnosis of concussion. There is currently no definitive evidence on the performance of sideline tests, and expert opinion is again the best level of evidence we have in most areas of concussion evaluation and treatment. Currently expert opinion leans heavily toward multimodal testing such as the Sport Concussion Assessment Tool or SCAT, which is currently in its fifth iteration (however important to note that studies have not been done comparing this version to previous iterations to determine superiority) [2, 3, 23–25]. Unfortunately, all sideline screening tools are laden with the high risk of bias because of the marked heterogeneity in diagnostic accuracy. Discussed below are some of the most common and most studied concussion assessment tools. These should always be used in conjunction with good clinical judgment and assessment by a trained medical professional.

21.5.1 Sport Concussion Assessment Tool (SCAT)

The SCAT has been around since the 2000s and has gone through multiple revisions since that time with the most current being the SCAT5 which came about with the fifth International Consensus Conference on Concussion in Sport. The SCAT combines multiple approaches including an immediate/acute assessment section which includes indications for emergency management, a rapid neurological screen, a graded symptom checklist, standardized assessment of concussion (SAC) cognitive testing—immediate and delayed word recall and repeat digits backwards, Maddocks questions, balance assessment with a modified Balance Error Scoring System (mBESS). The SCAT5 is designed to only be used by medical professionals as it is not designed to be used separately from the assessment of the athlete by the trained professional. There is a component referred to as the Concussion Recognition Tool 5 (CRT5) that has been developed for non-medically trained lay persons to identify possible SRC. The SCAT5 should take no less than 10 minutes to administer and is recommended for athletes aged 13 and older, with a separate Child SCAT5 for athletes aged 5–12. With changes to the word recall list and digits backwards testing to increase the number of words and proactively randomize the numbers given, there are hopes that this will improve the ceiling effect that is seen in older athletes, or athletes who have been rumored to memorize word lists. Unfortunately, there is little information on this test being used with athletes with disabilities, or athletes that speak a language other than English [2, 3, 24].

21.5.2 Balance Error Scoring System (BESS)

The BESS is a test of balance which involves the athlete completing three 20 second stance trials: double leg (hands on hips with feet together), single leg (using nondominant leg with hands on hips), tandem stance (nondominant foot behind dominant foot) on both firm and foam surfaces. The athlete's eyes should be closed during the test and errors are counted (opening eyes, hands coming off of hips, falling out of position, turning the hips more than 30 degrees, and being unable to return to the original position in more than 5 seconds). This test has been evaluated in studies in basketball athletes of both genders and all ages. There does seem to be differences in athletes testing ability dependent on sport (better performance in sports where balance is extremely important to performance such as gymnastics). It has been shown to have moderate to good reliability [26]. The SCAT5 uses the modified version (mBESS) without the foam surface component. It would be prudent to use the full BESS protocol when available for greater diagnostic accuracy.

21.5.3 King-Devick Test (K-D)

The K-D test is a 2-minute test performed by the athlete reading single-digit numbers that are displayed on cards or on an electronic tablet device. If the time needed to complete this post-injury is longer than previous baseline testing, this indicates a positive test and the athlete should be removed from play. Studies have been done on basketball athletes using the K-D test. Although there is some data that there is a learning curve with improvement in time after practicing the test to get a baseline, there is still data that shows that an increase in length of time to complete the test can be associated with increasing likelihood of SRC [27–29]. A newer alternative to the K-D test is the Mobile Universal Lexicon Evaluation System (MULES). It uses two pages of colored images and shows similar promise in longer time needed to complete the series vs baseline is indicative of possible SRC [30].

21.5.4 Computer-Based Neurocognitive Testing

Tests such as the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT), Automated Neuropsychological Assessment Matrix (ANAM), and the Concussion Sentinel to name a few are computer-based tests that generate a score over multiple domains including: attention span, working memory, sustained and selective attention time, non-verbal problem solving, and reaction time, as well as a symptom scale. They are typically used by making a comparison of baseline test results to the results obtained following SRC. A decrease in score is seen following concussion, and there has been some data showing that these tests can be done at time points after resolution of symptoms to determine if the athlete is appropriate to begin return to play protocol [31–34]. There has been debate to the test–retest reliability and validity of computer-based neuropsychological testing. Further research is needed in this area to aid in the clinician's appropriate use of when to test athletes and how to interpret the data in return to play decisions.

21.5.5 Vestibular Ocular Motor Screen Assessment (VOMS)

This is a rapid evaluation of vestibular and ocular function where the clinician evaluates smooth pursuits, saccades, convergence, fixating on a stationary object while moving the head side to side and up and down, and standing while tracking a moving object by turning the head and torso fully side to side. This test should take around 5–10 minutes to administer. A positive test is when the athlete reports symptom provocation such as worsening headache, dizziness, or nausea after each assessment. This test can be administered serially, over time, as there is no ceiling effect and could be useful if there is a reported worsening of symptoms with the serial testing [35].

21.6 Management/Return to Play/Return to Learn

Symptoms of SRC resolve spontaneously in the majority of adults and older adolescents in around 2 weeks, with younger athletes typically taking longer to recover with return to baseline around 4 weeks. It is important to discuss this with the athlete to set expectations for the recovery process. [21, 22, 36]

The most common predictor of recovery is the number and severity of acute and subacute symptoms following the injury, having more symptoms or more severe symptoms being closely correlated with a longer time to recovery. Headache or depression following injury is a risk factor that is often associated with increased return to baseline with symptoms sometimes lasting greater than 1 month. The same is true for athletes with a pre-injury history of depression as well as migraine headaches. ADHD and other learning disabilities have not been shown to result in increased time to recovery; however, athletes with these conditions could require increased interventions when planning the return-to-learn process [36, 37].

Some studies have been done to look at different treatment programs including multimodal rehabilitation supervised by physical therapists and vestibular rehabilitation. When reviewing date on multimodal supervised rehabilitation, which includes training in balance, musculoskeletal, aerobic, anaerobic, and sport-specific exercises, it is difficult to determine the benefits due to a wide range of methods used and unclear conclusions on whether or not athletes that participated in this received benefit in decreased time to returning to competition. Vestibular rehabilitation does have a large amount of positive evidence for improving symptoms; however, this should be limited to athletes that are experiencing specific vestibular deficits and should be targeted toward these [20, 38, 39].

The NCAA, NBA, and WNBA all have concussion policies, protocols, and best practice statements that are updated nearly annually. The NCAA has declared a concussion best practice statement and requires all member schools to have a concussion safety protocol that aligns with this. The NBA and WNBA both have policies that include education to all athletes, coaches, and training staff, appropriate evaluation and management, and return-to-play protocols [40–42].

After an athlete has been diagnosed with a concussion, that athlete should not return to activity on that same day, and should not begin a return-to-play program until deemed appropriate by a physician. The mainstay for managing SRC has been prescribed rest until the athlete is symptom-free. The idea being that rest should ease discomfort during the recovery period and also promote recovery for the brain by decreasing demands. Athletes should be instructed to refrain from both physical and cognitive activities such as workouts, conditioning, weight training, physical education class, reading or other academic work, and limiting screen time including TV, computer, and cell phone use [2, 3, 39, 43].

Recent studies show that the old idea of "rest is best" following concussions until symptoms have completely resolved is not necessarily true. The idea of early subthreshold aerobic exercise individualized to every athlete suffering from concussion now has a significant amount of data touting its outcomes over those of complete rest. It shows that prescribing subsymptom threshold aerobic exercise within 1 week of concussion results in a reduced incidence of delayed recovery beyond 30 days. It was also shown to be safe when compared with a stretching intervention, with no athletes experiencing worsening of symptoms or prolonged recovery times. This is done by performing an exercise tolerance assessment, the most widely used being the Buffalo Concussion Treadmill Test (BCTT), at the initial visit where concussion was diagnosed by a sports medicine physician. A subsymptom threshold exercise prescription should be written to target a heart rate of 80% of what was achieved during the BCTT (when the athlete began to develop symptoms), for 20 min/day, 6–7 days/week. A new heart rate can be determined weekly as long as the participant remains symptomatic [43–46].

21.6.1 Return-to-Play (RTP)

Athletes should be seen and cleared by a physician prior to beginning an RTP protocol. Following the 24–48 hours rest period, athletes should begin with Stage One, symptom limited activity, which includes return to normal cognitive and physical activities that do not exacerbate concussion symptoms as well as a prescription for subsymptom threshold exercise with the BCTT as discussed above. For school-aged basketball athletes, this can include returning to school activities such as class and home, discussed further in the Return-to-Learn section, as well as walking to classes. Once concussion symptoms are resolved, the athlete can proceed to the next level as long as he/she does not experience any return of concussion symptoms. Each step should take around 24 hours, resulting in completing the RTP protocol in around 1 week. The athlete will go through a progression of increasing physical demands and sport-specific activities until completed without return of symptoms. The RTP protocol should be individualized and monitored closely. Athletes should appear back to their baseline function which for some elite athletes could be at a higher level than others [2, 3, 44]. An example protocol is outlined below:

Similar steps should be followed in Return-to-Learn. The athlete should be able to return to school without exacerbation of symptoms. Modifications should be allowed for including breaks during the school day, reduced in class and homework assignments, increased time for completing assignments, testing in quiet, distraction-free environment, limiting the use of computers or other screens, avoiding loud places such as the cafeteria or music class. It is important to remember that in athletes that are school-aged, return-to-learn should take place prior to or simultaneously with RTP (i.e., athletes should not be returned to sport if they are unable to return to the classroom) [2, 3].

21.7 Complications

There are multiple long-term complications that can arise from SRC. Some of these include persistent postconcussive symptoms, the risks associated with repetitive SRC, and lower extremity musculoskeletal injuries.

There are significant risks associated with premature return to play and delayed reporting of symptoms including continuing to play after sustaining a concussion such as more severe symptoms and prolonged recovery. In a study that looked at both basketball athletes as well as athletes from other sports, athletes that delayed the reporting of their concussion symptoms had a significantly increased number of symptoms, severity of symptoms, duration of symptoms, and time lost to concussion. The immediate reporting of symptoms and removal from play also decreased head impacts taking place during the acute period after the original injury [43, 47].

Postconcussion syndrome, or persistent post-concussive symptoms, is defined as symptoms that continue beyond the expected recovery window (more than 2 weeks in adults, more than 4 weeks in children). These can have a significant negative impact on the daily life of the athlete. It was once recommended to continue complete rest during this time; however, more recent data has shown that subsymptom threshold aerobic exercise could be more beneficial in aiding recovery. It has been used both in attempting to prevent prolonged recovery as well as part of prolonged recovery [45, 47].

Repetitive SRC can lead to increased length of recovery, the possibility of sustaining a concussion through a less forceful injury, as well as increased severity of the concussive symptoms. Data has shown that athletes that have sustained one concussion are three times more likely to have another concussion. There has also been data to show an increased risk of lower extremity musculoskeletal injury following a concussion, and this has been shown to be a bigger risk in female athletes than in male athletes. This increased risk is thought to be due to persistent subclinical effects or alterations in neurocognition. Athletes with decreased neurocognitive performance may have a difficult time with anticipating the actions of their opponents leading to difficulty in dodging versus bracing for collision while taking a charge underneath the basket [47, 48].

Chronic Traumatic Encephalopathy (CTE) has become a growing concern in the athletic community. Although no direct link has been able to be established between CTE and concussions, most research is currently focused on linking it to repetitive brain trauma (RBT). CTE is considered a progressive neurodegenerative disease and with symptoms including behavior and mood problems and impaired cognitive function. No large studies have been performed in basketball athletes and CTE, with most studies having been done using retired National Football League athletes. The data that is currently available does indicate that exposure to RBT is one of the largest risk factors for development of CTE [49].

21.8 Obtaining Rights to Image

21.8.1 Prevention

Although almost every area of study for concussion needs further research from the definition to the appropriate treatment, research looking into prevention strategies should also be high on the list of priorities. Concussion legislation currently exists across all 50 states in the United States, as well as implementation of the CSIG in both national and international sports organizations, including the implementation of a formal concussion protocol in the National Basketball Association [37, 41]. Some of the main strategies for primary prevention have been in both education as well as rule changes in sports. The NCAA has outlined in their guideline for managing concussions that schools provide athletes and coaches with educational materials on concussions and that a form must be signed by every athlete stating that they have reviewed these guidelines [19, 40, 50]. Educational initiatives, such as the HEADS UP campaign created by the CDC, have been attempting to increase the awareness of concussions [51]. Areas for future research focus around the risk factors for concussion (history of prior concussion, female sex), the most common mechanism for concussion (player to player contact), the use of sport-specific equipment in the role of prevention and rule changes (in basketball, changes have been made to the court including the restricted area under the basket) [50, 52]. Although not necessarily primary prevention, the number of certified athletic trainers working in the collegiate setting has also increased around 86% from 1995 to 2005 and has most certainly continued to increase from then [9]. This would ideally lead to improved player adherence to immediate removal from competition and outcomes following an appropriate Return-To-Play protocol.

21.9 Conclusion

SRC is an important focus for medical professionals, athletes, coaches, and anyone closely involved in sport. In basketball, SRC affects players of all age ranges, both sexes, elite-level athletes in the National Basketball Association and National Collegiate Athletic Association, to youth athletes participating recreationally. Further research needs include all aspects of SRC from definition to management. Important points to remember include to err on the side of caution when suspecting SRC as it is always better to remove the athlete from competition early, and delayed removal can result in increased time for return to competition. Focus on appropriate and supervised Return-to-Play and Return-to-Learn protocols is needed to reduce the long-term risks of concussion including increased risk of musculoskeletal injury and repeat concussions. It will be important to increase the effort placed on primary prevention with education and awareness of the signs, symptoms, and sequelae of SRC for athletes and coaches.

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