Goals & Objectives:
To understand the importance of the pre-participation exam and to gain the skills necessary to perform an adequate exam and recognize common problems.

- Gain a better understanding of the importance of the cardiovascular risk factors elicited in the history and a greater understanding of the importance of the cardiovascular exam.
- Become familiar with classification of sports by contact vs. noncontact (Module I) and by levels of dynamic components in order to adequately counsel potential athletes.
- Understand presentation and management of concussion, including baseline neuropsychological testing and a strict return-to-play protocol with cognitive and physical rest.

Pre-Meeting Preparation:
Please read the following enclosures:
- “Cardiovascular Pre-participation Sports Physical” (PIR, 2006)
  - Bethesda Conference Sports Classifications (original version of Table 3)

Conference Agenda:
- Review Sports Physical II Quiz
- Complete Sports Physical II Cases
- **Exercise:** Perform SCAT2 w/partner.

Post-Conference: Board Review Q&A

Extra-Credit:
- **36th Bethesda Conference:** Eligibility Recommendations for Competitive Athletes with Cardiovascular Abnormalities *J Am Coll Cardiol, 2005*; 1313-1375—scroll down
- “Sudden Cardiac Death in Athletes: What is Role of Screening?” *Curr Opin Cardio, 2013*
- “Sports-Related Concussion in Children and Adolescents” (AAP-CPG, 2010)
- “Heads Up: For Parents”; “Heads Up: For Providers” (CDC Concussion Program)
- Local Programs: S.C.O.R.E. @ CNMC; Kennedy Krieger Neurorehab Clinic
- Assessment Tools: Acute Concussion Evaluation (ACE); ImPACT (see “Best Practices”)

Cardiovascular Preparticipation Sports Screening

Anoop Singh, MD,* Michael Silberbach, MD†

Objectives After reading this article, readers should be able to:

1. Describe the key cardiac elements of the preparticipation examination.
2. Identify red flags in a patient’s cardiac history and physical examination that warrant consultation with a cardiologist.
3. Characterize the cardiovascular findings of the well-trained athlete.
4. Recognize the common causes of sudden cardiac death on the playing field.
5. Discuss the absolute and relative contraindications to athletic participation.

Background In the United States, the preparticipation examination (PPE) has become a standard for athletic clearance of high school students in nearly every state. This screening serves many purposes, but a primary goal is to restrict athletic participation of those who may be predisposed to dying on the playing field.

The death of a high school athlete devastates the child’s family, significantly affects the local community, and often generates extensive media coverage. Fortunately, sudden death remains a rare phenomenon; best estimates predict an incidence of 1 per 200,000 high school athlete-years. In 75% of such cases, cardiovascular disease is the cause. Accordingly, medical professionals must have a keen sense for detecting silent cardiac disease in young athletes.

History Taking The medical history is the most important part of the cardiovascular PPE. It is best to ask open-ended questions of the patient. A volunteered complaint warrants greater attention than a “yes/no” response. A checklist of questions that probes for potential cardiac disease is also helpful (see the form available in the online version of this article only).

Family concerns or observations complement the picture of the adolescent’s health. Indeed, the American Heart Association recommends that a parent verify all elements of the history.

The personal history focuses on symptoms such as chest pain, chest tightness, dyspnea, near-syncope, syncope, dizziness, exercise intolerance, and fatigue. The setting in which symptoms occur is very important. Symptoms in the context of athletic activity may be a harbinger of cardiovascular disease. For example, a history suggestive of vasovagal syncope is less concerning than one of exercise-related syncope. On the other hand, palpitations may be more noticeable and worrisome when they occur at rest.

A detailed medication history includes both prescribed medications and supplements. When asking about illicit drug use, particular attention should be given to performance-enhancing drugs such as androgenic steroids, human growth hormone, and amphetamines.

Important components of the
past medical history include rheumatic fever, Kawasaki disease, myocarditis, arrhythmias, congenital heart disease, heart murmurs, or hypertension. Essential hypertension, increasingly common in the adolescent population, always warrants an evaluation for secondary causes. Finally, unexplained seizures or near-drowning raise the possibility of cardiac ion channel defects, such as the long QT syndrome (LQTS).

The family history is an integral part of the screening process because it may initiate additional evaluation of an asymptomatic patient. Pertinent family history includes congenital heart disease, Marfan syndrome or other connective tissue disorders, cardiomyopathy, and LQTS or other arrhythmias. Searching for silent cardiac disease entails asking specifically about unexplained sudden death in the family, such as unexplained drowning, near-drowning, seizures, or an automobile fatality, especially involving a family member younger than 50 years of age.

Physical Examination
Vital signs are an important aspect of the physical examination. The heart rate and blood pressure are compared with age-specific norms. Hypertension in children is defined as a blood pressure greater than the 90th percentile for age, height, and sex. Hypertension warrants, at a minimum, four extremity blood pressure measurements and another measurement at a separate office visit.

The general examination of the patient includes an overall assessment for features suggestive of Marfan syndrome, such as kyphoscoliosis, pectus deformity, arm span greater than height, joint hypermobility, arachnodactyly, and a tall and thin body habitus.

Auscultation of the chest focuses on heart sounds, clicks, and cardiac murmurs and is performed with the patient in both the supine and standing positions. The standing position accentuates the dynamic obstruction murmur of hypertrophic cardiomyopathy. The abdomen must be palpated to detect organomegaly. Finally, the physical examination must include assessment of femoral pulses to screen for aortic coarctation.

When to Refer
Referring a patient to a pediatric cardiologist depends on the experience and comfort level of the primary care practitioner. Although each case has its own nuances, there are “red flags” in the history and examination that usually prompt consultation with a pediatric cardiologist (Table 1).

Cardiology Evaluation
A patient referred to a pediatric cardiologist may or may not require any testing, depending on the results of the history and physical examination. When more information is needed, a chest radiograph and electrocardiogram (ECG) often are obtained. However, left ventricular hypertrophy is difficult to diagnose on a plain film, and as many as 15% of those who have cardiac hypertrophy have a completely normal 12-lead ECG tracing. Accordingly, an echocardiogram is often part of the primary investigation in referred patients. Additional tests at the cardiologist’s disposal include ambulatory ECG monitoring, 30-day ECG-event monitoring, exercise stress testing, electrophysiology studies, stress echocardiograms, cardiac magnetic resonance imaging, cardiac catheterization, and angiography.

The responsibilities of the pediatric cardiologist are threefold: 1) finding cardiovascular disease in undiagnosed patients and initiating therapy, 2) identifying those patients at risk for sudden cardiac death, and 3) clearing healthy individuals for full athletic participation.

There is, however, a gray area between healthy-appearing and diseased hearts. The well-trained athlete’s heart falls into this indeterminate category.

The Athlete’s Heart
Just as aerobic and isometric exercise have visible effects on skeletal muscle, athletic training remodels cardiac muscle. Such morphologic changes present a challenge to the clinician, who must distinguish between be-
nign adaptation to exercise and cardiac disease.

Endurance training normally results in enlargement of the left ventricular cavity due to an increased stroke volume. Basal cardiac output is unaffected because the well-conditioned athlete’s resting heart rate is decreased. However, the degree of left ventricular enlargement can approach dimensions seen primarily in diseased hearts.

Another conundrum is presented by left ventricular hypertrophy. Studies have shown that 2% of highly trained male athletes demonstrate significant increases in left ventricular wall thickness. Thus, echocardiographically determined cardiac measurements may overlap with diagnostic criteria for hypertrophic cardiomyopathy. In these patients, the suspicion increases if there is a positive family history for cardiomyopathy, an asymmetry between the septal and posterior left ventricular wall thickness by echocardiography, a lack of concurrent left ventricular cavity enlargement, an abnormal ECG tracing, or no decrease in thickness with deconditioning.

In addition to structural changes, the athlete’s heart displays unusual ECG patterns, arrhythmias, and conduction abnormalities. An Italian study showed that 40% of athletes had abnormal electrical patterns on ECG recordings in a population in whom only 5% had a cardiovascular abnormality. Ambulatory ECG monitoring in normal athletes may show junctional rhythm at rest, frequent premature ventricular beats, ventricular couplets, or nonsustained ventricular tachycardia that can be confused with ventricular irritation from myocarditis.

Athletes who have left ventricular enlargement or hypertrophy and are deemed otherwise healthy should be cleared to participate in sports. However, it should be noted that such physiologic changes cannot be labeled definitively as benign. One long-term echocardiographic study following elite athletes showed that cardiac chamber enlargement persisted despite deconditioning in 20% of the retired athletes. Thus, the significance of exercise-induced ventricular remodeling remains undefined.

Sudden Death

The exact number of young athletes dying during competitive sports is uncertain. Incidence estimates range from 1 per 44,000 to 1 per 200,000 athlete-years. Approximately 75% of all sudden deaths are due to cardiovascular disease, with hypertrophic cardiomyopathy being the most common cause. Fatal events due to commotio cordis comprise the bulk of sports-related deaths not due to underlying cardiovascular disease. Knowing that the presenting event of previously undetected cardiovascular disease may be death makes a compelling case for the importance of the PPE.

Hypertrophic Cardiomyopathy (HCM)

HCM is the most common cause of sudden cardiac death in young athletes. HCM has an autosomal dominant inheritance pattern, with more than 400 mutations on 12 genes described thus far. The prevalence in the general population is estimated to be 0.2%. Clinical features that may raise suspicion for the disease include symptoms of left ventricular outflow obstruction, a heart murmur, family history of HCM, or an abnormal ECG tracing. Echocardiography demonstrates left ventricular hypertrophy that classically is asymmetric. However, absence of cardiac hypertrophy does not rule out the presence of HCM. At the cellular level, myofibrillar disarray creates a substrate for electrical instability. Sudden death is likely the result of re-entrant ventricular arrhythmias.

Marfan Syndrome

Marfan syndrome is an autosomal dominant disorder caused by mutations in the gene encoding the protein fibrillin, a key component of connective tissue. The estimated prevalence ranges from 1 per 5,000 to 1 per 10,000. Clinical features include kyphoscoliosis, pectus deformities, arm span greater than height, joint hypermobility, arachnodactyly, pes planus, lens dislocation, myopia, and a history of spontaneous pneumothorax. Cardiac manifestations include aortic root dilatation, aortic dissection, and mitral valve prolapse. The diagnosis is based on the family history and clinical criteria. Sudden cardiac death is due to dissection and rupture of the aorta.

Congenital LQTS

LQTS involves the generation of an abnormal myocardial action potential due to defects in cell membrane-
associated ion channel proteins. The diagnosis is considered when a prolonged QTc interval [Bazett formula (QT in msecs and RR in secs): QTc=QT/√RR] accompanies a history of syncope. Sensorineural deafness, present in the autosomal recessive form of LQTS (Jervell and Lange-Nielsen syndrome), may be an additional clue. Syncope is due to self-limited episodes of polymorphic ventricular tachycardia called torsades de pointes (Figure). Prolonged QTc interval and a positive family history are important risk factors for sudden death. Although the arrhythmia may occur at any age, there is a predilection for cardiac events in adolescence. Sudden death occurs when the arrhythmia degenerates into ventricular fibrillation.

**Commotio Cordis**

Commotio cordis causes 20% of all sudden deaths in young athletes. It occurs when blunt, nonpenetrating trauma to the chest produces ventricular fibrillation. The blow often is neither excessive nor associated with structural injury. Arrhythmias may be induced by enhanced energy transfer to the heart through the child’s compliant chest wall coinciding with a vulnerable period of cardiac repolarization. Projectiles such as baseballs and hockey pucks have been implicated most often in commotio cordis. Survival is less than 15% but improves if prompt cardiopulmonary resuscitation and defibrillation occur.

**Eligibility and Disqualification From Sports**

Young athletes who have cardiovascular disease are at greater risk for sudden death than are nonathletes who have cardiac disease. Perhaps extreme exercise stress triggers rare events such as malignant arrhythmias that otherwise would remain hidden.

Thus, the rationale for athletic disqualification is that the cessation of athletic activity may be protective.

The current recommendations for sports eligibility are based on the consensus opinion outlined in the 36th Bethesda Conference guidelines. Although the recommendations generally are conservative, only a handful of cardiovascular conditions require disqualification from all sports (Table 2). The Bethesda eligibility criteria do not apply to non-competitive, recreational activities. The American Heart Association has published separate guidelines.

The clinician must consider multiple factors, both physical and psychological, before disqualifying a particular patient. In many cases, the activities may be limited and not eliminated. For example, individuals who have Marfan syndrome or an implantable cardioverter-defibrillator are cautioned to avoid sports that carry a risk of bodily collision.

Because different sports carry different risks, it may be possible to tailor recommendations to an individual patient. It is possible to categorize various activities into static and dynamic exercise components, permitting classification in terms of the type of stress (Table 3). Static exercise involves isometric muscle contraction, resulting in an increasing pressure load on the heart. Static exercise should be avoided by patients who have left heart obstructive disease, regurgitant aortic valves, or connective tissue disorders where aortic dilation is a risk. However, it may be appropriate to recommend moderate dynamic and low static activities for these individuals. Dynamic exercises, on the other hand, require isotonic muscle contraction and typically result in increasing the cardiac output. High-intensity dynamic exercises may be stressful for patients who have even mild ventricular dysfunction. Such patients might be restricted to low dynamic/low static competitive sports.

**Conclusion**

The PPE is the optimal tool available to primary care practitioners for preventing heart disease-related deaths on the playing field. However, there is considerable variability in the details of the screening process, and many states have either no or inadequate examination forms. Standardizing the history and physical form and creating accreditation criteria for clinicians who perform the examination would be two good steps toward optimizing the PPE. The cost/benefit ratio of obtaining an ECG or

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**Table 2. Absolute Contraindications to Sports Participation**

- Pulmonary vascular disease with cyanosis and large right-to-left shunt
- Severe pulmonary hypertension
- Severe aortic stenosis or regurgitation
- Severe mitral stenosis or regurgitation
- Cardiomyopathies
- Vascular form of Ehlers-Danlos syndrome
- Coronary anomalies of wrong sinus origin
- Catecholaminergic polymorphic ventricular tachycardia
- Acute phase of pericarditis
- Acute phase of myocarditis (at least 6 mo)
- Acute phase of Kawasaki disease (at least 8 wk)
focused cardiac ultrasonography to rule out hypertrophic cardiomyopathy continues to be debated in the United States. A recent consensus statement from Europe has advocated the use of 12-lead ECGs based on the 25-year experience in Italy where electrocardiography has been an integral part of the PPE. (See commentary by Dr Renato Vitiello in the Internet-only pages.) This article has focused on identifying silent cardiovascular disease and defining criteria for determining sports eligibility in young athletes. It is important to remember that the incidence of sudden cardiac death during sports participation is extremely low. In the United States, accidents, homicide, and suicide are far more prevalent problems, causing 10,000 deaths a year in 15- to 19-year-olds. Although the primary care practitioner assiduously seeks to identify heart disease during the screening visit, it is equally important to promote a physically active lifestyle that encourages both mental and cardiovascular health.

**EDITORIAL BOARD NOTE.** In the United States, medical evaluation prior to participation in sports is standard practice, but national guidelines for the PPE are not established. In Italy, a federal law sets a single, high standard for the entire country that requires certification for screeners and an ECG in addition to the history and physical examination. In this month’s Internet-only pages of PIR, Dr Renato Vitiello cites data suggesting that sudden death from HCM in athletes can be reduced by this approach. The Italian perspective may soon be adopted by all of Europe. — Michael Silberbach, MD

### Table 3. Classification of Sports According to Type of Exercise

<table>
<thead>
<tr>
<th>Low Dynamic</th>
<th>Moderate Dynamic</th>
<th>High Dynamic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Static</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Billiards</td>
<td>Baseball</td>
<td>Badminton</td>
</tr>
<tr>
<td>Bowling</td>
<td>Softball</td>
<td>Field hockey</td>
</tr>
<tr>
<td>Cricket</td>
<td>Fencing</td>
<td>Racquetball</td>
</tr>
<tr>
<td>Golf</td>
<td>Table tennis</td>
<td>Soccer</td>
</tr>
<tr>
<td>Riffley</td>
<td>Volleyball</td>
<td>Tennis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Track (long distance)</td>
</tr>
<tr>
<td>Moderate Static</td>
<td>Field events</td>
<td>Basketball</td>
</tr>
<tr>
<td>Archery</td>
<td>Figure skating</td>
<td>Ice hockey</td>
</tr>
<tr>
<td>Auto racing</td>
<td>Football/Rugby</td>
<td>Lacrosse</td>
</tr>
<tr>
<td>Diving</td>
<td>Rodeo</td>
<td>Track (middle distance)</td>
</tr>
<tr>
<td>Equestrian</td>
<td>Surfing</td>
<td>Swimming</td>
</tr>
<tr>
<td>Motorcycling</td>
<td>Track (sprinting)</td>
<td>Cross-country skiing</td>
</tr>
<tr>
<td>High Static</td>
<td>Bodybuilding</td>
<td>Boxing</td>
</tr>
<tr>
<td>Bobsledding</td>
<td>Downhill skiing</td>
<td>Canoeing/Kayaking</td>
</tr>
<tr>
<td>Field (throwing)</td>
<td>Snowboarding</td>
<td>Cycling</td>
</tr>
<tr>
<td>Gymnastics</td>
<td>Skiing</td>
<td>Rowing</td>
</tr>
<tr>
<td>Sailing/Windsurfing</td>
<td>Wrestling</td>
<td>Speed skating</td>
</tr>
<tr>
<td>Sport climbing</td>
<td></td>
<td>Triathlon/Decathlon</td>
</tr>
<tr>
<td>Weight lifting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Modified from Task Force 8; classification of sports. *J Am Coll Cardiol.* 2005;5:1366. Copyright 2005. The American College of Cardiology Foundation and American Heart Association, Inc. Permission granted for one time use. Additional reproduction is not permitted without permission of the ACC/AHA.

Suggested Reading


Glover DW, Maron BJ. Profile of preparticipation cardiovascular screening for high school athletes. *JAMA.* 1998;279:1817–1819


Classification of sports. This classification is based on peak static and dynamic components achieved during competition. It should be noted, however, that higher values may be reached during training. The increasing dynamic component is defined in terms of the estimated percent of maximal oxygen uptake (MaxO₂) achieved and results in an increasing cardiac output. The increasing static component is related to the estimated percent of maximal voluntary contraction (MVC) reached and results in an increasing blood pressure load. The lowest total cardiovascular demands (cardiac output and blood pressure) are shown in green and the highest in red. Blue, yellow, and orange depict low moderate, moderate, and high moderate total cardiovascular demands. *Danger of bodily collision. †Increased risk if syncope occurs.

Figure Legend:
Concussion is a disturbance in brain function caused by direct or indirect force to the head. It is a functional rather than structural injury that results from shear stress to brain tissue caused by rotational or angular forces—direct impact to the head is not required. Initial evaluation involves eliminating cervical spine injury and serious traumatic brain injury. Headache is the most common symptom of concussion, although a variety of clinical domains (e.g., somatic, cognitive, affective) can be affected. Signs and symptoms are nonspecific; therefore, a temporal relationship between an appropriate mechanism of injury and symptoms must be determined. There are numerous assessment tools to aid diagnosis, including symptom checklists, neuropsychological tests, postural stability tests, and sideline assessment tools. These tools are also used to monitor recovery. Cognitive and physical rest are the cornerstones of initial management. There are no specific treatments for concussion; therefore, focus is on managing symptoms and return to play. Because concussion recovery is variable, rigid classification systems have mostly been abandoned in favor of an individualized approach. A graded return-to-play protocol can be implemented once a patient has recovered in all affected domains. Children, adolescents, and those with a history of concussions may require a longer recovery period. There is limited research on the management of concussions in children and adolescents, but concern for potential consequences of injury to the developing brain suggests that a more conservative approach to management is appropriate in these patients. (Am Fam Physician. 2012;85(2):123-132. Copyright © 2012 American Academy of Family Physicians.)
Presentation

Concussion is a functional rather than structural injury that can affect somatic, cognitive, and affective domains.1,8,10,20 Sleep disturbances are also common.10,21 If any of these domains are impaired, concussion should be considered1; however, other conditions cause similar symptoms (e.g., heat illness, exertional migraines, sleep disorders).9,10,16 To diagnose a concussion, a temporal relationship between an appropriate mechanism of injury and onset or worsening of symptoms must be established.10

Headache is the most common symptom of concussion.9,14,22,23 Other common symptoms include dizziness, balance disturbances, and disorientation.14,16,22-24 Loss of consciousness, once considered a hallmark of concussion, occurs in less than 10 percent of patients.9,12,16,22 Selected symptoms of concussion are listed in Table 2.5,8,10,12,16,19-21,23,25

Classification

There is no consensus regarding classification of concussions.2,9 Although numerous severity scales exist, none are validated scientifically.12,26 Previous classification systems (e.g., Cantu, American Academy of Neurology) focused on loss of consciousness and amnesia; however, research has demonstrated that such markers do not

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**Table 1. Definition of Concussion from the Third International Conference on Concussion in Sport**

A complex pathophysiologic process affecting the brain, induced by traumatic biomechanical forces

Several common features that incorporate clinical, pathologic, and biomechanical injury constructs that may be used in defining the nature of a concussive head injury include the following:

Concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an “impulsive” force transmitted to the head

Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously

Concussion may result in neuropathologic changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury

Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness; resolution of the clinical and cognitive symptoms typically follows a sequential course; however, it is important to note that in a small percentage of cases, postconcussive symptoms may be prolonged

No abnormality on standard structural neuroimaging studies is seen in concussion

Table 2. Selected Symptoms of Concussion

<table>
<thead>
<tr>
<th>Affective/emotional</th>
<th>Sleep†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anxiety/haversness†</td>
<td>Decreased sleep</td>
</tr>
<tr>
<td>Clinginess</td>
<td>Difficulty initiating sleep</td>
</tr>
<tr>
<td>Depression†</td>
<td>Drowsiness‡</td>
</tr>
<tr>
<td>Emotional liability</td>
<td>Increased sleep*</td>
</tr>
<tr>
<td>Irritability†</td>
<td>Somatic/physical</td>
</tr>
<tr>
<td>Personality changes</td>
<td>Blurred vision‡</td>
</tr>
<tr>
<td>Sadness</td>
<td>Convulsions</td>
</tr>
<tr>
<td>Cognitive</td>
<td>Dizziness/poor balance‡</td>
</tr>
<tr>
<td>Amnesia</td>
<td>Fatigue‡</td>
</tr>
<tr>
<td>Confusion‡</td>
<td>Headache‡</td>
</tr>
<tr>
<td>Delayed verbal and other responses</td>
<td>Light-headedness†</td>
</tr>
<tr>
<td>Difficulty concentrating‡</td>
<td>Light sensitivity‡</td>
</tr>
<tr>
<td>Difficulty remembering‡</td>
<td>Nausea‡</td>
</tr>
<tr>
<td>Disorientation†</td>
<td>Noise sensitivity‡</td>
</tr>
<tr>
<td>Feeling foggy‡</td>
<td>Numbness/tingling</td>
</tr>
<tr>
<td>Feeling slowed down‡</td>
<td>Tinnitus†</td>
</tr>
<tr>
<td>Feeling stunned</td>
<td>Vomiting‡</td>
</tr>
<tr>
<td>Inability to focus</td>
<td></td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td></td>
</tr>
<tr>
<td>Slurred speech</td>
<td></td>
</tr>
<tr>
<td>Vacant stare</td>
<td></td>
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</tbody>
</table>

*—American Academy of Neurology defines as an early symptom, lasting minutes to hours.†
‡—American Academy of Neurology defines as a late symptom, lasting days to weeks.¶
§—Part of the 12-item Concussion Symptom Inventory, the only empirically derived symptom checklist.\(^a\)
Information from references 5, 8 through 10, 12, 16, 19 through 21, 23, and 25.

Concussion

accurately reflect concussion severity or recovery.\(^8,10,12,14,20\)
The International Conference on Concussion in Sport (ICCS) proposed classification based on simple versus complex presentations; however, this was applied retrospectively and therefore was not an acceptable guide to treatment.\(^1\)

An ideal classification system would determine severity at the time of injury, provide prognostic information, and help guide return-to-play decisions. Because such a system does not exist, an individualized approach of monitoring symptoms to resolution is recommended, followed by a graded return-to-play strategy.\(^1,5,8,20\)

Pathophysiology

Previously, most reported concussions were a result of falls or motor vehicle collisions.\(^2\) Recent studies of younger populations suggest most concussions occur during sporting events,\(^4,26\) with greatest risk during competitions.\(^3,9,20\)

Although there are no definitive data on whether males or females are at greater risk of concussions, different mechanisms of injury have been suggested. Males seem prone to concussion through player-to-player contact, whereas concussions in females tend to be caused by contact with the playing surface or equipment.\(^27\)

Concussion is caused by rotational and angular forces to the brain, and direct impact to the head is not required.\(^9,10,12,20\) Shear forces disrupt neural membranes, allowing potassium efflux into extracellular space. Resultant increases of calcium and excitatory amino acids are followed by further potassium efflux, leading to suppression of neuron activity.\(^8,10,12,20\) As sodium-potassium pumps restore balance, there is increased energy requirement, yet a paradoxical decrease in cerebral blood flow. Disruptions of autonomic regulation can persist for several weeks, and the brain may be vulnerable to additional injury.\(^12,28\)

Natural History

Symptoms of concussion typically present immediately after injury, but may be delayed several hours.\(^10,16,21\) Concussion symptoms usually last less than 72 hours,\(^16\) and most concussions resolve spontaneously within seven to 10 days.\(^1\) Recovery may be prolonged in children, adolescents,\(^1,3,9,12,17\) and those with previous concussions.\(^23,29\)

Assessment of symptoms has traditionally been used to monitor recovery; however, the role of cognitive dysfunction has received significant attention. Although described inconsistently in the literature,\(^4\) cognitive function likely recovers independently of symptoms. This raises concern for increased risk of additional injury even after symptoms have resolved.

Factors predictive of recovery are poorly defined. Traditional markers (i.e., loss of consciousness, amnesia, convulsions) were extrapolated from data of more severe traumatic brain injuries. Studies have demonstrated that brief loss of consciousness is not associated with prolonged recovery,\(^5,26\) and that convulsions immediately after injury are benign.\(^26\) The significance of amnesia is less clear. Recent findings suggest that prolonged headache (more than 60 hours), fatigue, tiredness, fogginess, or presence of more than three symptoms at presentation may be associated with prolonged recovery.\(^14\)

Assessment Tools

Most concussions lead to subtle changes; therefore, evaluation can be challenging.\(^5,30\) Numerous assessment tools exist to aid diagnosis and management
(Table 3). Although none are exclusively effective, 8 combining tools increases sensitivity and specificity. 1,16,31 Assessment tools are most beneficial when baseline measurements are available for comparison. 8

**SYMPTOM CHECKLISTS**

Most guidelines primarily recommend checklists that allow for patients to self-report their concussion symptoms 16,19; however, symptoms may be delayed, may not be reported, or were already present at baseline. 1,16 Most checklists have been developed through clinical experience and have significant similarities, yet none are considered superior. 19,24

**NEUROPSYCHOLOGICAL TESTING**

Neuropsychological tests are designed to identify subtle cognitive deficits. Written tests are labor-intensive and must be interpreted, whereas computer-based tests can be administered rapidly and to multiple patients simultaneously. Results best interpreted when compared with baseline data; affected by psychiatric disorders, physical symptoms, cultural factors, and motivation/effort. These tests are not validated, and no data demonstrate that they affect outcomes when used to guide return to play. There are limited baseline data in children younger than 12 years; child-specific computerized tests are under development.
based tests allow for rapid administration to multiple patients simultaneously.16 There is no consensus on which tests are most effective.5,9,10,16,19,20 A meta-analysis found no statistically significant difference in sensitivity 14 days after injury among written tests, computer-based tests, and the Standardized Assessment of Concussion (SAC; a sideline assessment tool).20 Neuropsychological testing is often considered the cornerstone of concussion evaluation; however, there is no evidence that it affects outcomes.5,9,10,12,19,20 There is also disagreement on the degree of recovery necessary for safe return to play.25

POSTURAL STABILITY TESTING
Concussion leads to impaired balance, which typically lasts three to five days.1,5,16,26,31 Postural stability testing is an integral part of evaluation1; however, there is insufficient evidence on its use.31 Some balance testing requires sophisticated equipment; however, the Balance Error Scoring System requires only a foam block and can be performed on the sideline of an athletic event.

SIDELINE ASSESSMENT TOOLS
Common sideline tools include the SAC and Sport Concussion Assessment Tool 2 (SCAT2). These tools assess several domains to diagnose concussion and monitor recovery. The SAC has been validated in athletes who are junior high school–aged and older. Emergency department versions are validated in adults, although they are not optimal for use in children.29 The SCAT2 has not been validated; however, it is widely used and the most sophisticated sideline assessment tool available.18 The SCAT2 includes a symptom checklist, concentration and memory tasks (Maddock’s questions), the SAC, the Balance Error Scoring System, and the Glasgow Coma Scale. The SCAT2 is available for download in the online version of this article or at http://www.cces.ca/en/files-116.

Initial Evaluation
Figure 1 is a suggested algorithm for the evaluation of concussion.1,2,5,8,9,12,16,18,21,31,32 For obvious head and neck injuries, assessment begins at the site of injury.1,8,9,12,20 and focuses on evaluating the cervical spine.8 In unconscious persons, cervical spine injury must be assumed.9,12,25 Table 4 includes neurologic examination findings that may indicate more significant traumatic brain injury and the need for hospital evaluation.1,5,10

SIDELINE EVALUATION
Further evaluation can occur on the sideline or in the training room. With concussion, neurologic findings are normal other than mental status and balance...
Table 4. Neurologic Examination Findings Suggesting Severe Injury in Patients with Suspected Concussion

<table>
<thead>
<tr>
<th>Type of assessment*</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance†</td>
<td>Romberg sign, postural instability, unsteadiness</td>
</tr>
<tr>
<td>Cranial nerves</td>
<td>Vision problems; unequal or fixed, dilated pupils; abnormal extraocular movements; or other abnormal cranial nerve findings may be suggestive of brainstem lesion</td>
</tr>
<tr>
<td>Deep tendon reflexes</td>
<td>Hyperreflexia or Babinski reflex suggests upper motor neuron lesion</td>
</tr>
<tr>
<td>Finger-to-nose test</td>
<td>Abnormal findings suggest coordination deficit</td>
</tr>
<tr>
<td>Gait</td>
<td>Ataxic gait may suggest cerebellar dysfunction</td>
</tr>
<tr>
<td>Mental status‡</td>
<td>Prolonged loss of consciousness (more than 60 seconds); somnolence or confusion; disorientation; deficit in language, speech, or long-term memory</td>
</tr>
<tr>
<td>Muscular strength</td>
<td>Weakness or unequal strength, decreased tone; involuntary movements may indicate basal ganglia or cerebellar injury</td>
</tr>
<tr>
<td>Sensory assessment of dermatomes§</td>
<td>Numbness or abnormal sensation can be traced to spinal nerve root</td>
</tr>
</tbody>
</table>

*—Evidence is lacking as to what a focused neurologic examination should include. Most patients with a concussion have cognitive and memory deficits; therefore, any focal neurologic deficit should prompt immediate evaluation for possible intracranial lesion.

†—Standard balance examinations are not sensitive to subtle changes caused by a concussion. Postural stability tests are sensitive enough for diagnosis (see Table 3 for examples).

‡—Standard orientation questions are not sensitive to subtle changes caused by concussion. Maddock’s questions are sensitive and effective for sideline assessment.

§—Sensory examination is subjective and may be difficult to perform on uncooperative patients or those with cognitive deficits.

Information from references 1, 5, and 10.

Brain injuries, skull fractures, and cervical spine injuries. If it is determined that imaging is warranted (Table 5), computed tomography is the initial modality of choice because of availability and sensitivity for diagnosing intracranial hemorrhage. Magnetic resonance imaging is acceptable acutely, but is more appropriate for evaluation of prolonged deficits. Plain radiography of the head has no role in the evaluation of possible concussion. Newer imaging modalities (e.g., functional magnetic resonance imaging) are under investigation; however, evidence is limited, few are readily available, and none have fully established clinical application.

If the patient has no significant cervical spine or intracranial injury, home care with observation is appropriate provided there is a responsible caretaker and sufficient ability to seek medical care if needed; the patient and caretaker should receive written instructions on when to seek medical attention. Follow-up is necessary because return-to-play decisions cannot be made acutely. Periodic weakening is controversial; although this practice may allow for detection of progressive neurologic decline, sleep deprivation may exacerbate concussion symptoms.

Management

Management of concussion is summarized in Table 6. Essential elements include rest followed by a graded return-to-play strategy. For most patients, the SCAT2 can be used alone to monitor recovery and guide return-to-play decisions.

Complete cognitive and physical rest are cornerstones of initial management because activity may exacerbate concussion symptoms and delay recovery. After resolution of symptoms, postural and cognitive testing (within the SCAT2) can confirm that the patient has recovered completely. A graded return-to-play protocol may then be implemented. Athletes should not return to play until they are completely recovered from the concussion and free of medications that may mask the symptoms of the concussion. In those at risk of prolonged recovery, formal neuropsychological testing and referral to a health care professional experienced in concussion management may be considered. Reevaluation several months after recovery is prudent to screen for depressive symptoms.
Evidence regarding pharmacologic therapy is limited. Treatment focuses on symptom management, including the same medications appropriate in patients without a concussion.13 Medications that may mask worsening symptoms or confuse changes in mental status should be avoided. Medications that may worsen the potential for intracranial bleeding (e.g., nonsteroidal anti-inflammatory drugs) should be used with caution.

**Special Considerations**

**SAME-DAY RETURN TO PLAY**

Athletes should not return to play the same day of sustaining a concussion,1,8,10,18 and most athletic organizations and state laws prohibit it. However, limited data have prompted some to suggest exceptions for professional athletes if sufficient sideline resources exist to assess the athlete and if the athlete demonstrates complete recovery.1,28 This exception does not apply to younger athletes.1,10,12,18

**CHILDREN AND ADOLESCENTS**

Managing concussion in the developing brain is a unique challenge,12 and the approach must be different than that for adults.11,20 Most research on concussion management applies to persons who are high school–aged or older. Little is known about concussions in children; therefore, conservative management is appropriate (e.g., a longer asymptomatic period before return to play).1,9,11,18,20

Special considerations and recommendations for managing concussions in children are included in Table 7.1,7-9,12,17,18,20

**MULTIPLE CONCUSSIONS**

Epidemiologic studies suggest long-term cognitive deficits with multiple concussions; however, medical research is conflicting.7,9,10,23,25,26 Those with previous concussions have increased risk of recurrent injury9,10,20,23,25 and have longer recovery periods.7,9,20,23,25,29 There are no guidelines regarding athletic disqualification or retirement; however, it may be prudent to disqualify athletes who sustain concussions with increasing frequency or in response to decreased impact.

**SECOND IMPACT SYNDROME**

Second impact syndrome can occur if an athlete returns to play before full resolution of a concussion.28 After a concussion, the brain may be susceptible to extremes of blood pressure.17,28 A catecholamine surge from a second impact to the head or body may cause vascular congestion, cerebral edema, increased intracranial pressure, and ultimately coma or death.8,10,12,20,25,28 There are few documented cases,19,25 but all have occurred in persons younger than 20 years.8,12 Although the existence of second impact syndrome is controversial,10,28 it is universally accepted that no athlete should return to play after a concussion while symptomatic.9,10

**Prevention, Education, and Legislation**

There is no evidence that protective gear prevents concussions.1,8,10,12,33 Helmets and mouth guards reduce risk of skull and dental fractures, but neither has been demonstrated to reduce the incidence of concussion.5,12,33 Rule changes to eliminate dangerous behaviors in sports may have a more protective effect.

Education may reduce violence in sports and allow early recognition of concussion symptoms to prevent further injury.8 The Centers for Disease Control and Prevention has instituted the Heads Up campaign to promote concussion education. Educational and clinical management tools are available at http://cdc.gov/concussion/headsup.
Table 6. Elements of Concussion Management

<table>
<thead>
<tr>
<th>Element</th>
<th>Recommendations</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive rest</td>
<td>Avoid text messaging or video games</td>
<td>Avoid activities that require attention or concentration</td>
</tr>
<tr>
<td></td>
<td>Limit television and computer use</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decrease schoolwork</td>
<td></td>
</tr>
<tr>
<td>Physical rest</td>
<td>Avoid any physical activity that exacerbates symptoms (e.g., aerobic exercise, lifting weights, household chores, sexual activity)</td>
<td>Severe or worsening headache, persistent vomiting, or seizures may suggest a need for neuroimaging</td>
</tr>
<tr>
<td>Medications/interventions</td>
<td>Wear sunglasses for photophobia</td>
<td>There is poor evidence for use of medications for postconcussive symptoms; therefore, medication choices are the same for those without concussion</td>
</tr>
<tr>
<td></td>
<td>Wear earplugs or noise canceling headphones for phonophobia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Take medications to alleviate specific symptoms (e.g., nonsteroidal anti-inflammatory drugs, acetaminophen, or amitriptyline for persistent headaches; sleep aids, anxiolytics, selective serotonin reuptake inhibitors for depressive symptoms)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Be aware that some medications may mask postconcussive symptoms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avoid acute use of nonsteroidal anti-inflammatory drugs if there is potential for intracranial bleeding</td>
<td></td>
</tr>
<tr>
<td>Transition back to school</td>
<td>Alert school personnel to injury, and initiate slow reintegration</td>
<td>Usually can be accomplished informally, but formal interventions may be required (e.g., IEP, 504 plan)</td>
</tr>
<tr>
<td></td>
<td>Consider the following: forgiveness of missed assignments and more time to complete tests and schoolwork, standard breaks and rest periods as needed, decreased schoolwork, distraction-free work areas, note taker</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avoid standardized testing during recovery</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor carefully for two to three months after concussion for scholastic difficulties</td>
<td></td>
</tr>
<tr>
<td>Graded return to play</td>
<td>After rest and resolution of symptoms, athletes may progress through a return-to-play protocol; each of the following steps should take 24 hours:</td>
<td>Patient must be symptom-free and medication-free before starting return-to-play protocol</td>
</tr>
<tr>
<td></td>
<td>Nonimpact aerobic exercise</td>
<td>If any symptoms develop, activity should be stopped immediately; 24 hours after symptoms resolve, protocol may resume at the last step for which the athlete was asymptomatic</td>
</tr>
<tr>
<td></td>
<td>Sport-specific exercise (nonimpact drills)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Noncontact training drills</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full contact practice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Return to normal play</td>
<td></td>
</tr>
<tr>
<td>Higher-risk patients</td>
<td>Factors that may suggest prolonged recovery or caution for return to play:</td>
<td>Consider multidisciplinary approach (e.g., referral to health care professional experienced in concussion management, formal neuropsychological testing, communication with coach and training staff)</td>
</tr>
<tr>
<td></td>
<td>More than three symptoms at presentation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specific symptoms (i.e., fatigue, tiredness, or fogginess)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Headache lasting more than 60 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loss of consciousness for more than 60 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amnesia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>History of concussion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age younger than 18 years</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comorbid conditions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medication use (psychotropic drugs, anticoagulants)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dangerous style of athletic play</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High-risk sport (contact, collision)</td>
<td></td>
</tr>
</tbody>
</table>

IEP = individualized education program.

Information from references 1, 9, 10, 12, 18, and 20.
In 2009, Washington State enacted the Zackery Lystedt Law requiring concussion education for coaches, athletes, and parents. The law also mandates removal of athletes from activity if there is any suspicion of concussion, and return to play must be cleared by a licensed health care professional. Other states have since enacted similar legislation.

The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the U.S. Army Medical Department or the U.S. Army Service at large.

Data Sources: A PubMed search was completed in Clinical Queries using the key terms concussion, traumatic brain injury, and brain injury, with additional searches narrowed by the terms epidemiology, assessment, evaluation, management, treatment, and imaging. The search included meta-analyses, randomized controlled trials, clinical trials, and...
**SCAT2**

Sport Concussion Assessment Tool 2

**Symptom Evaluation**

**How do you feel?**

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

<table>
<thead>
<tr>
<th>Symptom</th>
<th>None</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>“Pressure in head”</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Neck Pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nausea or vomiting</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Blurred vision</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Balance problems</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling like &quot;in a fog&quot;</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>“Don’t feel right”</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Fatigue or low energy</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Confusion</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Trouble falling asleep (if applicable)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>More emotional</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Irritability</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sadness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nervous or Anxious</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total number of symptoms** (Maximum possible 22)

**Symptom severity score**

(Add all scores in table, maximum possible: 22 x 6 = 132)

- Do the symptoms get worse with physical activity? Y N
- Do the symptoms get worse with mental activity? Y N

**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

---

**APPENDIX 1**

THE SCAT2.

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FROM THE AMERICAN ACADEMY OF PEDIATRICS
Cognitive & Physical Evaluation

1. Symptom score (from page 1)
   22 minus number of symptoms
   of 22

2. Physical signs score
   Was there loss of consciousness or unresponsiveness? Y N
   If yes, how long? Minutes
   Was there a balance problem/unsteadiness? Y N
   Physical signs score (1 point for each negative response) of 2

3. 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
   Obey commands 6

   Glasgow Coma score (E + V + M) of 15
   GCS should be recorded for all situations in case of subsequent deterioration.

4. Sideline Assessment – Maddocks Score
   "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)
   At 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 3
   Maddocks score is validated for sideline diagnosis of concussion only and is not included in SCAT 2 summary score for serial testing.

5. Cognitive assessment
   Standardized Assessment of Concussion (SAC)
   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
   "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.

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

   Immediate memory score of 15

   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.

   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 | 3 | 5-3-9-1-4-8 | 8-3-1-9-6-4 | 7-2-4-8-5-6

   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
   Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan | 0 | 1 | 0 | 1 | 0 | 1 | 0

   Concentration score of 5

---

1. This tool has been developed by a group of international experts at the 3rd International Consensus meeting on Concussion in Sport held in Zurich, Switzerland in November 2018. The full details of the conference outcomes and the authors of the tool are published in British Journal of Sports Medicine, 2020, volume 44, supplement 1.
APPENDIX 1
Continued.

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

Balance 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.

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

Condition | Total errors |
--- | --- |
Double Leg Stance (feet together) | of 10 |
Single leg stance (non-dominant foot) | of 10 |
Tandem stance (non-dominant foot at back) | of 10 |
Balance examination score (30 minus total errors) | of 30 |

7 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). 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 as quickly and as accurately as possible."

Which arm was tested: □ Left □ Right

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.

Coordination score

8 Cognitive assessment
Standardized Assessment of Concussion (SAC)
Delayed recall
"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."

Circle each word correctly recalled. Total score equals number of words recalled.

<table>
<thead>
<tr>
<th>List</th>
<th>Alternative word list</th>
</tr>
</thead>
<tbody>
<tr>
<td>elbow</td>
<td>candle</td>
</tr>
<tr>
<td>apple</td>
<td>paper</td>
</tr>
<tr>
<td>carpet</td>
<td>sugar</td>
</tr>
<tr>
<td>saddle</td>
<td>sandwich</td>
</tr>
<tr>
<td>bubble</td>
<td>wagon</td>
</tr>
<tr>
<td></td>
<td>sunset</td>
</tr>
<tr>
<td></td>
<td>lemon</td>
</tr>
<tr>
<td></td>
<td>insect</td>
</tr>
</tbody>
</table>

Delayed recall score

Overall score
Test domain | Score
--- | ---
Symptom score | of 22
Physical signs score | of 2
Glasgow Coma score (E + V + M) | of 15
Balance examination score | of 30
Coordination score | of 1
Subtotal | of 70
Orientation score | of 5
Immediate memory score | of 5
Concentration score | of 5
Delayed recall score | of 5
SAC subtotal | of 30
SCAT2 total | of 100
Maddocks Score | of 5

Definitive normative data for a SCAT2 "cut-off" score is not available at this time and will be developed in prospective studies. Embedded within the SCAT2 is the SAC score that can be utilized separately in concussion management. The scoring system also takes on particular clinical significance during serial assessment where it can be used to document either a decline or an improvement in neurological functioning.

Scoring data from the SCAT2 or SAC 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.
Sports Physical II Quiz

1. What are the “Red Flags” of cardiovascular history/physical that should prompt further evaluation prior to clearance? *Go around the table and list one “Red Flag”:*

2. The incidence of sudden death ranges from 1 per 44,000 and 1 per 200,000 athlete-years, with ___ percent due to cardiovascular disease. Complete the following table:

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<thead>
<tr>
<th>Condition</th>
<th>Mechanism of sudden death</th>
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3. Based on Bethesda Conference Sports Classifications, what sports are young athletes cleared for, who have the following heart conditions?

   a. Marfan syndrome with normal aortic root diameter; currently cleared by cardiology for **class ___ and ___** competitive sports play.

   b. Recent dx of SVT with episodes causing breathlessness and dizziness, recently started on medication, currently cleared by cardiology for **class ____** sports.

   c. Moderate Mitral Regurgitation with mild LVH, currently cleared by cardiology for **class ______________** competitive sports play.

4. CONCUSSION True or False:
   
   A. Concussions result only from a direct blow to the head, face, or neck.

   B. Concussions result in structural injury to the brain.

   C. Loss of consciousness is a critical historical clue that determines concussion management.

   D. Concussion results in an impairment in neurologic function that usually resolves spontaneously.

   E. The developing brain is more vulnerable to reinjury & may take longer to heal from TBI:
5. What are the “Red Flags” of concussion history/physical that suggest prolonged recovery or caution for return-to-play? What clinical features would _also_ indicate neuro-imaging?

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<th>Red Flags for Prolonged Recovery</th>
<th>Indications for Neuroimaging</th>
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Case 1:
Michael is a 17 year-old male who comes to see you with his mom. He is on the varsity football team and the regional championship series is about to start this weekend. The first game is against his school’s biggest rival, the Honey Badgers. He forgot to come in before the season started, but because he is one of his team’s star players, his coach let him slide. Now the school administration has become aware and he cannot play in this weekend’s big game until you sign his forms. He thinks a scout will be there. “Help me, Doc!”

What do you need to know in order to complete his sports clearance paperwork?

His past medical history is benign, no major illness, no hospitalizations. He takes no medications or supplements except a protein powder after practice. Family history unremarkable: no cardiac history or sudden death. When you ask specifically about injuries, Mom does report that he broke his ankle as a freshman and had it pinned by orthopedics, but “they said he was ok to play now.” He denies any pain or instability when playing football. You ask him if he has ever had a concussion. He says, “No way, doc. I’m pretty tough. I’ve never passed out from a hit.”

Do you want to know anything else about his injury history?

On further questioning, with mom’s prompting, Michael admits that he has had a few hits where he felt dazed for a few minutes afterwards, but he says he felt fine after a few minutes and was able to still play, so he never told his coach. The most recent of these was less than 1 month ago. He denies any memory loss before or after any of his hits. He does say that he occasionally gets headaches “just like everybody” but they are “no big deal” and respond to Motrin.

What are you concerned about? Will you clear Michael to participate in his big game against the Honey Badgers this weekend? “Com’ on Doc!”

You discuss some of these concerns with Michael and his mom, and she is surprised that none of his football coaches have ever called his “head dings” concussions and educated them about potential consequences. “What should we do if he gets another concussion? Are there any precautions we can take?”

What sort of anticipatory guidance will you give Michael and his mother?

Bonus: What is the law which requires concussion education for coaches, athletes, and parents? Has it been enacted in Maryland, D.C., and Virginia?
Case 2:
Jay is a 15 year-old male who presents to clinic on “Sports Physical Day”. You have churned through 4 physicals so far. The corpsmen bring you his vitals sheet and you note the following:

HR 90
BP 145/95
Weight 52 kg
Height 184 cm

What history is most important to obtain when Jay is brought back to your room?

Jay tells you that he is center for his school’s basketball team, but also wants to start weight-lifting to “bulk up”. He denies exertional chest pain or dyspnea, syncope, or history of heart murmur. PMHx is positive for history of “shoulder dislocation” after a collision with another player during a game. Jay’s athletic trainer relocated his shoulder, and he has had no other joint issues. His HEADSS exam is unremarkable, and he denies use of alcohol, tobacco, or other recreational drugs, including supplements. His father reports history of HTN in multiple family members, but no other cardiac disease or premature deaths.

What will you focus on during your physical exam?

On your exam, you note that he has a thin body habitus. HR is regular. There are no murmurs or extra heart sounds, and femoral pulses are 2+ bilaterally. Lungs are clear. There is no organomegaly. 2-min orthopedic exam is normal, and there is no kyphoscoliosis, pectus deformity, joint hypermobility, or arachnodactyly. He is Tanner 5 and has no hernias.

What is your assessment of Jay?
What will you write on his Pre-participation Evaluation Form (Cleared, Cleared with further evaluation, Not cleared)? Can Jay still participate in basketball & weight-lifting?

What are the absolute contraindications to sports participation? Is HTN included?

Before Jay leaves with his signed forms, his father asked whether you will do a “screening EKG” for Jay, as he has read in the news that this can prevent sudden death. Imagine that Jay’s exam was completely normal, how will you respond?
Sports Physical II Board Review

1. A 14-year-old boy loses consciousness while playing basketball. He regains consciousness in 30 seconds and is transported to a pediatric emergency department. Results of head computed tomography scan, electroencephalography, and echocardiography are within normal limits. Electrocardiography results are interpreted as abnormal, with a heart rate of 90 beats/min, PR interval of 150 msec, and QTc interval of 550.

Of the following, the MOST likely explanation for this patient's syncopal episode is
   A. complete atrioventricular block
   B. first-degree atrioventricular block
   C. hypertrophic cardiomyopathy
   D. long QT syndrome
   E. supraventricular tachycardia due to Wolff-Parkinson-White syndrome

2. A 16-year-old girl who is new to your practice comes to the clinic for a physical examination prior to enrollment in a summer volleyball camp. She is generally healthy, and she does well academically. On physical examination, you note that she is unusually tall and slender, and she appears to have long fingers and toes. You are concerned that she could have Marfan syndrome, and you refer her for a clinical genetics evaluation.

Of the following, the additional finding that would MOST strongly suggest the diagnosis of Marfan syndrome for this girl is
   A. high myopia
   B. long, narrow face
   C. mitral valve prolapsed
   D. narrow palatal contour
   E. spontaneous pneumothorax

3. An 18-year-old girl presents with a history of occasional mild chest pain of 1 week's duration. The episodes occur at rest and have not affected her performance as a competitive long-distance swimmer. On physical examination, her heart rate is 48 beats/min and blood pressure is 105/65 mm Hg. Electrocardiography demonstrates left ventricular hypertrophy, which is confirmed by echocardiography.

Of the following, the MOST likely cause of these findings is
   A. aortic stenosis
   B. athlete's heart
   C. cardiac conduction disturbance
   D. coronary artery anomaly
   E. hypertrophic cardiomyopathy
4. A family has just relocated to your community, and you are evaluating their 12-year-old son for the first time this afternoon. Family history reveals that the boy’s father and grandmother had premature cardiovascular disease. The boy’s parents are concerned about risk of heart disease.

Of the following, the MOST important next step in this child’s evaluation is

A. echocardiography
B. electrocardiography
C. fasting lipoprotein analysis
D. random cholesterol measurement
E. referral to the cardiology clinic