REVIEW ARTICLE

Current Concepts in the Office-Based Treatment of the Concussed Athlete

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KEYWORDS:

Sport-Related Concussion

Head Injuries

Neuropsychological Testing

Vestibular Therapy

Neuro-Optometry

Context: Concussion has emerged as one of the most challenging conditions in medicine. With the currently changing and evolving diagnosis and treatment paradigms in concussion management, a comprehensive review of the current literature was necessary. This article focuses on the in-office evaluation, diagnosis and treatment of the concussed athlete as opposed to on-field assessment. This article will guide the primary care physician through a logical evaluation and treatment process for this challenging injury.

Evidence Acquisition: A thorough and comprehensive review of the current literature was performed via PubMed, Medline, and Google Scholar.

Study Design: Clinical Review.

Level of Evidence: Level 5

Results: Upon review of the current medical and allied health literature, a systematic and step-wise approach to obtaining key historical points, physical examination, medical imaging, additional diagnostic testing, and treatment both medically and by allied health professionals was developed to give primary care physicians a structured protocol to follow in the diagnosis and treatment of concussion in the office-based setting.

Conclusion: This article gives primary care physicians a current and progressive approach to the diagnosis, evaluation, work-up, and treatment of the concussed athlete in the in-office setting concerning concussion management.

INTRODUCTION

Sports Related Concussion (SRC) has emerged as one of the most challenging conditions in medicine. Continued media coverage both in the news and entertainment has created much confusion amongst athletes about treatment options and future consequences regarding this injury. Thus, SRC has continued to be a challenging condition to diagnose and treat, and athletes often present with several of the following questions when seeking treatment:

- Is this really SRC?
- Are the symptoms that I am having normal for SRC?
- Is rest still best?
- Are there treatments now for SRC?
- How long will it take me to recover?
- Can I go to school and/or work?
- When can I return to sports?

The goals of the treating physician are to determine the presence or absence of SRC, reassure the patient that his/her symptoms are consistent with SRC if diagnosed, and provide the patient with an individualized treatment plan to provide for optimal recovery.

Further, the physician should aim to prevent Second Impact and Post Concussion Syndrome, mitigate symptoms, decrease symptom duration, determine if the athlete is safe to return to learn, and if appropriate, play, and reduce the possibility of cumulative effects of SRC including its controversial association with Chronic Traumatic Encephalopathy.

As SRC is continually evolving in terms of nomenclature, diagnosis, and treatment, ongoing review of the current concepts of SRC is essential not only for sports medicine physicians, but for all practitioners. Only by continually reviewing the literature and individualizing treatment to the symptoms of the athlete, will the physician be successful in determining if and when the athlete can be safely returned to sport.

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CLINICAL RECOMMENDATION	EVIDENCE RATING	REFERENCES
Medical imaging yields no information in concussion management unless to determine if structural brain injury has occurred	A	3
There is no currently endorsed laboratory test or biomarker by the CISG	A	3
VOMS is significantly helpful in discerning vestibulo-ocular symptomatology in association with concussion	A	6
Vision therapy may be a helpful modality to use in concussion management.	B	20,21
Rest should be the mainstay of continued care in the concussed athlete	C	3
There is limited data to support the use of medications in concussion management except for symptom control.	B	1,3,4,8
Neuropsychological testing and treatment secondary to is a definitive assistant in concussion management	B	3
Cognitive behavioral therapy is emerging as an adjunct to treatment in the concussed patient with associated mood symptomatology	B	22

BACKGROUND:

SRC is the most common head injury in athletics, with less that 10 percent resulting in loss of consciousness.[1] An estimated 1.1 to 1.9 million sport and recreationally related concussions occur in the United States every year in those under age 18.[2] Concussion occurs most frequently in collision and contact sports, and can be caused by a head to head collision between athletes, or by a blow to the head from the ground or other objects.[1] Impact forces to the chest, back, neck, or face that radiate to the head may also cause a concussion.

The basic definition of SRC, developed by the Concussion in Sport Group (CISG) and released in the Spring 2017 Consensus Statement on Concussion in Sport – the 5th International Conference on Concussion in Sport Berlin 2016, is as follows:

"SRC 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:

- 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.

The clinical signs and symptoms cannot be explained by drug, alcohol, or medication use, other injuries, or other comorbidities."[3]

The gold standard, which has remained in place since the first CISG in 2004, is that if there is any doubt SRC has occurred, the athlete should be removed from the competition immediately and seen by a practitioner with experience in SRC evaluation and management within the following 48-72 hours for a more thorough examination.[4]

MEDICAL MANAGEMENT:

Management of SRC, per the 2016 CISG Consensus Statement, consists of the 11 Rs of SRC – Recognize, Remove, Re-evaluate, Rest, Rehabilitation, Refer, Recover, Return to sport, Reconsider, Residual effects and sequelae, and Risk reduction.[3]

In the office setting, assessment often begins before the athlete enters the examination room. As the athlete enters a new environment, the reaction of his/her vestibular-ocular system to this new environment often yields clinical information that is observable prior to obtaining a history or physical examination.

Athletes are encouraged to bring with them a family member or second historian as well as any information that may help in the evaluation of the current concussive episode, including:

- Any radiological studies such as CT Scan or MRI
- Any computerized neurocognitive testing, including both baseline and post-testing (i.e. IMPACT, etc.)
- The Sport Concussion Assessment Tool (SCAT5) and Balance Error Scoring System (BESS) scores
- The Pre-participation Physical Examination Exam (PPE)

These materials and historians are helpful as the athlete often cannot recall his/her history due to the injury and parents/guardians are often challenged in recalling an accurate history due to the complexity of SRC and the concussion office visit.

HISTORY:

A detailed history is the most important component of the athlete encounter. Questions that should be asked during the encounter:

1. How many head injuries has the athlete had in the past?
   - When did they occur?
   - How did they occur?
   - What type of symptoms did the athlete have?
   - How long did the symptoms last?
   - Did they lose consciousness?
   - Did they have amnesia (anterograde or retrograde)?
2. Are the current symptoms and injury associated with loss of consciousness or amnesia, and what type?
3. Did the athlete report on-field dizziness?
4. Does the athlete have a history of motion sickness?
5. What kind of headache does the athlete have and does it worsen with exertion or schoolwork?
6. Does the athlete get dizzy with movement?
7. Does the athlete get fatigued at the end or a certain point in the day?
8. Is the athlete more sensitive to light or noise?
9. Is the athlete more distracted?
10. Does the athlete have trouble falling asleep or staying asleep?
11. Is the athlete moody or irritable?
12. Does the athlete feel “foggy” or “removed”?
13. How many practices or games has the athlete missed?
14. How many school days or tests has the athlete missed?
15. Has the athlete’s symptoms affected his/her classes or grades?
16. How long did it take the athlete to recover from past concussions?
17. Did the athlete have incidents/symptoms from any hits to chest, neck or face that radiated to the head (e.g., whiplash) that were not reported as a concussion?

The answers to the above history questions can mimic other sports medicine conditions seen in competition, such as heat illness or dehydration. Categorization of symptoms often makes it easier to correlate certain aspects of physical examination findings to establish treatment. The strongest and most consistent predictor of slower recovery from SRC is severity of the patient’s initial symptoms on the first day, or initial few days, after injury.[3] Patients with co-morbid migraine headaches and mood disorders are often at risk for protracted recovery. While AD/HD and other learning disabilities require more careful evaluation and follow-up, they do not seem to be solely responsible for protracted recovery.[3]

While several classification systems have been used in the past, more recently the University of Pittsburgh Medical Center (UPMC) Classification System offered categorization of concussion symptoms into six different categories, which can occur in isolation or in any combination, and include cervicogenic, vestibular, ocular, post-traumatic migraine, cognitive/fatigue, and anxiety/mood.[5]

For the purposes of this paper, a modified version of the UPMC Classification System containing the following categories is reviewed:

1. Cervicogenic
   - Cervical Strain
   - Tension Headache
2. Cognitive
   - Attention
   - Fogginess
   - Fatigue
   - Cognitive slowing
3. Emotionality
   - Depression
   - Anxiety
   - Sadness
   - Nervous
   - Irritable

4. Sleep Disturbance
   - Difficulty falling asleep
   - Inability to remain asleep
   - Sleeping more than usual
   - Sleeping less than usual

5. Vestibular
   - Dysfunction in balance and coordination

6. Ocular
   - Inability of the ocular system to work appropriately
     - » Difficulty with convergence
     - » Difficulty with divergence
     - » Difficulty with smooth pursuits
     - » Difficulty with saccadic eye movement
     - » Difficulty with accommodation
     - » Difficulty with VOR (Vestibulo-ocular reflex) or VMS (Visual Motion Sensitivity)

PHYSICAL EXAM:

A complete physical examination is an essential component of the in-office evaluation. This exam begins with a detailed neurological examination assessing vital signs, analyses of speech and gait, cranial nerve testing, visual field testing, upper extremity and lower extremity sensation, range of motion and strength, deep tendon reflexes, Romberg, Pronator Drift, Tandem Walk, Heel to Shin, Finger to Nose Testing, and the Vestibular-Ocular Motor Screen.

The Vestibular/Ocular Motor Screen (VOMS) is one of the more valuable resources in evaluation, diagnosis, and treatment of concussion. Given the importance of the vestibular-ocular system to the recovery of the concussed athlete, it is highly recommended to include VOMS testing as part of the standard physical examination.[6]

VOMS begins with examination of smooth pursuits, performed similarly to traditional extra ocular muscle testing. Smooth pursuits are examined horizontally and vertically with the examiner looking for non-physiological nystagmus, inability to track, or dizziness/nausea *(Image 1, page 36).*

Saccadic eye movement is then measured as the examiner stands away from the athlete's eyes, with his/her fingers 12 inches apart horizontally and then vertically on either side of the athlete's head. The athlete is instructed to look back and forth between the examiner's fingers for 15 seconds. The examiner is again looking for non-physiological nystagmus, latency of onset, speed, accuracy, and conjugate movement. Failure of the test occurs with delayed or inaccurate saccades, or disconjugate eye movement *(Images 2 and 3, page 36).*

Evaluation of the Vestibular-ocular reflex (VOR) is an examination of gaze stability. Testing is performed by observing the athlete while s/he stares at his/her own thumb while moving the head horizontally, and then vertically, without blurriness or dizziness. Similar to saccadic eye movements, VOR testing is performed for approximately 15 seconds. Test failure is characterized by the inability of the athlete to maintain focus/stabilize gaze on his/her thumb in either the vertical or the horizontal positions *(Image 4, page 36).*

The Visual Motion Sensitivity Test, (VMS) measures response to optokinetic activity. On this test, the athlete focuses on his/her thumb while moving the head and thumb in tandem, both horizontally and then vertically, while maintaining focus on the thumb for 15 seconds. Failure of this test is characterized by the athlete's inability to follow the "fixed" object, i.e., his/her thumb *(Images 5 and 6, page 36).*

Near point of convergence (NPC) is the point nearest to the bridge of the athlete's nose at which s/he is able to maintain binocular fusion while focusing on a target moving inward at approximately 1 to 2 seconds/centimeter. While the research is mixed, distances of NPC in children greater than 6 cm, and NPC in adults greater than 8 cm, are considered a failed examination[7] *(Image 7, page 36).*

If at any time during these tests the athlete has a return of concussive symptoms, this is also a failed test.

In addition to ocular testing, balance testing is recommended as part of the overall physical examination. Balance testing can be performed in a variety of different ways. Commercially, there are applications available that offer clinicians a modality from which to measure balance from their mobile devices. There are also several commercially available force-plate technology apparatuses that can measure an athlete's balance. The Balance Error Scoring System (BESS) is a simple test that can be performed without technology, is part of the Sport Concussion Assessment Tool 5th Edition (SCAT5), and measures the athlete's balance in three positions - double leg, single leg, and tandem stances - on first a firm and then foam surface with the eyes closed. Athletes lose points on the test for each error.[3,4,6,8,9] Due to subjective differences between test administrators, BESS testing results should be approached with caution.

IMAGING

The CISG has recognized that neuroimaging is usually normal and contributes little to evaluating concussion. Neuroimaging is used primarily when there has been prolonged disturbed consciousness, when the athlete presents with focal neurological deficits or persistent cognitive symptoms, or when there is suspicion of a structural abnormality, cerebral bleed, or seizure activity. Computed Tomography (CT) is used to rule out hemorrhages and fractures. Magnetic Resonance Imaging (MRI) is used to assess structural and functional abnormalities, and is being used more often as there is no radiation exposure. The weighted images produced by diffusion-tensor imaging (DTI) often can elucidate structural brain abnormalities in protracted cases or post-concussion syndrome.[10] Functional MRI (fMRI), which is typically performed while the athlete simultaneously completes a cognitive task, has been used more extensively in concussion research but is not yet standard of clinical care.[1,3,4,8,9]

IMAGE 1:

IMAGE 2:

IMAGE 3:

IMAGE 4:

IMAGE 5:

IMAGE 6:

IMAGE 7:

Image interpretation:
Image One – Smooth Pursuits
Image Two, Three – Saccades
Image Four – Vestibular-Ocular Reflex Test
Image Five, Six – Visual Motion Sensitivity Test
Image Seven - Near Point of Convergence Test

LABORATORY TESTING:

There currently are no definitive fluid biomarkers or genetic testing used in the evaluation of SRC.[3] Though the CISG has endorsed no fluid biomarkers or genetic testing in the evaluation of SRC, the FDA has just endorsed the first laboratory blood test used to evaluate mTBI/concussion.[11]

POST CONCUSSION TREATMENT:

Patient Education

Symptomatic athletes should be immediately removed from play.[3] In the immediately concussed athlete, first-line treatment in concussion management should be complete mental and physical rest for no more than the first 24 - 48 hours, including no physical education or sports. Use of electronics should be eliminated or significantly decreased until the patient is asymptomatic with use, and then the patient should be encouraged to engage in progressive cognitive and physical activity below the threshold of symptom exacerbation.[3] Should symptoms reemerge with use, the patient should be encouraged to back off of electronics until symptom free, and then begin to reengage until symptomatic, and then continue in this cycle in an attempt to elongate his/her ability to engage in the use of electronics while symptom free, i.e., "push and recover, push and recover."

Immediately, and through the course of recovery, diet should consist of three meals a day, including encouragement of a protein diet, with adequate and increased hydration of at least 80 ounces per day. Mild exercise such as walking, stretching, or moderate yoga should be encouraged. Sleep should be 7 to 9 hours, without napping, and no electronic devices should be used in the bedroom at bedtime.[5] The athlete should also be counseled at this time on the necessity of an individualized treatment paradigm to lessen symptoms, decrease duration of concussion, prevent possible long term complications of concussion based on the individual patient's case, and to explain to the athlete the requirements of when s/he can return to learn, and if appropriate, return to play.

Treatment is often executed by a multi-disciplined team

Vestibular Therapy

Vestibular therapy is a cornerstone of concussion treatment targeting dizziness, vertigo, balance, vision, and visual discrimination associated with concussion. Vestibular therapy uses current vestibular, physical, and occupational therapy maneuvers. There are five main categories of the exercises done in vestibular therapy through which the athlete progresses given sequential successes.[10]

1. Coordination of the eyes and head.
   - Exercises target rehabilitation of deficits found on examination of VOR, VMS, smooth pursuits, anticipatory gaze shifts, image targeting, vergence, accommodation, and/or saccadic eye movements.
2. Sitting balance exercises.
   - These can include maintaining balance while sitting upright, weight shifting side-to-side, or bouncing.
3. Standing static balance exercises.
   - These can include the athlete standing in place while upright or weight shifting. Athletes can also be asked to stand on one leg, stand on the rocker board, or stand with one foot on a step. This category includes sit to stand exercises.
4. Standing dynamic balance exercises.
   - These can include the athlete standing and moving without walking. The athlete may walk in place, step forward, step backward, step side to side, step up and down, and/or turn around.
5. Ambulation exercises.
   - In these exercises the athlete moves forward, backward, on stairs, skips, jogs, or runs. The modifiers of these exercises include posture, surface, size of base support, position of arms, position of trunk, direction of head movements, direction of whole body movements, visual input, presence or absence of a cognitive task, and special circumstances.

Vestibular exercises are recorded in frequency and duration

Vestibular therapists often use true physical therapy modalities for comorbid cervical or peri-scapular strain and/or tension headache. Treatment may include manual therapy, range of motion exercises, and strength training.

Osteopathic physicians are specifically trained in osteopathic manipulative treatment and injection therapy which can assist in the treatment of concussed athletes. After a thorough structural examination, osteopathic manipulative techniques that can be considered include gentle range of motion (ROM) exercises, stretching exercises, myofascial release, and muscle energy.

Exertion therapy is being used more frequently in concussion management. In addition to decreasing deconditioning, it can be helpful in distinguishing anxiety and/or depression symptoms from those truly associated with concussion. Symptoms that peak with exertion, yet diminish with cessation of activity and return to rest are often related to SRC, while those that remain once exertion has ceased and rest has been restored, often can be related to associated anxiety. Exertion typically begins with static exercises, followed by exercises challenging the vestibulo-ocular system. Judgment of the athlete's exertional tolerance allows the therapist to progress the athlete through a continuum, typically from the exercise bicycle, to the elliptical, the treadmill, resistance training, and finally to sport specific activity.

NEUROPSYCHOLOGICAL ASSESSMENT/CONSULTATION:

Baseline and post-injury neuropsychological (NP) assessment was not considered as a requirement by the CISG; however, it often yields useful information.[3] NP is multifaceted, and typically consists of either short, often computerized, screeners, or more formal, comprehensive, pencil and paper neuropsychological batteries. Computerized NP tests, e.g. ImPACT (Immediate Post-Concussion Assessment and Cognitive Testing), can be administered by a wide variety of clinicians and offers snapshots of an athlete's cognition that are easily replicable in short periods of time given acceptable practice of effects.[4,12] Furthermore, it has been demonstrated that the addition of NP testing to symptom self-report forms "adds value" to the clinician's ability to diagnose SRC correctly, in those with true SRC.[13]

While computerized measures are more easily applicable for baseline testing, when an athlete's recovery becomes protracted, the use of a comprehensive NP battery, administered and interpreted by a neuropsychologist trained to evaluate subtle neurocognitive deficits, is often recommended by the treating physician. 4 When NP assessment is deemed medically necessary, the medical necessity for the inclusion of measures assessing effort and performance validity is implied.[14] Measurement of an athlete's effort on NP testing is critical to determining validity of test results and subsequently offering information to the physician in making RTP decision.[15]

It has been commonly accepted that in order to return to play more quickly, athletes always will provide maximum effort on NP testing. However, as effort relates to the sports medicine population, it was demonstrated that over three comprehensive NP testing sessions, approximately 28% of this athletic population was sub-optimally engaged for at least one session, and there is a subgroup of young athletes who were disengaged in testing over the course of the entire three-session NP evaluation, regardless of gender, history of previous concussion, psychiatric or learning diagnoses, or use of prescription medication.[16] While these data refer to comprehensive neuropsychological testing, administered by a doctoral level neuropsychologist, research has demonstrated that athletes may exert suboptimal effort on baseline computerized neuropsychological testing, in the presence of sports medicine physicians and related clinicians, as well. It has been demonstrated that within ImPACT, review of failure to identify distractors increases the clinician's ability to detect malingering when used with the already embedded validity scales.[17]

COGNITIVE REHABILITATION THERAPY:

Following NP assessment, Cognitive Rehabilitation Therapy (CRT) may be recommended to support the athlete in his/her area(s) of deficit, which may include NP domains such as memory, attention, executive functioning, and/or processing speed, etc. Therapy may be with a cognitive rehabilitation specialist working on specific skill set training and strategies for learning, and/or home-based, skill specific computer programs. Strategies targeted in CRT may be incorporated into the athlete's 504 Accommodations Plan or Individualized Education Program (IEP). Research demonstrates that while there has been efficacy of CRT following concussive injuries, successful rehabilitation may be mediated by type of injury, age, and timing of intervention.[18,19]

NEURO OPTOMETRIC CONSULTATION:

Disturbances to the neuro-optometric system are one of the most common and challenging sequelae of SRC. These changes can include problems with convergence, divergence, smooth pursuits, saccades, accommodation, VOR, and VMS. Collectively, disturbances to the visual system secondary to concussion are known as Post Trauma Vision Syndrome (PTVS). Symptoms resulting from PTVS include: convergence insufficiency, high exophoria or exotropia, accommodative dysfunction, low blink rate, difficulties in attention/concentration, ocular motor difficulties, and visuospatial distortions with associated neuromotor affects.[20] Physicians may need to consider curtailing driving in patients with PTVS *(Table 1).*

While vestibular therapy often incorporates treatment of the neuro-optometric system, continued symptomatology within the neuro-optometric system often necessitates referral to a neuro-optometrist.

OPTOMETRIC VISUAL DEVICES/VISION THERAPY:

The three primary optometric treatments include in-office therapy, in-home therapy, and lenses, with in-office and in-home therapies often used in tandem. Therapies target vergence, accommodation, tracking, visual memory, and/or visual attention, and must be balanced with the academic, homework, and therapy load of the athlete as they often are a trigger for headache in the symptomatic athlete.

Glasses are often used temporarily with concussed athletes, and may include corrective lenses, Irlen lenses, lenses with an anti-refractive coating, or prisms.[21] Intra-office vision therapy and home-based therapies typically include active treatments such as "pencil-push ups," therapy with base-in prisms, computer programs, stereoscopes, and free-space fusion cards. Though research is mixed, a combination of in-home and office-based therapies has yielded the most efficacy.[7]

PSYCHIATRIC/PSYCHOLOGICAL CONSULTATION:

Psychiatric and/or psychological consult has definitive application in SRC management. Early detection of athletes with either premorbid, emerging, or comorbid anxiety/depressive symptoms is critical to successful SRC management. There is increasing evidence that athletes with post concussive symptoms respond well to Cognitive Behavioral Therapy;[22] however, the training and type of clinician is critical to the possible success of the intervention. Depression is considered the paramount psychiatric condition for serious complications related to the treatment and recovery, as many symptoms of major depression mirror those of SRC (e.g. difficulties with attention, concentration, cognition, fatigue, irritability, headaches, relational, and occupational and academic problems, etc....)[23]

Athletes with significant psychiatric symptomatology may require consultation with a psychiatrist regarding pharmacological intervention. Given the potential side effects of psychiatric medications, particularly the risks of suicidal ideation in the adolescent population with the use of SSRIs, psychiatrists are an integral part of the SRC team. Oftentimes, pharmacological and non-pharmacological approaches are utilized simultaneously.[24]

COGNITIVE BEHAVIORAL THERAPY

Cognitive behavior therapy (CBT) is often useful for those athletes who demonstrate true psychopathology and related symptoms. When considering CBT for an athlete, referral to a doctoral level psychiatrist or psychologist should be considered, as the specific recommendation for CBT is typically provided by a trained psychiatric practitioner, following formal neuropsychological testing or psychiatric examination. Current evidence exists that

TABLE 1:

Common Neuro-Optometric Conditions and Their Effects on Concussion

CONDITION	PHYSIOLOGY	MANIFESTATION
Convergence insufficiency	Insufficient ability to use eyes as a "team" to converge/lock on a target	Difficulties with reading
Ocular motor dysfunction	Inability of the eyes to work together to track a moving target and switch fixation points	Accurate visual scanning and exploration; reading or copying from a smartboard
Accommodation Infacility	Inability to maintain clarity while shifting attention/focus from one distance to another rapidly and accurately	Maintenance of focus at reading distance; academic efficiency; comfort focusing on an object
Visual intake-visual memory	The inability to obtain maximum visual information in the shortest possible time and retain this information over an adequate period of time	Reading comprehension and spelling
Visual-motor integration	The inability to integrate visual input with motor output.	Copying notes from a whiteboard or projector screen, or transferring answers to test papers similar to Scantron formats
Fusional Dysfunction	Binocular dysfunction affecting near and distant visual tasks	Blur and/or double vision

CBT may be an effective treatment for post-concussion syndrome, and there is limited evidence that rehabilitation programs that include a psychotherapeutic/mindfulness and/or relaxation element are beneficial for persisting symptoms.[22] In contrast with previously held beliefs, dispersion of information, education, and reassurance alone may not be as convincingly efficacious as active treatments.[22] Furthermore, research does not support the use of educational materials alone to affect behavior change.[25] Therapy can be done in an outpatient or school setting, and should be coordinated with the athlete's 504 Plan or IEP.

MEDICATIONS

There is limited data to support the use of medications in SRC.[3] Medications are not recommended in the first 10 to 14 days of SRC management as athletes typically recover on their own,[1,3,4,8] and if considered, they should be prescribed by experienced SRC clinicians, and are used to control specific symptoms, modify the underlying pathophysiology of SRC, or to shorten symptom duration. Non-steroidal anti-inflammatory medications (NSAIDs) may cause rebound headache; however, they may be considered in concurrent cases of cervical or peri-scapular strain, or tension headache. Use of acetaminophen is considered a better choice than NSAIDs; however, it also can cause rebound headache. Tramadol or tramadol/acetaminophen can manage headaches in those athletes over 18 with no comorbid seizure history. Muscle relaxants are helpful for cervicogenic headache. Data is mixed on the efficacy of "vitamin therapy" for headache control. Vitamins B2, Omega 3 Fatty Acids, magnesium, and coenzyme Q often help with migraine and have been successful in some concussed athletes. True post-traumatic migraine (headache associated with nausea and photophobia and/or phonophobia) can be treated with propranolol, verapamil, amitriptyline, nortriptyline, or the triptans. The social/emotional symptoms of SRC are often treated with selective serotonin reuptake inhibitors (SSRIs) or lorazepam. Sertraline is often successful in the treatment of the psychological effects of SRC; however, escitalopram is commonly prescribed. Cognitive and attention symptoms are often treated with stimulant medications, and methylphenidate or atomoxetine are often used in the SRC population. Amantadine, an antiviral drug, has been shown to assist with cognition.[26] Clonazepam is often used in patients with significant vestibular symptoms often accompanied by anxiety. Insomnia is often treated with melatonin, diphenhydramine, hydroxyzine, trazodone, and more rarely, zolpidem.

NEUROLOGY CONSULTATION:

Consultation with Neurology is considered in certain situations. Neurology co-management is helpful in situations where the concussed athlete is dealing with true neurological co-morbidities. These situations would include:

1. Abnormal medical imaging
2. Pre/Co-morbid headache syndromes
3. Pre/Co-morbid Attention-Deficit/Hyperactivity Disorder (AD/HD)
4. Pre/Co-morbid neurological conditions
5. Any newly diagnosed or suspected neurological conditions

CURRENT CONCEPTS IN EDUCATION

As SRC is evolving as one of the most challenging conditions in medicine, effectively managing Return to Learn (RTL) is evolving as one of the most challenging aspects in education. While there are standardized Return to Play (RTP) protocol, current RTL protocol continue to evolve – though are consistently of a stepwise approach.[27]

Return to Learn:

Further complicating effective RTL, pre-existing AD/HD, learning disabilities, depression, and/or anxiety may worsen symptoms and protract recovery[28] *(Table 4, page 42).*

Practitioners may facilitate recovery by allowing a brief absence from school initially, as overtaxing cognition may worsen symptoms and possibly prolong recovery.[29] However, students typically return to school while symptomatic, as a primary goal of SRC management is to keep disruptions to the student's life to a minimum. School based accommodations target balancing the level of the athlete's academic workload with the progression of the athlete's cognitive recovery, and are monitored carefully as academic difficulties post-injury impact symptom report, and may also be associated with the emersion of anxiety and/or depression.[27,29]

Medical and education providers must work reciprocally to communicate the academic expectations and accommodations necessary to support a gradual RTL process.[30] Providing symptomatic students with subject-specific supports during the post-injury recovery period is necessary, particularly as students progress through more demanding phases of academia.[27] There is a general consensus that communication between the athlete and his/her caregivers and medical and educations teams is critical to maximizing recovery outcomes.[30]

Post concussion, athletes often experience academically based difficulties related to physicality, cognition, and emotionality, all of which may increase with schoolwork, computer work, and testing. [29] *(Tables 2 and 3)*

Return to Play:

Athletes should be encouraged to engage in tolerated exercise activity during the course of recovery. Activity should begin with walking, and is often dictated by performance in exertion therapy. The decision for RTP to actual sport for athletes continues to be determined by the experience and knowledge of the attending or team physician. There continues to be no timeline or formula with which to return an athlete to normal game play. All RTP decisions should be individualized, [31] and factors that warrant further consideration of return to contact/collision sports include the following: [3]

1. Smaller impacts causing worsening symptoms or longer recovery with repetitive SRCs.
2. Extended symptom numbers, severity, or duration in athletes with repetitive SRC.
3. Extended time for formal or computerized neuropsychological testing to return to baseline level.
4. Increased frequency of repetitive SRCs or shortened periods between repetitive SRCs.
5. Age of athlete and number of SRCs sustained.
6. Role of pre-existing conditions and co-morbidities, and their influence on concussion symptoms/duration.
7. Impact of athlete's daily/regular medications on SRC.
8. Role of type of sport, rules of sport, and athlete's behavior in sport, related to risk of further SRC.

At the discretion of the attending or team physician, athletes should be considered to begin the RTP program when they have met the following criteria:

1. Symptom Free for 24 to 48 hours without the assistance of medication.[4]
2. 24 to 48 hours of executed normal activity, which for a student athlete in a full contact sport, would be full activity in school (if school is in session) without accommodations, and for a student in a noncontact sport, such as swimming, cross country, etc., would be full activity in school (if school is in session) with minimal accommodations. The goal being to return the athlete to the highest level of sport safely allowed in the subset of student athletes who have unremitting residual symptoms.
3. Though controversial, if computerized neuropsychological testing is used in management, and baseline testing was performed, there should be return of computerized neurocognitive testing to baseline; if no baseline was obtained, computerized neurocognitive testing should be at least average for age and sex matched peers.

Progression through the RTP protocol should proceed stepwise. If post concussive symptoms recur, the athlete should return to the previous asymptomatic level, and then begin progression again within 24 hours. The steps should proceed as follows in Table 5, (*page 42)*: [3,8,9,10]

If the athlete is unable to complete any step of the RTP program, or cannot compete the program without symptoms, s/he should be referred back to the physician for reassessment.

While SRC has emerged as one of the most challenging conditions in medicine, today there are objective measures that have made in-office evaluation and management of SRC more manageable for the clinician. Immediate recognition of SRC and early intervention by the physician can decrease symptomatology, lessen duration of SRC, and prevent long term complications. While considering the modifying factors associated with SRC, the decision to return an athlete to sport continues to rely on the individual experience and practices of each attending or team physician. As every State, and the District of Columbia, now has a concussion law, knowledge of not only the diagnosis and treatment of SRC, but also the State and/or scholastic guidelines dictating return to learn and play, is imperative to every physician treating SRC. As these continue to be updated and revised, it is critical that any physician caring for concussed athletes remain updated on current changes to the literature in order to provide immediate, comprehensive, and individualized care to the athlete, as well as to allow for a more rapid return to learn, and if appropriate, return to play.

TABLE 2:

Common Academic Based Difficulties and Their Expressed Symptoms with Concussion and Suggested Accommodations

SYMPTOM	COMPLAINTS	DIFFICULTIES	ACCOMMODATIONS
Physical	Headaches, photo/phonophobia, Dizziness, imbalance, dissomnolence, exertional sensitivity	Irritability, gait, arousal, sleep, and concentration, which may worsen in loud and bright environments, or with over-activity	Rest breaks, sunglasses, preferential seating, environmental alternatives to lunchroom, assemblies, hallways, preferential class transition, later start time, shortened day, reduce cognitive or physical demands; complete work in small increments
Cognitive	Attention/Concentration, i.e. Short focus on lecture, classwork, homework Memory working / consolidation / retrieval Processing speed Cognitive fatigue	Holding instructions in mind, reading comprehension, math calculation and applications, writing, Retaining new information, accessing learned information Keep pace with work demand, process verbal information effectively Decreased arousal/activation, poor basic attention, working memory, and concentration Student may push through symptoms to prevent falling behind	Repetition, written instructions, note-taking, calculator, short reading passages, chunking, recognition cues Extended time, slow down verbal info, comprehension checking Rest breaks during classes, homework, and exams, workload reduction, alternate forms of testing
Emotional	Anxiety Depression/Withdrawal Irritability	Withdrawal from school/friends (stigma/activity restrictions) Poor stress tolerance, alienate peers/teachers	Engage student with friends at lunch/recess Reduce stimulation, stressors, and workload, rest breaks, shorter assignments, break down tasks[13]

TABLE 3:

Role of Members of the Academic Support Team in Concussion and Suggested Plan of Action

SCHOOL PERSONNEL	STUDENT NEEDS	PLAN
Certified Athletic Trainer and/or school nurse	The person of first contact who disseminates information and coordinates the treatment of the athlete with the educational and medical team	Often Liaison between family, coaches, academic and medical team.
Guidance Counselor	Short-term academic accommodations	Works with the student and medical team to develop a Section 504 Accommodations Plan
General Education Teacher	Translate plan to classroom	Working knowledge of Section 504 Accommodations related to concussion in the classroom
Child Study Team	Long-term educational intervention	Works with Guidance Counselor to transition 504 to an Individualized Education Program (IEP) – An IEP signifies that the student now requires a specialized education curriculum administered in an inclusion classroom by a special education teacher as opposed accommodations in a general education classroom with a regular education teacher
Special Education Teacher	Translate plan to classroom	Working knowledge of how to educate students with brain injuries in the classroom who require specialized education using a specialized curriculum

TABLE 4:

Return to Learn[3]

AIM	ACTIVITY	GOAL
Daily activities without symptoms	Reading, texting, screen time beginning with 5 to 15 minute intervals	Gradual return to typical activities
School activities	Homework, reading, or other cognitive activities	Increase tolerance to cognitive work
Return to school part time	Gradual reintroduction of schoolwork. May begin with half day with breaks if needed	Increased academic activities
Return to school full time	Gradually work to full school day	Return to full academic activities and perform makeup work

TABLE 5:

Return to Play[3]

STEP:	LEVEL:
1.	No activity with athlete at complete rest
2.	Light aerobic exercises (i.e. walking, swimming, stationary cycling). Goal is to increase heart rate to 70% of maximal effort. No resistance training.
3.	Sport specific training (i.e. skating drills for hockey, or running drills for soccer) Goal to add movement No head impact activities
4.	Noncontact drills progressing to more complex drills Goal is to add exercise, coordination, and cognitive load Progressive resistance training may begin at this step
5.	Full contact training after medical clearance Goal is to restore confidence and assess functional skills by coaching staff for return to gameplay

ACKNOWLEDGMENTS:
The authors would like to thank Jessica Kempa, ATC, and Kimberly Merlino for their contributions to this manuscript, which are greatly appreciated by the authors.

AUTHOR DISCLOSURES:
No relevant financial affiliations.

REFERENCES:

1. Johnson KM, McCrory P, Mohtadi NG, Meeuwisse W. Evidence Based Review of Sport-Related Concussion. Clinical Journal of Sport Medicine. 2001;11:150-9.
2. Bryan MA, Rowhani-Rahbar A, Comstock RD, Rivera F. Sports- and Recreation-Related Concussions in US Youth. Pediatrics. 2016 Jul;138(1) .
3. McCrory P, Meeuwisse W, Dvorak J, Bailes, J, Broglio S, Cantu Ret al. Consensus Statement on Concussion in Sport – the 5th International Conference on Concussion in Sport held Berlin, October 2016. Br J Sports Med 2017; 0-10.
4. McCrory P, Meeuwisse W, Aubry M, Cantu B, Dvorak J, Echemendia RJ, et al. Summary and Agreement Statement of the 4th International Conference on Concussion in Sport, Zurich 2012. Br J Sports Med. 2013 Feb;47:250-258.
5. Collins M, Kontos A, Maroon J, Fu F. Emerging Frontiers in Concussion: Advancements in Assessment, Management, and Rehabilitation; 2013 June 7-9; Pittsburg PA.
6. Mucha A, Collins MW, Elbin RJ, Furman JM, Troutman-Enseki C, DeWolf RM, et al. A Brief Vestibular/Ocular Motor Screening (VOMS) Assessment to Evaluate Concussions: Preliminary Findings. Am J Sports Med. 2014 Oct 26;42(10): 2479-86.
7. Cooper J, Jamal N. Convergence Insufficiency- a major review. Optometry Review. American Optometric Association. 2012.
8. McCrory P, Meeuwisse W, Johnston K, Dvorak J, Aubry M, Molloy M, et al. Summary and Agreement Statement of the 3rd International Conference on Concussion in Sport, Zurich 2008. Clinical Journal of Sports Medicine. 2009 May 19(3); 185-200.
9. Virji-Babul N, Borich M R, Makan N, Moore T, Frew K, Emery C A, et al. Diffusion tensor imaging of sports-related concussion in adolescents. Pediatric Neurology. 2013 June;48(1), 24-29.
10. Alsalaheen BA, Whitney SL, Mucha A, Morris LO, Furman JM, Sparto PJ. Exercise prescription patterns in patients treated with vestibular rehabilitation after concussion. Physiother Res Int. 2013 Jun; 18(2): 100-8.
11. Rabin, T. (2018). FDA authorizes marketing of first blood test to aid in the evaluation of concussion in adults: New quick testing option to help reduce need for CT scans, radiation exposure for patients. Available from the Federal Drug Administration at https://www.fda.gov/newsevents/newsroom/pressannouncements/ucm596531.htm.
12. Schatz P, Pardini JE, Lovell MR, Collins MW, Podell K. Sensitivity and specificity of the ImPACT test battery for concussion in athletes. Arch Clin Neuropsychol. 2006;21(1):91-99.
13. Van Kampen DA, Lovell MR, Pardini JE, Collins MW, Fu FH. The "value added" of neurocognitive testing after sports-related concussion. Am J Sports Med. 2006;34(10):1630-1635.
14. Bush SS, Ruff RM, Troster A, Barth J, Koffler SP, Pliskin NH, et al. NAN position paper: Symptom validity assessment: Practice issues and medical necessity. Archives of Clinical Neuropsychology. 2005.
15. Heilbronner RL, Sweet JJ, Morgan JE, Larrabee G J, Millis SR. American Academy of Clinical Neuropsychology Consensus Conference Statement on the Neuropsychological Assessment of Effort, Response Bias, and Malingering. Clin Neuropsychol. 2009 Sep;23(7):1093-129.
16. Chase D, Schatz P, Symk N, Franks RR (2018) The Stability of Engagement Over Comprehensive Neuropsychological Assessment in Student Athletes Diagnosed with Sports Related Concussion, Developmental Neuropsychology, 43:4, 345-355.
17. Schatz, P., Glatts, C. (2013). "Sandbagging" Baseline Test Performance on ImPACT, Without Detection, Is More Difficult than It Appears. Arch Clin Neuropsychol., May;28(3):236-44.
18. Rohling ML, Faust ME, Beverly B, Demakis G. Effectiveness of cognitive rehabilitation following acquired brain injury: a meta-analytic re-examination of Cicerone et al.'s (2000, 2005) systematic reviews. Neuropsychology. 2009 Jan; (1):20-39.
19. Dawson DR, Anderson ND, Binns MA, Bottari C, Damianakis T, Hunt A, Polatajko HJ, Zwarenstein M. Managing executive dysfunction following acquired brain injury and stroke using an ecologically valid rehabilitation approach: a study protocol for a randomized, controlled trial. Trials. 2013, 14:306.
20. Suter PS, Harvey LH. Vision Rehabilitation: Multidisciplinary Care of the Patient Following Brain Injury. 2011. P.9.
21. Doble JE, Feinberg DL, Rosner MS, Rosner AJ. Identification of Binocular Vision Dysfunction (Vertical Heterophoria) in Traumatic Brain Injury Patients and Effects of Individualized Prismatic Spectacle Lenses in the Treatment of Post concussive Symptoms: A Retrospective Analysis. PM&R 2010; 2 (4):244.
22. Al Sayegh A, Sandford D, Carson AJ. Psychological approaches to treatment of post concussion syndrome: a systematic review. Journal of Neurology, Neurosurgery and Psychiatry. 2010; 81 (10): 1128-34.
23. Iverson, G. Misdiagnosis of the persistent post concussion syndrome in patients with depression. Archives of Clinical Neuropsychology 2006;21: 303-310.
24. Vaishnavi S, Rao V, Fann JR. Neuropsychiatric problems after traumatic brain injury: unraveling the silent epidemic. Psychosomatics. 2009; 50(3): 198-205.
25. Mrazik, M., Dennison, C.R., Brooks, B.L., Yeates, K.O., Babul, S., Naidu, D. A qualitative review of sports concussion education: prime time for evidence-based knowledge translation. Br J Sports Med. 2015 August 25.
26. Reddy CC, Collins M, Lovell M, Kontos AP, Efficacy of amantadine treatment on symptoms and neurocognitive performance among adolescents following sports-related concussion. J Head Trauma Regabil. 2013 Jul-Aug;28(4):260-5.
27. Ransom DM, Vaughan CG, Pratson L, Sady MD, McGill CA, Gioia GA. Academic Effects of Concussion in Children and Adolescents. Pediatrics. 2015 May 11:135 (6). 1043-50.
28. Iverson GL, Atkins J, Zafonte R, Berkner P. Factors Influencing Post-Concussion-Like Symptom Reporting in Adolescent Athletes. 10th World Congress on Brain Injury, 2014 Mar 19-22. San Francisco, California.
29. Halsted ME, McAvoy, K, Devore, CD, Carl R, Lee, M, Logan, K, et. Al. Clinical Report: Returning to Learning Following a Concussion. Council on Sports Medicine and Fitness, And Council on School Health. Pediatrics. 2013 Oct 27; 132:5 948-957.
30. Gioa GA. Medical-School Partnership in Guiding Return to School Following Mild Traumatic Brain Injury in Youth. Journal of Child Neurology 1-16. Dec 2014.
31. Herring SA, Cantu RC, Guskiewicz KM, Putukian M, Kibler WB, et al. "Concussion (Mild Traumatic Brain Injury) and the Team Physician: A Consensus Statement -2011 Update. Medicine and Science in Sports and Exercise, 2011: 2412-2422.