EMERGENCY RESPONSE FOR THE ATHLETE

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Contents: Emergency Response for the Athlete

Medical Emergencies in Athletics

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Learning Goals:

Upon completion of this section, the learner will:

1. Identify and describe the types of first responders and their training requirements in the US.
2. Differentiate among fractures those with a high potential for loss of limb or life and the required immediate treatment in the sporting venue.
3. Describe the 3 most serious types of cardiac injury leading to death.
4. Apply knowledge of the various categories of injury to adapt a sideline medical kit for coverage of various sports.
5. Recall in order, the steps of the Primary and Secondary assessment during emergency care of the injured athlete.
6. Given a wound, determine the best dressing to utilize.
7. List the signs and symptoms of shock and the most appropriate treatment
8. Explain the rules of splinting.
9. Complete a sample Emergency Action Plan for your facility.

Objectives:

1. Given an injured athlete scenario, apply the tools and skills learned in the primary and secondary assessment to treat the athlete on the field of play.
2. Choose the correct splint to use on an athlete with a suspected ankle fracture.

Introduction

The term Emergency Responder or First Responder has many meanings, definitions and connotations. The National Institutes for Occupational Safety and Health (NIOSH) reports there are over 3.5 million emergency response workers in the United States, such as firefighters, law enforcement officers, emergency medical personnel, cleanup, repair, restoration and recovery workers supporting accidents, natural disasters or terrorists' attacks including nearly 2 million career public safety workers employed full-time in corrections, emergency medical services, firefighting, and law enforcement.[1] First responders are those often certified to provide prehospital care in certain jurisdictions such as wilderness responders or community first aid responders. These personnel attend to medical emergencies until a higher level of care or certified personnel arrive. The US Homeland Security Presidential Directive HSPD-8 identifies first responders as:

> Those individuals, who in the early stages of an incident, are responsible for the protection and preservation of life, property, evidence and the environment including emergency response providers as defined in Section 2 of the Homeland Security Act of 2002 (6 U.S.C. 101), as well as emergency management, public health, clinical care, public works and other skilled support personnel…that provide immediate support services during prevention, response and recovery operations.[2] Additional definitions include Federal, state and local governmental and non-governmental emergency public safety, fire, law enforcement, emergency response, emergency medical (including Hospital emergency facilities) and related personnel, agencies and authorities.[1]

Licensing and prehospital emergency medical care and oversight of emergency medical services (EMS) are governed at the state level. The Federal government does have a model scope of practice including minimum skills for Emergency Medical Responders (EMR), Emergency Medical Technicians (EMT), Advanced EMT (AEMT) and paramedics established by the National Highway Transportation Safety Administration (NHTSA). While states set their own requirements, a quasi-national certification body exists. The National Registry of Emergency Medical Technicians (NREMT) offers a certification based on the NHSTA curriculum.[3,4] Specific to prehospital emergency care within the realm of athletics and sports venues, certified athletic trainers (ATC) and board-certified sports physical therapists (SCS) engage in the evaluation and management of injured athletes. According to the National Athletic Trainers' Association (NATA), certified athletic trainers are health care professionals who collaborate with physicians and provide services compromised of prevention, clinical diagnoses, therapeutic intervention, rehabilitation and emergency care of injuries and medical conditions.[5,6] Board-certified sports physical therapists, as recognized by the American Board of Physical Therapy Specialties, are physical therapists with advanced knowledge and skills in the specialty area of sports.[7] It is common for sports physical therapists to possess dual credentials as ATC or EMTs.

Athletic trainers initially managed emergencies in sports medicine as early as the late 1800s. Formal curriculum and oversight begin in the 1950s with the formation of the NATA.[6] In 1954, the ACSM was formed, the predecessor to the American Physical Therapy Association (APTA). With change and growth, in 1974 the APTA recognized its first specialty section was formed, and the sports section gained approval in 1981.[7] Since that time, the academic curriculum for sports providers in both athletic training and physical therapy education has advanced significantly, where both ATCs and PTs work in various sporting venues including professional, Olympic, college, high school, club sports and non-traditional venues such as the performing arts on Broadway and Cirque de Soleil.

Administrative Responsibilities

In 2013, the Boston marathon forever changed the way Emergency Medicine in the sporting environment would be planned and managed. Types of sports and competition influence the nature and frequency of injuries, medical coverage provided, as well as the personnel and equipment needed. Motor and equestrian sports carry a significant risk of trauma. Rugby and football are high-risk sports. American football and equestrian sports have a significant risk for spinal injuries. Non-contact sports such as golf, tennis and running have a broad range of

overuse injuries, however, they can also result in more orthopedic and trauma related injuries. All sports carry the risk of cardiac events as well as emergencies of anaphylaxis, asthma and hypoglycemia. Spectators and staff are also not immune to emergency medical conditions.[8,9] The EMR must consider the ages, skills, and any relevant medical history of the athlete. Prior screening may be beneficial or impractical. Travel with athletes requires consideration of vaccination, food, and diseases prior to or during the stay. The EMR may only be responsible for the athletes and staff. Who coordinates care of spectators and crowds? Does the opponent have a capable medical staff trained in emergencies that can be called on to assist? The EMR must be familiar with the venue, available key personnel, ambulance request and access and facilities. The Hillsborough disaster of 1989 and subsequent Gibson report recommended a separate medical staff for crowds greater than 2000 and an onsite ambulance for crowds over 5000 or more.[8]

Contractual Agreements

The EMR may be employed or contracted for a team, school, or event organizer. Several key questions should be asked in lieu of such agreements. What medical staff is necessary for the event? Are there protocols and a physician on site to provide oversite and standing orders? Other categories that need to be considered are transportation, communication, medical equipment, medications, documentation, security and insurance. How are volunteers vetted and trained prior to an event?

Whether providing care at a high school football game or a nationally renowned marathon, sports providers must collaborate with the local EMS including but not limited to arranging for permits, protocols, and transportation.[8] In 1966, the NHTSA established minimal standards for out of hospital care for accident victims. In 1969, the first Emergency Medical Technician training program was established. There are currently four levels of certification / licensure with variation in skills, practice, knowledge qualification, services provided, risk, level of supervision, autonomy, critical thinking and judgment. All are part of a continuum of care. Table 1 lists the levels and training requirements according to provider.[3,4] The EMS system still relies on the public for being first on the scene and identifying the emergency and initiating the call to begin the chain of survival with EMS.[3,4,10] In the sports environment, it is the ATC, PT or physician that may initiate the chain of survival. All events should have a written Emergency Action Plan (EAP) as recommended by the NATA.[5,11-17]

Table 1. National EMS Scope of Practice Model*[3,4]			
Emergency Medical Responder (EMR)	Primary focus is to initiate immediate lifesaving care to critical patients Function as part of a	Possesses basic knowledge and skills necessary to provide lifesaving interventions while awaiting additional EMS response and to assist	Educational Requirements: One of the eligibility requirements at this level is successful completion of an accredited Emergency

	comprehensive EMS response, under medical oversight Perform basic interventions with minimal equipment	higher level personnel at the scene and during transport.	Medical Responder training program.
Emergency Medical Technician (EMT)	Primary focus is to provide basic emergency medical care and transportation for critical and emergent patients Function as part of a comprehensive EMS response, under medical oversight Perform interventions with the basic equipment typically found on an ambulance.	Possesses the basic knowledge and skills necessary to provide patient care and transportation.	Educational Requirements: One of the eligibility requirements for licensure at this level is successful completion of an accredited Emergency Medical Technician course
Advanced Emergency Medical Technician (AEMT)	Primary focus is to provide basic and limited advanced emergency medical care and transportation for critical and emergent patients AEMTs perform interventions with the basic and advanced equipment typically found on an ambulance.	Possesses basic knowledge and skills necessary to provide patient care and transportation. Advanced Emergency Medical Technicians function as part of a comprehensive EMS response, under medical oversight	Educational Requirements: One of the eligibility requirements for licensure at this level is successful completion of an accredited Advanced Emergency Medical Technician course
Paramedic	Is an allied health professional whose primary focus is to provide advanced emergency medical care for critical	Possesses the complex knowledge and skills necessary to provide patient care and transportation.	Educational Requirements: Because of the amount of complex decision making, one of the eligibility requirements

	and emergent patients who access the EMS Paramedics perform interventions with the basic and advanced equipment typically found on an ambulance The Paramedic is a link from the scene into the health care system	Paramedics function as part of a comprehensive EMS response, under medical oversight	for licensure requires successful completion of a nationally accredited Paramedic program at the certificate or associates degree level

*For the purpose of this model, one licensure level is *substantially* different from other licensure levels in:

- Skills
- Knowledge
- Services provided
- Level of supervisory responsibility
- Judgment/critical thinking/decision making
- Practice environment
- Qualifications
- Risk
- Amount of autonomy

The skills utilized by the sports EMR are paramount to early assessment of life threating situations including ensuring airway, breathing, and circulation, in addition to assessing for severe bleeding, shock, and providing venue care and determining the need for definitive care. The EMR must be prepared for all types of trauma including those that may occur to spectators, coaches, or others tangentially involved in the venue. The process of primary and secondary assessment is tried and true. The concept of the sports provider as part of the EMS system is key in assessing and treating athletes in emergencies. Sports PTs and ATCs serve a similar capacity as an EMR with focus on the athlete, while using of evidence-based practice within the scope of their license or practice act. These professionals often have the benefit of knowing the athlete well, as well as understanding stress and the emotional impact of an injury.[5,19,20]

Epidemiology

Athletic injury severity occurs along a continuum. Many sports injuries are minor (sprains, strains, abrasions), which require immediate care and treatment with subsequent return to play. Other injuries are more serious and require further assessment and treatment, and may necessitate follow up to ensure the athlete is safe to return to play. Other injuries are life threatening involving the “ABC’s” which include airway, breathing, and circulation. Other life threatening injuries include severe bleeding, cardiac emergencies, shock or other catastrophic injury that must be promptly recognized and acted upon immediately to preserve life. The National Center for Catastrophic Sports Injury Research (NCCSIR) tracks catastrophic injuries and illnesses pertaining to organized sports participation for the collegiate, high school, and

youth levels, with the intent to enhance the prevention, recognition, management and rehabilitation of catastrophic injuries in athletics. Catastrophic injuries include those that result in permanent disability, serious head injuries, cervical spine fractures, temporary paralysis, sudden cardiac arrest or sudden cardiac disruption, exercise-related heat stroke, or fatalities.[21] Sports medicine providers need to be aware of these injuries and work towards decisions that improve safety and decrease risk. Rule changes, written EAP protocols, and access to advanced medical care can all improve outcomes and the safety of sports participants.[5,8,11-17,19,21]

Although football garners the most attention for both catastrophic injury and fatalities, other sports such as swimming and diving, as well as pole vaulting are among other sports with significant injury rates. In the last ten years, there have been fatal injuries in other sports including baseball.[21] Table 2 lists several examples of fatal injuries according to sport. Each sport influences the nature and frequency of injury as do other factors, including practice vs competition, skill level, age of the athlete, preexisting pathology, protective equipment, playing surfaces, environmental factors, and on-site medical staff to oversee participation and pre-screening efforts.[8,11-13,17,19,20,22-28]

Table 2. Report of Catastrophic Injuries/Illness in High School & College; 2012 – 2015*

	2012/13	**2013/14**	**2014/15**
Baseball			1/1
Cross country	1/0		
Football	10/5	27/2	18/3
Gymnastics			1/0
Ice Hockey	0/1	1/0	1/0
Lacrosse			2/0
Soccer			1/1
Softball			0/1
Track & Field	1/0		
Wrestling		1/0	

*Sports not reported had no catastrophic injuries/illnesses for years reported

Sports medicine providers share responsibility for the health, well-being, and care of athletes. This includes the athletes, the organization, spectators and crowds, the teams, and the medical staff present. When caring for any of these populations, healthcare personnel need to be aware and familiar with the venue, key locations, and access to definitive care. Several questions regarding coverage responsibilities should be proactively addressed. Are we responsible for the other participants? Spectators? The Hillsborough disaster of 1989 brought many of these factors to the forefront of venue management.[8]

Other Responsibilities

The sports medicine venue provider needs to be aware of weather conditions and the effects of weather on athletic participation. Are the proper protocols and standards in places to care for

athletes? Who ultimately makes the decision for "go – no go "decision?[26] NATA has clearly articulated position statement on Emergency Planning in Athletics as well as Exertional Heat Illness, Lightning Safety, Prevention of Sudden Death in Sports, and Acute Management of the Cervical Spine Injured Athlete.[11-17,27-29] The EAP addressed areas of communication, transportation, equipment, medications, documentation, and security. All the planning, prevention, and administrative tasks are paramount to safe participating and action during an emergency. All participants benefit from trained emergency responders who are present and able to recognize, evaluate, treat, and refer injured athletes as soon as possible to lessen a more serious injury and to refer the athlete to advanced care as necessary.

Primary Assessment

The initial or primary assessment or survey is designed to detect all immediate threats to life. These include airway, breathing, and circulation (ABC's), as well as severe bleeding and shock. The primary assessment has six components: [8,11]

1. **General Impression**. Looking at the scene, determining the mechanism of injury, seriousness and condition of the injured athlete. Other impressions include level of distress, mental status, and observation of visible injuries.
2. **Mental Status**. Using the Alert, Verbal, Painful, Unresponsive (AVPU) scale, the first priority is determining level of responsiveness. Alert athletes are responsive, awake, oriented and talking. In the Verbal level, the athlete responds to loud stimulus and the response may include grunts, speaking, groans or eye-to-eye contact. Painful response such as a sternal rub or pinch will elicit a response from the athlete. Unresponsive is the final level of status.
3. **Airway**. In an unresponsive athlete, the airway must be opened and assessed for breathing using either a head-tilt-chin-lift or jaw-thrust technique. The airway should be assessed for five to ten seconds using visual and palpable clues.
4. **Breathing**. Once the airway is open, an assessment of breathing must be done. Observe for the chest to rise and feel for air exchange. Listen to the quality of the breath sounds.
5. **Circulation**. Assessing the pulse at the carotid or radial artery if there is breathing. Check skin signs including color temperature and moisture.
6. **Bleeding and Shock**. Observing and treating for profuse, bright red spurting bleeding that is indicative of an arterial bleed. Any uncontrolled bleeding may become life threatening and lead to shock.

At this point in the primary assessment, if the person is unresponsive, has a blocked airway, is not breathing, has no pulse, ***or*** has severe arterial bleeding, immediate action must be taken. Calling for advanced medical care, arranging transportation, beginning cardiopulmonary resuscitation (CPR), rescue breathing, or treatment for bleeding and shock. It is imperative for the EMR to have supplies and equipment to provide care and protect themselves while rendering care. Personal protective equipment includes gloves, mask, eyewear and a resuscitation mask. Additionally, if oxygen is available, its use should be encouraged. Care to stop bleeding includes using sterile dressings, trauma dressing, or a

tourniquet if appropriate. The goal is to stabilize and sustain life until advanced care arrives and transports the athlete to definitive care.[5,10,18]

Airway & Breathing

Several medical emergencies, illnesses, or injuries can lead to compromise of an athlete's airway. Airway injuries may be caused by trauma to the face, skull, and neck. Soft tissue injuries and bleeding to the oral or nasal cavity causes swelling and may lead to immediate or delayed airway compromise. Injuries to the larynx or trachea will also produce soft tissue swelling and possible damage to cartilage or fractures of the larynx, distorting the airway. Paralysis may occur due to damage of the laryngeal nerve or the carotid artery. These primarily occur in sports with contact or collision "clothesline" injuries or from sharp blades such as hockey skates. Athletes with these types of injuries need to have a full assessment of the airway and cervical spine with consideration given to dyspnea, hoarseness, laryngeal tenderness, stridor or painful or difficulty swallowing or talking.[5,10,18] The EMR should also look for other signs of respiratory distress including fear, agitation and cyanosis.[5,8,10,18]

Acute Asthma. Outdoor venues are a greater trigger for attacks and include pollen and grasses while dust or chemicals may trigger indoor attacks. The classic presentation includes wheezing, breathlessness, and coughing. Dry and cold air contributes to exercise-induced asthma, which irritates the airway mucosa whereas classic symptoms usually occur toward the end or after vigorous exercise. Treatment should be initiated with the appropriate medications such as a short acting β-2 agonist.[5,8] Standing protocols may call for use of an inhaler or nebulizer if the athlete does not have their own inhaler.[18,29] Other emergencies that create shortness of breath (SOB) and require differential diagnoses include anaphylaxis, pneumonia, pneumothorax, and pulmonary edema. The key is the exam and severity of peak expiratory flow (PEF). In moderate SOB, symptoms will increase PEF at 50-75% of peak, and severe PEF of 33-50% respiration will increase heart rate and respiration. Athletes will be unable to complete a sentence in one breathe. Life threatening airway emergencies include signs and symptoms of PEF < 33%, no breath sounds, cyanotic, bradycardic, hypotensive and decreased or lack of responsiveness with an 02 saturation of less than 92%.[5,18] The position of comfort for these athletes is a sitting or tripod position. Complete the primary assessment and vital signs, and use emergency oxygen at 15 L/minute with a non-rebreather mask, and if appropriate, a nebulizer and or prednisone for five days.[5]

Anaphylaxis is a systemic response from an allergen after the first exposure with a sensitization. The response is a Type 1 immunoglobin-mediated response to common allergens such as nuts, strawberries, and insect venom. It is imperative for the EMR to be aware of their athletes' medical history and carry appropriate treatment such as an EpiPen®. Injection of epinephrine is considered a "life first" action and should be used if anaphylaxis has occurred.[5,8,18] Anaphylaxis manifests with the signs and symptoms that include swelling of the airway, tongue, and mucosa, and tingling of the lips. The epinephrine needs to be injected through the thigh, and circulated into the blood stream before it can act systemically. Usually 5 to 10 minutes is required for the medication to have positive effects. Therefore, inject into a highly vascular large muscle like the thigh or butt, then CALL 911 - because the EpiPen® can be a temporizing measure, but there is still danger after getting the injection because it does not

work that fast.[30] People with true anaphylaxis are anxious, often have a skin rash, or swelling. When someone with anaphylaxis arrives to the emergency room, epinephrine is administered immediately, and the patient is prepared for a breathing tube or cricothyroidotomy because the likelihood is low that epinephrine will reduce throat swelling in time. Anaphylaxis is a Type 1 hypersensitivity reaction caused by a large cascade of inflammatory proteins cause blood vessels to become "leaky", spilling fluid into the tissues of the throat, causing swelling and throat closing. The epinephrine helps to partially reverse this process, but it takes time for swelling to resolve; the fluid in those swollen tissues will suddenly just disappear. Flushed skin, difficulty and increased breathing rates, rashes and urticaria are all responses.[18,30]

Seizures. Seizures can compromise the airway. Initially keep the athletes safe from injury by moving objects out of the way. As soon as the seizure ends, assess both cardiac and respiratory systems in the primary assessment. The athlete may have decreased LOC, may request to be put in a position of comfort, and/or require oxygen/medication. Nothing should be placed in the mouth of a seizing athlete and the responder should look for any emergency identification tags.[5,8,18]

Pulmonary Embolism. PE's are not common in athletes, but can result from post-surgical complications or travel. Presentation may include chest pain, SOB, calf pain, and decreased O_2 saturation. These athletes can present with cardiac arrest. Immediate care in needed along with emergency oxygen. A history may include previous deep vein thrombosis or recent calf pain.[5,8]

Pneumonia. While not an acute emergency, pneumonia should be considered in athletes who are sick and have symptoms of SOB, cough, felling ill, lack of appetite, fatigue, and non-cardiac chest pain. Oxygen saturation rates can be below 94%. These athletes should be transported to emergency care for intravenous (IV) fluids and medications.[5,8,18]

Other Causes. Pulmonary edema must be considered in athletes with airway difficulties while at altitude. Other metabolic causes of respiratory distress may include metabolic acidosis seen in young athletes with diabetes due to diabetic ketoacidosis. The SOB may be progressive as the athletes tries to "blow off" carbon dioxide. Saturation rates are usually 99%.[5,8] The key to assessment – always return to the primary and secondary survey and the SAMPLE questions to assist with a pre-definitive care diagnoses.[5,8,18]

Pleuritic pain is classically sharp and worse with breathing. Pericarditis is made worse lying flat and eased by sitting up or in the tripod position. Musculoskeletal chest pain is often a diagnosis of exclusion unless precipitated by trauma. Non-pleuritic causes of chest pain include gastritis, pancreatitis, aortic dissection, and myocardial infarction.[5] Although not common in athletes, consideration of sudden death and other cardiac emergencies will be discussed in a later section.

Bleeding & Circulation

Soft tissue injuries, particularly to the epidermis, dermis, and subcutaneous tissues, are a frequent occurrence in sports. Wounds, whether open or closed, can occur from contact with playing surfaces, clubs, sticks, balls, other athletes or footwear, equipment, and apparatus. Abrasions, avulsions, amputations, lacerations, punctures and burns all create open wounds, whereas contusions, ruptures, and closed lacerations occur in underlying tissues with no break in the skin layers.[5,8,18,19] Abrasions are due to sheer forces being exposed to a rough surface. These are common in sports such as football, rugby, lacrosse, and soccer. A tearing force or sharp objects such as ice skates can result in avulsions, but unlike an amputation where the body part is completely severed, avulsions still have an attachment. Blisters are common on the feet with running events created by shear forces that increase friction - trapping fluid beneath the skin. Incisions are a type of laceration with clean and regular edges, as opposed to laceration that may be dirty and irregular. Punctures are the result of a penetrating object into the skin.[5,8,18,19]

Injuries that occur beneath the skin or deeper within the cavities of the body are considered closed since the integrity of the epidermis is intact. Contusions are very common in sports and can result from blunt trauma creating a hemorrhage under the skin. Direct trauma can produce shear and tension forces that cause internal lacerations or ruptures to organs and tissues. The EMR must use the primary and secondary assessment to determine the severity of the soft tissue injuries and treat accordingly. Severe bleeding from a large laceration or amputation may send the injured athlete into shock. Assessing bleeding for venous, capillary, or pulsating sources will determine care, the type of dressing and bandage to use, including the need for a tourniquet. Closed wounds can be more difficult to assess, so attention to pain and the description of the injury are key in determining the location or referral pattern of the injury. Observe for swelling, ecchymosis, rebound tenderness, and shock as well as ABC's.[5,8,18,19,31]

Simple abrasions and open wounds should be cleaned and dressed, regardless of the RTP status of the athlete. The athletes' position and sport must be considered when applying dressings and bandages. Cleaning should be performed with enough vigor to debride and clean the wound base. Saline solution (0.9%) or tap water can be used. Acetic acid, povidone iodine, sodium hypochlorite, and hydrogen peroxide are all harmful, or cytotoxic, to underlying tissue.[5,8,18,19] Initial bleeding should be stopped with direct pressure via gloved fingertips or hand. Dressings should be added but never removed. Once bleeding is controlled, the dressing should be secured with a bandage. Some dressings are self-adhesive and waterproof, and may not need additional bandaging.[5,8,18,19] Table 3 lists various types of dressings.

Table 3. Types of Dressings	
Gauze	Serves as bandages, dressings or sponges. Can stick to wounds when removed.
Tulie or impregnated gauze	Greasy gauze impregnated with petroleum jelly. Does not stick. Works well for flat or shallow wounds
Semi permeable films	Polyurethane membrane and acrylic adhesive. Transparency allows for wound visualization. Works well for shallow and low exudate wounds
Amorphous hydrogels	Intended to add hydration and eliminate necrotic tissue for wound beds that are necrotic/sloughy
Hydrocolloids	Semi permeable polyurethane film in the form of a solid. Swells with exudate and forms gel. Light to heavy exudate
Alginates	Calcium alginate with absorbent fibers. Good for debridement, and heavy exudate wounds. Can cause dryness. Changed daily
Collagens	Collagens can take on several forms. Encourages the growth of new collagen, maintains a moist healing environment.
Hydrofibers	Soft pads or ribbon dressing made from sodium carboxymethyl cellulose fibers used to absorb exudate and moist environment for packing of deep wounds.

Seriously bleeding wounds or arterial bleeding will require the use of a tourniquet. Cleanliness of the wound is not a priority. The use of a tourniquet is an emergency and the EMR is choosing life over limb. The tourniquet should be applied approximately two inches proximal to the wound, but not over a joint. Pull the band tight and then twist the lever until bleeding stops. Lock in the lever and be sure to note the time. EMS will often write “T” and the time on the trauma victim’s forehead.[18,30]

Hypoperfusion

Shock is an inadequate amount of blood delivered or lost creating a “state” in the body. There are many variables with shock and include loss of fluids, changes in vessels, blood pressure, heart rate, all to shunt blood away from the extremities to major organs to maintain pressure and vitality. The seriousness of the injury does not necessarily correlate to the presentation of shock. Shock can occur in non-life-threatening injuries and to those not even injured. Some emergencies such as severe blood loss or damage to internal organs can increase the likelihood of developing shock.[5,8,18,19,30,31] Signs and symptoms include pale, cool, gray skin. The athlete may feel nauseous or vomit due to the rush of blood to the digestive system. Blood pressure drops due to change and decreases in heart rate and pumping action. Table 4 lists the definitions of the types of shock. Regardless of the cause, shock can be classified as compensated, decompensated, or irreversible. Compensated shock results from the body’s effort to decrease tissue perfusion – creating an increase in heart rate and respiration.

Table 4. Types of Shock and Characteristics	
Hemorrhagic	Severe lack of blood or fluids in the body, most common type
Obstructive	Obstruction in blood flow such as a pulmonary embolism
Neurogenic/ Vasogenic	Due to trauma, inadequate blood flow in vessels around spinal cord or inadequate volume returning to the heart
Anaphylactic	Exposure to an allergen causes immune system to release chemicals that flood the body
Septic	Due to (bacterial) infection, organ injury occurs with significant drop in blood pressure and abnormal cellular metabolism
Cardiogenic	Heart's inability to supply adequate blood circulation to the vital organs, usually from trauma to the heart
Hypoglycemic	Abnormally low level of blood sugar in system
Metabolic	Excess buildup of acid due to metabolic acidosis
Psychogenic	Low blood pressure due to excessive excitement, or sensory interaction stimulates the vagus nerve and dilation of blood vessels
Respiratory	Often from acute respiratory distress syndrome with widespread inflammation of the lungs

Constriction of blood vessels and redirection of blood to vital organs occurs. Decompensated shock occurs when the body cannot adjust to the fluid blood loss and systolic pressure drops below 99 mmHg. It is difficult to obtain a distal pulse and organ failure can occur. Irreversible shock the body is unable to correct or adjust for blood loss, and hypoxia leads to tissue damage and death.[5,18,30,31] During the initial assessment it is necessary for the EMR to recognize and treat shock, and if present, the severe blood loss, splint for pain control, elevate the lower extremities if there are no suspected injuries to the lower extremities or spine, control body temperature and provide emergency oxygen if available. No oral fluids should be given, as the patient will often report intense thirst.[5,18,30,31]

Secondary Assessment

The next step is the secondary assessment or survey, which includes a focused history and physical exam.[5,18] The purpose of the secondary assessment is to identify and care for specific injuries or medical problems. Concerning athletics, this portion of the exam may be completed after the athlete is safely moved off the field of play to the sideline or locker room. The goal is a rapid exam of the entire body while obtaining a patient history and vital signs. One of the most common acronyms used to trigger the secondary assessment questions is SAMPLE. Whether you are familiar with the athlete or not, a quick introduction and some calming words will go a long way in obtaining the information needed and keep the athlete focused on the exam.[5,18]

S Signs and symptoms

A Allergies

M Medications including over the counter

P Pertinent past medical history

L Last oral intake

E Events leading up to the incident

Next complete a rapid head to toe assessment using the acronym DCAPBTLS to further identify injuries.[5,8,18,30]

D Deformity

C Contusion

A Avulsion

P Penetrations

B Burn

T Tenderness

L Lacerations

S Swelling

Vitals signs should be taken during the secondary assessment including pulse, respiration, and blood pressure. Use a portable pulse oximeter if available for oxygen saturation levels. Assess skin color and temperature, pupils, and other appropriate signs to further gain information to provide a full picture of the athlete's injuries. Respiration should be assessed for rate, depth, sounds, and effort. Skin signs include color, temperature, and moisture, as well as assessing for shock. Pupil exam is a valuable tool to provide information regarding a head or spine injury. Pupils should be assessed for size, equality, and reaction to light.[5,8,18,30] The head to toe assessment is meant to be rapid but thorough taking no more than a few minutes. Within each body part, specific items should be evaluated.

Head: profuse bleeding can occur from small wounds or lacerations. Look for deformities, depressions or impaled or avulsed lesions. Assess the ear and nasal canals for clear fluid (cerebral spinal fluid).

Neck: point tenderness or deformity. Any positive findings the exam is halted, and cervical stabilization commences until the athlete has a rigid cervical collar and positioned on a spine board.

Chest: bruising, deformities, or asymmetrical chest movements

Abdomen: palpate the four quadrants for tenderness, swelling, rigidity and pain

Back: tenderness

Pelvis: tenderness, deformity and pain, and any signs of fractures

Genitals: look for signs of incontinence, bleeding, priapism in males.

Extremities: deformity, swelling, bleeding, bone protrusions, or obvious fractures. Assess distal pulses and capillary refill if possible. In most circumstances, do not remove the footwear but do cut away any clothing or items that may restrict circulation.[5,8,18,30]

The order after the primary assessment will depend on several factors including the specific situation, if the athlete's injury was witnessed, if the athlete has no primary assessment concerns and if the athlete can verbalize a serious injury or if that is obvious to the EMR. If the athlete has severe trauma, and this is clear then the EMR should begin a focused trauma assessment. If it is unclear or there is no trauma, then the head to toe assessment should be next.[30,32]

At this point, if the athlete has not been removed from the competition/ practice area that will need to be done in the safest manner.

Moving the Injured Athlete

Once the primary and secondary assessments are complete, the EMR needs to decide how to move the athlete from the athletic venue to the appropriate location, which may include the sideline, training room, locker room, or other facility to complete the examination. For true sports emergencies, athletes should be placed on a rigid immobilization device or carefully lifted onto a stretcher and then moved via a golf cart or gator. For those athletes whose injuries are less serious, attempts should be made to secure the injured body part with splinting materials and then move the athlete off the field either under their own power or with assistance. Athletes may be assisted via several different types of lifts or carries such as a walking assist, or two-person seat carry.[5,8,18,31]

A more specific, focused assessment on a stable athlete assessing specific injuries may now occur. This assessment may include palpation, range of motion (ROM), strength testing, special tests, and functional tests specific to the region to determine the seriousness of the injury or the ability of the athlete to return to play.[5,19] This section will now transition to specific emergencies, assessments, treatments, and other concerns.

Face & Skull

Skull and neck injuries are common in contact sports and range from minor injuries with no neurologic involvement, to various degrees of concussion, traumatic brain injury (TBI), and catastrophic cervical spine injuries. In the United Kingdom, TBI accounts for 15-20% of deaths in 5-35-year old's. Most are not sports related. The NATA task force on head and spine injured athletes notes that any blow can cause serious harm to the brain (concussion) or spinal cord (cervical) with disruption of the blood supply leading to various injuries.[5,8,17,33]

Epidural Hematoma. This results from a blow to the head causing a tear in the meningeal artery. Blood quickly accumulates between the skull and dura mater and is often associated

with a skull fracture. Initially there may be a headache or concerns for a concussion. This lucid period may last for hours or days until the bleeding leads to severe neurologic dysfunction, loss of consciousness, and death. Signs and symptoms include headache, dizziness, nausea /vomiting, dilated pupils, and respiratory difficulty.[5,8,34]

Subdural Hematoma. This injury is more common during sporting events, resulting from an acceleration / deceleration force to the head disrupting venous blood supply in the subdural space. These can be classified as acute or chronic. Acute subdural hematomas are characterized by headaches, cloudy thoughts, cranial nerve impairment, behavior changes, and a loss of consciousness in 48-72 hours. Chronic injuries may have no signs and symptoms for weeks until enough bleeding generates pressure in the subdural space.[5,8,34]

Skull Fracture. Any blunt trauma to the skull can cause a fracture. During the secondary assessment, the EMR provider should look and feel for depressions, bumps, and fragments about the skull. Signs and symptoms include headache, nausea / vomiting, CSF or blood in the ears and nose, and raccoon eyes, or battle sign. This is a medical emergency and requires immediate transport.[5,8,18,19,32,34]

Less severe injuries involving the scalp include lacerations, contusions, or abrasions. The EMR needs to remember the skull has a rich blood supply and significant bleeding may occur. This can lead to shock or other concerns for the athlete and bystanders. Direct pressure is indicated if there are no signs and symptoms of a fracture.[5,8,18,19,32,34] All EMR sports providers should be able to perform cranial nerve testing. Table 5 is a list of cranial nerves and their functions.

Table 5. Cranial Neve Testing

Cranial Nerve		Function
I.	Olfactory	Smell
II.	Optic	Vision
III.	Oculomotor	Pupil reaction
IV.	Trochlear	Lateral and inferior eye movement
V.	Trigeminal	Mastication and facial sensation
VI.	Abducens	Lateral eye movement
VII.	Facial	Taste, expression
VIII.	Vestibulocochlear	Hearing, equilibrium
IX.	Glossopharyngeal	Swallow, gag, tongue sensation
X.	Vagus	Speech, swallowing
XI.	Accessory	Trapezius and sternocleidomastoid innervation
XII.	Hypoglossal	Tongue movement

Maxillofacial injuries (MFI) are very common in athletes and research shows that dental guards and face shields do help reduce the frequency and seriousness of these injuries.[5,8,18,19,34] Injuries range from cuts and abrasions, to dental trauma and several facial fractures that have life threatening complications. The EMR must always consider the cervical spine and concussion as possible complications to maxillofacial trauma. MFI is usually caused by a direct hit from an object or athlete. Treatment should include thorough wound cleansing, tetanus

booster, and thoughtful consideration of skin closure techniques to lessen scars. The principles of MFI management are understanding the mechanism of injury (MOI), determining LOC, assessing pain, vision, sensation, and observing for facial or oral asymmetry in both motor and sensory function. A close examination of the teeth and depth of lacerations are included. Assess facial nerve and motor function, soft tissue injury and skin closure methods, aesthetics, and possible evaluation by a plastic surgeon. Assess the eyes for vision and trauma, the mouth for full thickness wounds requiring sutures and the teeth for avulsions, displacement or fracture.[5,8,17-20,32-37]

The most common facial fracture is a nasal fracture. Epistaxis (bleeding from the nose) can by unilateral or bilateral. External pressure should be applied to stop bleeding with the head held slightly forward. Caution should be used with any nasal packing as a septal hematoma can form and need draining. Fractures should be referred to an otorhinolaryngology (ear, nose, and throat) specialist. Any clear fluid from the ears or nose may be a sign of CSF, and the athlete should be managed accordingly.[5,8,18-20,30,32,34]

Eye Injuries

Eye injuries are reduced using helmets and protective eyewear. The playing area should be clear and large enough to avoid athletes running into walls or other obstacles, goal posts, benches, or other obstacles and those should be padded. Sports involving projectiles (hockey pucks, softballs, baseballs, etc.) clubs, or contact /collision sports are all causes of eye injury. In the US, there are over 40,000 eye injuries each year and the leading cause of blindness in children. Many of these are preventable. Racquet sports are the most dangerous followed by baseball. The sports classification system by the American Medical Association (AMA) can be misleading for eye injuries, as golf and racquet sports are classified as *other*, but have a great potential for eye injuries. Protective eyewear with a polycarbonate lenses should be worn and satisfy the American Society of Testing Materials (ASTM) Standards or pass the Canadian Standards Association (CSA).[35,36]

Eye trauma varies from minor external trauma to severe ocular injury. The extent of the injury to the eye is often in direct proportion to the speed, mass, and hardness of the object.[36] Direct blows to the eye may result in lid lacerations, corneal abrasions, and ruptures of the globe. Objects larger than the orbital opening may cause a blowout fracture of the orbital floor medial wall, while preserving the globe. A hyphema – blood on the anterior chamber, commotio retina, retinal or vitreous hemorrhage or choroidal rupture, and retinal detachment, can all be caused by blunt trauma.[5,8,35,36] Pre-participation physicals should include an ocular history with special attention to risk factors for injury including myopia, retinal surgery, detached retina or other injuries. Caution and informed decisions should be given to these athletes about participation in high-risk sports and ensure the use of sports goggles if approved.[35,36] Examination after an injury should include primary and secondary assessments and evaluation for concussion and cervical spine injury. Assess visual field as well as cranial nerves. Bleeding should be stopped with direct pressure. Pupils need to be checked for inequality and afferent defect.[5,8,18-20,30,32,35,36] The pupils should have full mobility in all directions, while lack of

elevation can be due to orbital floor fracture. Double vision is a concern for significant eye or possible head injury. Examine the external portion of the eye including the underlying bone for steps offs on the orbital rim. Assess the opening and closing of the jaw and any associated pain, as well as paresthesia in the infraorbital regions (trigeminal nerve) which is another sign of an orbital floor fracture.[5,8,18-20,30,32,35,36] Table 6 is a list of signs and symptoms for immediate referral.

Table 6. Signs & Symptoms for Immediate Referral for Eye Trauma	
Bleeding that is uncontrolled	Severe pain
Skeletal/orbital deformity	Eyelid - laceration
Vision – loss, blurred, double vision	Pupils – unequal size or reactivity
Globe – discoloration, abnormality, debris	Light sensitivity
Loss or restriction of eye movement/eyelid elevation	Floaters

Treatment is based on the findings and a decision to return to play should include not only the diagnoses and treatment of the eye injury, but overall peripheral vision and the athlete's reaction times. Corneal abrasions are diagnosed with a fluorescent stain and blue light. Treatment is topical anesthesia and antibiotics. Immediate return to play in not recommended. Foreign bodies, either superficial or concealed (underlid contact lens), should be flushed with sterile water for twenty minutes. A moistened swab may also be used to remove a superficial object on the eye. Eyelid lacerations must be evaluated to rule out any injuries to the globe and surrounding tissues. Approximating the ends in the margin involved and immediate referral is recommended.[5,8,18-20,30,32,35,36]

Blunt trauma must be fully evaluated for facial and globe injuries, pupil, and cranial nerve involvement. Referral is strongly recommended with no return to play until cleared by ophthalmology. Hyphemas should be evaluated and require rest to prevent recurrent bleeding, with recurrent bleeding within the week is associated with a poor prognosis.[5,8,18-20,30,32,35,36] Athletes who are functional monocular (corrected visual acuity less than 20/40) must wear appropriate eye protection, including under a facemask and wear these lenses during non-sports related activities as well. Participation by monocular athletes in boxing, wrestling, martial arts, and other collision/contact sports should be strongly discouraged and fully evaluated by an ophthalmologist.[35,36]

Orbital blowout fractures occur when an object larger than the eye hits the socket and creates a downward and inward pressure against the orbital floor and medial wall, resulting in a fracture, periorbital swelling and ecchymosis. Again, vision must be assessed for infraorbital nerve damage, paresthesia's, or entrapment. Diplopia is a common sign and prolapse of the orbital contents through the floor is an emergency.[5,8,35,36]

Zygomatic fractures result in significant swelling over the cheeks and can affect the orbital nerve. Symptoms include black eyes, subconjunctival hemorrhage, possible diplopia, and if the 3rd cranial nerve is entrapped, restricted eye movement. Assess the mouth opening to rule out a depressed arch fracture that impinges on the temporalis muscles. Most of these will require referral for fixation.[5,8,18-20,32,34-36]

Nasal Injuries. Epistaxis is very common in sports collision and contact sports. Lacerations and fractures are also common and all usually the result of direct contact with the athlete's nose. Epistaxis, or nosebleed, is not always a direct reflection of injury severity. If no septum or external laceration is identified, focus should be on stopping the bleeding. Finger pressure with the athlete's head positioned slightly forward will allow the athlete to breathe and reduce the chance of swallowing blood. Light packing with moist cotton plugs can control bleeding and allow the athlete to return to play if there are no other symptoms. Septal injuries or internal lacerations require further evaluation and treatment.[5,8,18-20,32,34,37]

Lacerations are common from contact with rackets or other sports equipment. It is imperative to rule out any underlying nasal fracture. A simple laceration should be cleaned and dressed with the wound edges approximated, and stitches can be delayed for 24 hours to allow continued competition. With respect to facial lacerations, consideration for a plastic surgeon consultation and use of subcutaneous sutures to reduce scar and improve aesthetics should be explored. (37)

Nasal fractures, most common in boxing, will often have an associated laceration. The nose will appear deviated away from the force of the injury. Once edema increases, deformity is difficult to evaluate, and repairs may need to be postponed for seven to ten days. Any injury to the nose must also include an evaluation of the nasal septum. Undiagnosed septal hematomas can lead to abscesses and cartilage destruction and deformity.[5,8,18-20,32,37]

Working down the facial- skull structure, the mandible has a weak condylar neck which is susceptible to fracture. Signs and symptoms include pain, swelling, and possible bleeding, malocclusion, difficulty with jaw opening, and paresthesia on the ipsilateral lower lip. The jaw may be deviated to one side. Treatment includes radiographs (x-rays), IV antibiotics for open fractures, and surgical fixation.[5,8] In collision sports, the jaw is susceptible to trauma (hockey, basketball, boxing) including dislocation. The mouth will most often be in a locked open position with pain and swelling around the temporomandibular joint. If chronic, sideline relocation with manual pressure on the molars in an inferior posterior direction to relocate the condyles and joint can be effective. This is not recommended for a first-time dislocation.[5,8]

Fortunately, most of the injuries sustained by athletes in either practice or competition are not life threating; however, it is incumbent upon the EMR to be familiar with the appropriate evaluation, treatment, and decisions about return to play guidelines to prevent a relatively minor injury from being mismanaged and causing further injury or lost participation time.

Significant time will be spent in the practical portion of the EMR course reviewing both concussion and spine injury management of the athlete. Suggested reading for updated information on concussion management includes:[5,8,9,11,17,21,33]

- NATA Position Statement Management of Sports Concussion
- Sideline Concussion Assessment Tool 5 (SCAT5)
- International conference on concussion in Sports, latest update Berlin October 2016
- Prevalence of concussion among US adolescents and correlated Factors

- Association between Early Participation in Physical Activity Following Acute Concussion and Persistent Post Concussive Symptoms in Children and Adolescents
- Postmortem Autopsy – Confirmation of Antemortem [F-18]FDDNP-PET Scans in a Football Player with Chronic Traumatic Encephalopathy (Omalu et al. 2017, *Neurosurgery*)
- NATA Position Statement: Management of the Spine Injured Athlete
- Pre-hospital Emergency Removal of Football Helmets using two techniques.
- USA Football Heads up Football Certification

An important consideration for an athlete with a suspected spine injury is the process during the on-field assessment. If the athlete is unresponsive, assume a cervical injury and manually stabilize to restrict motion. Remove the equipment and apply a cervical collar and immobilize the athlete to a spine board. If conscious, the sports provider needs to clear the spine - ensuring no midline cervical spine tenderness on the posterior aspect, as well as no focal neurologic dysfunction. The athlete is alert and oriented and there is not another area of injury that may be masking the neck pain. Next have the athlete complete active motion prior to gentle isometrics and gentle passive range of motion. If the athlete is conscious but has neck pain and tenderness to palpation, a step deformity and inability to move neck, immediately assume manual stabilization, remove gear, apply collar and board the athlete.[5,17,18,32]

Exercise Associated Collapse and Sudden Cardiac Death

Many types of injuries, illnesses, or environmental conditions might cause an athlete to collapse. These can be benign such as Exercise Associated Collapse (EAC) or life threatening such as Sudden Cardiac Death (SCD). EAC is the inability to stand or ambulate unassisted due to symptoms of lightheadedness, dizziness, or syncope. This is a common occurrence in endurance events like marathons due to postural hypotension at the completion of the event. As the athletes slows down or stops moving at the finish, the calf muscles are not serving as an active pump to prevent blood pooling in the legs. Thus, the athletes collapses.[5,8] In the primary assessment of airway, breathing and circulation, these are normal in the supine position, but a systolic blood pressure drops of greater the 20 mmHg from supine to stand is not uncommon. The athlete may have a transient change in level of consciousness, but elevating the legs helps to speed recovery. The athlete's fluid status and glucose are often normal. The athlete may be able to report a past history of EAC with other endurance event participation. Treatment is quick and rapid improvements occur with elevating the legs, oral fluids, and progressive changes in posture.[5,8,13,19,20,22,38]

A greater concern with collapse occurs when an athlete goes down before the finish line, and these episodes are often cardiac issues. Since 2000, more than 50 athletes under the age of 41 have experienced sudden cardiac death. Soccer leads with 27 deaths followed by American football with eight, basketball and ice hockey with six each, and baseball with three.[22,38,39]

A recent article in the New England Journal of Medicine stated "sudden cardiac death during participation in competitive sports is rare, the causes are varied, and more than 80% of cases would not have been identified with the use of systematic clinical pre-participation screening alone or in combination with electrocardiography-based pre-participation screening."[15] The incidence of sudden cardiac arrest (SCA) during competitive sports is 0.76 cases per 100,000 athlete-years. It is rare, and in some cases due to structural heart disease that cannot be diagnosed during pre-participation screens. In this study, 74 SCA occurred during sports participation with only two cases diagnosed as Hypertrophic Cardiac myopathy (HCM) and no cases of arrhythmogenic right ventricular cardiomyopathy (ARVC). The results of this study concluded that if the 74 athletes were all screened, the diagnoses would have been missed 97% of the time. NATA's Inter-Association Task Force Recommendations of Emergency Preparedness and Management of SCA in High School and College Athletic Programs includes summary points for management of the SCA.[13,14] Table 7 lists these.

Table 7. NATA Task Force Recommendations of Sudden Cardiac Arrest Management Summary Points	
Emergency Preparedness	Written and structured EAP Coordinator with EMS, public safety, school administrators Specific to the venue including communication, personnel, equipment, transportation Reviewed and practiced annually with all school staff
Management of SCA	Early activation of EMS, CPR, defibrillation, ACLS Suspect SCA in any collapsed / unresponsive athlete Apply AED as soon as possible Begin and continue CPR while waiting for AED Minimize CPR interruptions Continue CPR until advanced care arrives Athletes struck in the chest assume cardiac arrest from CC Help EMS get rapid access to the athlete

Cardiac distress or arrest is the result of an inadequate delivery or amount of oxygenated blood to the heart muscle that then interrupts the heart's electrical system. This interruption, often involves an arrhythmia – or loss of normal heart rhythm or irregular speed of contractions. It is estimated that ventricular fibrillation accounts for 40% of out of hospital cardiac arrests. SCA is the leading cause of death in young athletes despite efforts at identifying pre-existing conditions during physical examinations. In 56%, of deaths, SCD is the first symptom in athletes' less than thirty-five years of age.[24]

Hypertrophic cardiac myopathy is a congenital disorder described as abnormal thickening of the left ventricular wall at an early age leading to electrical conductivity problems, such as arrhythmias including ventricular fibrillation.

Arrhythmogenic right ventricular cardiomyopathy (ARVC) is an inherited disorder of the heart muscle, where scar tissue and fat take the place of damaged heart muscle over time - causing abnormal rhythms and weakening of the heart. A key sign is fainting after physical activity.[5,8]

Commotio Cordis is a result of a low impact blow to the chest wall that does not usually cause any musculoskeletal structural damage, but the blow occurs within a very narrow window of the heart cycle just before the peak of the T-wave. Commotio Cordis accounts for approximately 20% of all youth cardiac deaths.

The time from arrest to defibrillation is the greatest factor affecting survival after SCA. If bystander CPR is administered and defibrillation takes place within three to five minutes, survival rates were reported between 41-74%.[5,8,12,16,25] The sports provider must begin the primary assessment ensuring scene safety and immediately request access to an AED and call from more advanced medical support. The EMR must always consider playing surfaces and access. Chest compression must be done on a firm, rigid surface. Gymnastics, crew, wrestling, and swim and dive may require moving the unresponsive athlete to a location conducive for care. All team staff should be trained in CPR and additional training should be provided to others when at all possible.

Thorax

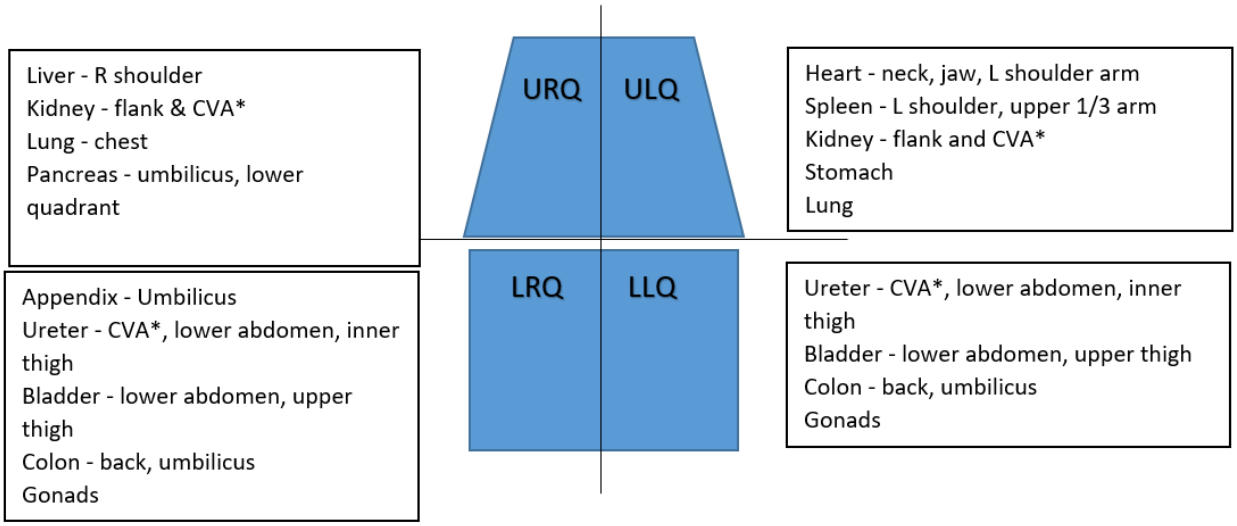
Thoracic injuries are usually due to trauma and not as common in the majority of sports, but awareness of injuries and underlying organs (especially the spleen, liver, kidneys) must always be considered in the assessment. The primary and secondary assessments are the same, but areas of emphasis include observation of breathing patterns. Observe for cyanosis and breath sounds. During the head to toe assessment, focus on the ribs. Ribs four through nine are where the majority of blunt trauma occurs. Direct blows from elbows or feet can cause pneumothorax, and ribs ten through twelve must include an assessment of the abdominal contents. Rib injuries will have pain with breathing and possible crepitus. Treatment is rest and pain medication. Pneumothoraxes, tension pneumothoraxes, flailed segments, cardiac tamponade, and hemothorax are rare in athletics.[5,8,18-20,30,32,34]

Abdomen

The abdomen and its contents are vulnerable to sudden decelerating movements, blunt trauma, or penetrating injuries. Shock is a likely outcome of abdominal injuries. There is a significant amount of room in the abdomen for blood to fill the cavity. Figure 1. displays the four quadrants of the abdomen, organs, and the areas of referred pain. EMRs must be cognizant of these pain patterns, underlying organs, and potential injury.[5,8,18,32,34] One of the most concerning organs is the spleen for a variety of reasons. Athletes with sickle cell trait have an increased risk of splenic infarct at moderate altitude. Mononucleosis can be associated with an enlarged spleen, and contact/collision sport participation must be withheld for six to eight weeks to protect the spleen from rupture. Injuries to the spleen can result in referred pain to

the left flank and shoulder (Kehr's sign). Pain from the kidneys will refer to the inferior costovertebral angle. Other organs can rupture or be crushed from blunt trauma, including punches/kicks, (during martial arts, from animals) or contact with equipment and apparatus during a fall.[5,8,18-20] The primary assessment should focus on airway, breathing, circulation and shock. Other sports injuries to the thorax and abdomen include strains (i.e. rectus abdominus) with a MOI of either a direct blow or twisting and extension of the truck. Liver and kidney failure can occur with severe heat illness. Unrelated to sports but common in adolescents and young adults is appendicitis.[5,8,18-20]

Figure 1. Quadrants of the thorax and abdomen. (facing athlete)

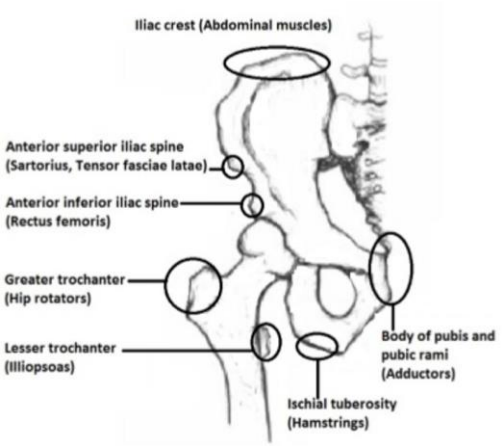


*CVA (Costovertebral angle)

Pelvis

Injuries to the pelvic region are common and severity can range from simple strain and muscle avulsions to pelvic ring fractures and completed stress fractures. Many of these injuries will present with similar symptoms and can involve abdominal contents as well as a referred pain pattern to the lower extremity, most often the knee.[5,8,18-20,30,32,34,40] Fractures of the pelvic ring and sacrum are often associated with equestrian and motor sports. Avulsion fractures are seen in adolescent athletes,[41] especially those who undergo a significant growth spurt. Figure 2 shows common avulsion sites on the pelvis. Stress fractures of the pubic rami and femoral neck are common in endurance athletes and those in military training programs. Females are at greater risk than males for stress fractures, as most will present with groin and knee pain. Differential diagnosis is completed with imaging such as computed tomography, magnetic resonance imaging, or bone scan.[5,8,18-20,30,32,34,40]

Figure 2. Common Pelvic Avulsion Sites



Dislocations of the hip take significant force with 90% in a posterior direction. The dislocated hip will be in a position of flexion, adduction, and internal rotation. Sports where these might be seen include football, rugby, skiing, and snowboarding. Hip dislocations, as well as femur fractures, are medical emergencies and should be evaluated carefully but expeditiously and referred for definitive care as soon as possible.[5,8,18-20,30,32,34,40]

The pelvic region is common for many soft tissue injuries as well. All should be assessed via the primary and secondary assessment to include shock. Table 8 outlines some common injuries to the pelvic region.

Table 8. Common Injuries to the Pelvic Region	
Greater trochanteric bursitis	Adductor muscle strain
Hip flexor strain	Hip pointer
Hamstring avulsion ischial tuberosity	Piriformis syndrome
Sacroiliac dysfunction	Iliopsoas avulsion lesser trochanter
Gluteus avulsion greater trochanter	Sartorius avulsion ASIS
Adductor avulsion symphysis	Abdominal avulsion iliac crest

Lower Extremity

Lower limb injuries account for approximately 50% of all sports injuries. Fractures and overuse injuries as well as trauma to ligamentous injuries are common. Fractures to the femur can be life threatening and require immediate care and management. Intravenous access should be initiated, and a traction splint applied. Fractures of the tibial plateau occur in skiing and other sports, and can be difficult to detect if not displaced. Concomitant injuries such as anterior cruciate ligament tears should also be evaluated in the focused assessment.[5,8,40] Other serious injuries include stress fractures, hamstring avulsions, and various soft tissue injuries. As part of the SAMPLE history and head to toe assessment, the EMR should be assessing for DCAPBTLS and ask additional questions with the injured athlete, teammates, or bystanders. All open

fractures should be covered and packed prior to splinting. Taking a photograph prior to packing and splinting may be helpful for ED staff upon receipt of the athlete. Remember to assess distal neurovascular status before and after splinting.[5,8,18-20,30,32,40]

Ankle injuries are most common in sports. Sports providers should be familiar with and utilize the Ottawa Ankle Guidelines[8,40] to determine the possibility of fractures and necessity for radiographs as these have a 90% sensitivity. Table 9 lists the Ottawa Ankle Rules. A multitude of injuries can occur in the ankle and foot. Table 10 provides a summary of these injuries. With each of these, the same approach should be taken by the sports provider: Primary assessment, secondary assessment, focused evaluation of the injured area, treatment, education, and follow up care or referral as appropriate. Common sense should be taken into consideration when deciding where to complete the secondary assessment. Once the EMR determines the athlete is conscious and breathing, the athlete may be moved off the playing area to a sideline to complete the secondary assessment and focused evaluation. The EMR must be aware of the rules of the sport such as injury time outs, when the athlete can be approached and if play with be stopped by an official.

Table 9.

Ottawa Ankle Rules to determine need for radiographs
An ankle x-ray series is only required if there is any pain in mallelolar zone and any of these findings:
Bony tenderness on the posterior edge or tip of the lateral malleolus (last 6 cm)
OR
Bony tenderness on the posterior edge OR tip of the medial malleolus (last 6 cm)
OR
Inability to bear weight both immediately AND in the Emergency Department
A foot x-ray series is only required if there is pain in midfoot zone and any of these findings:
Bony tenderness at the base of the 5th metatarsal
OR
Bony tenderness on the navicular
OR
Inability to bear weight both immediately AND in the Emergency Department

Table 10. Common Injuries to the Ankle & Foot	
Inversion sprain	Eversion sprain
Lateral malleolar fracture	Medial malleolar fracture
Talar dome osteochondral injury	Lateral/ posterior talar process fractures
Talar stress fractures	Ankle dislocation
Achilles tendon rupture	Tibialis posterior rupture
Tibialis posterior dislocation	Lateral ligament injuries
Deltoid ligament injuries	Syndesmotic injuries
Achilles tendonitis	Base of 5th metatarsal fracture
Calcaneal fractures	Anterior calcaneal process fracture
Calcaneal stress fracture	Navicular stress fracture
Lisfranc fracture dislocation	Sesamoid fracture
Sesmoiditis	

Upper Extremity

The upper extremities allow an athlete a significant degree of movement and dexterity, but with this comes increased risk of injury including falls on an outstretched hand (FOOSH), overuse, fractures, dislocations, strains, and sprains.[5,8,18-20,30,32] During the primary and secondary assessment, the EMR can gain valuable information by observing for deformity as well as how the athlete typically positions the upper extremity after injury. For clavicle fractures, the athlete supports the limb in internal rotation across the chest. For an AC joint injury, the athletes will support with upward pressure from the elbow. With a dislocation, the athletes will have the upper limb by the side, in a kyphotic position and some external rotation with a visible / palpable step off of the glenohumeral joint.[8] Anterior dislocations commonly result from either a FOOSH mechanism, or an externally rotated and abducted position of the shoulder with force applied. Evaluation must include assessment of the axillary nerve. Often if this is recurrent, the athlete will self-relocate with movement. If reduction is attempted, neurovascular status must be assessed before and after and imaging should be completed.[5,8,19,20,30,32]

Fractures of the neck of the humerus are not as common as the shaft in sports, and are usually due to a direct blow or FOOSH. Concern and evaluation of the radial nerve with wrist drop or sensory changes must be assessed. Scapular fractures occur from a direct blow to the posterior wall, and are usually treatment conservatively with a sling for four to six weeks.[5,8,19,20]

Responders must be cautious when dealing with emergencies of the elbow. Dislocations are most common in a posterior direction and may include a fracture. Palpation findings may alert the provider to a loss of the olecranon triangle or deformity at either the medial or lateral epicondyle. Relocation should not be attempted by anyone other than a skilled physician due to concerns or further damage to the artery and nerve.[5,8,19,20] Fractures at the elbow include supracondylar, common in children, due to a FOOSH with positive DOTS (deformities, open wounds, tenderness, swelling) on exam. Radial head and neck fractures are again common with a FOOSH and clinical signs include positive DOTS, and an inability to fully extend or supinate. Olecranon fractures are from a direct fall or landing on the elbow in a flexed position. Fixation is determined by fragment size and fracture displacement. Emergent injuries to the ulna and radius are from direct blows or FOOSH. Often called “defensive” injuries in sports, as the forearm is used to shield or lead a blow. Radiographs and evaluation will determine the need for external or internal fixation.[8]

The wrist presents a myriad of possible injuries from the sporting world, often from hyperextension or FOOSH mechanisms. During the secondary assessment, care must be given when evaluating the median nerve and distal pulses. Treatments often include open reduction, internal fixation (ORIF), and a return to function in six weeks. Other common injuries of the wrist include Colles, Smith, Barton’s, and scaphoid fractures, as well as lunate dislocation. The scaphoid fracture requires particular care and attention due to the high rate of avascular necrosis and nonunion, often requiring surgery.[5,8,19,20]

Hand injuries are common and can result from a multitude of causes, especially in athletes with no protective equipment or gloves for the hands. Fractures and wounds are seen with the

metacarpals and phalanges. Phalangeal injuries need to be closely evaluated for intra articular injuries and loss of the pulley tendon system. Volar plate injuries can be more commonly observed in basketball players and goalkeepers. Dislocations can occur in almost any sport, but the EMR needs to closely evaluate the distal interphalangeal joint for full flexion and extension. Mallet finger injuries are due to forced flexion on an extended finger and require splinting for six weeks. Injuries to athletes' thumbs include Bennett fractures and ulnar collateral ligament tears, often in skiers or athletes who hold a racquet or stick.[5,8,19,20]

Injuries from sprains to fractures benefit from splinting to reduce pain and safely move an athlete to another location. EMRs must understand and implement guidelines for splinting.

Splinting

Splinting is done for several reasons. In EMS, splinting is part of "packaging" the injured person to prepare for transport to definitive care. Sometimes, minimal splinting is done because it is more important to get the victim to a trauma center or operating room. In the sporting venue, splinting is frequently used to reduce pain and make an athlete more comfortable, reduce or limit further swelling, or protect an injury until definitive care is achieved. Several guidelines are recommended in Table 11 regarding splinting.[5,8,18,30,32]

Table 11. Guidelines for splinting
Splint for pain relief or to move an athlete
Remove jewelry or restrictive clothing around the injured area
Clean and bandage any open wounds before splinting
Do not cause more pain
Check pulse and sensation prior to and after splinting
If a joint is injured, immobilize the bones proximal and distal to the joint
If a bone is injured, immobilize the joints proximal and distal to the bone
Pad areas of bony prominences before tying on splint
Do not tie any securing straps directly over the fracture site

Conclusion

The venue of sports is a wide encompassing area ranging from recreational to professional, from pediatric to masters' athletes, and includes athletes with special needs, and in nontraditional sports. Illness, injury, and accidents are all part of sports participation. The emergency responder working with athletes needs to have the knowledge, experience, and preparation to quickly recognize medical emergencies in the venue and act quickly to prevent disability, catastrophic injury, or death. By understanding the role, and utilizing the skills of the primary and secondary assessment, the sports EMR makes the venue safer.

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Considerations for the Young Athlete: Children & Adolescents

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Learning Goals:

Upon completion of this section, the learner will:

1. Appreciate the terminology specific to the young athlete.
2. Identify fractures specific to the immature skeleton.
3. Understand Salter Harris fracture classification.
4. Differentiate traumatic injuries specific to the immature skeleton.
5. Recognize potential causes of the acutely limping athlete.
6. Understand the management of traumatic injuries in the young athlete.
7. Recognize and identify specific concerns regarding the young athlete.

Objectives:

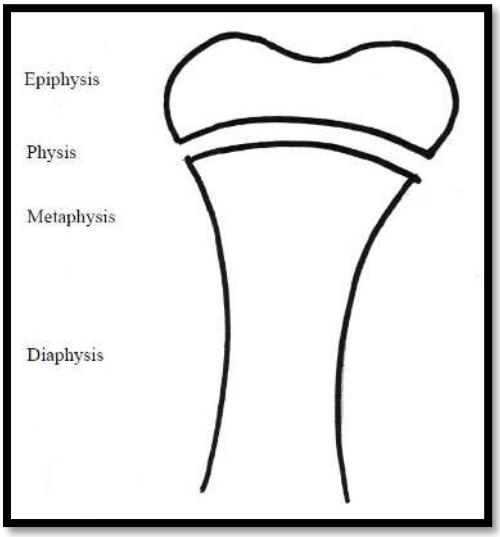
1. Given an 11-year-old female soccer player who fell and injured her left knee evaluate her for possible musculoskeletal injuries.
2. Compare possible shoulder injuries in adolescent male baseball players.

Introduction

The environment of youth sports has dramatically changed over the last 40 years with an increase in variety, expense, intensity and expectations for the young athlete. Pickup games with neighborhood friends have faded and organized sports, beginning at the kindergarten age, have made their way into most of American home.[1] In 2008, the National Council of Youth Sports estimated that 60 million young athletes ages 6 to 18 participated in organized sports.[2] With the growing numbers of participants, an increase in practice time and weekend-long tournaments, an obvious rise in both traumatic and overuse injuries is noted and of concern to the sports medicine community. Greater than fifty percent of injuries are from overuse.[3] Current statistics from the Center for Disease Control (CDC) report greater than 3.5 million sports and recreational injuries occur in five to twenty-four-year-old individuals annually.[4] Pre-adolescent sports specialization appears to be contributing to a rise in injury rates. In 2016, *The American Academy of Pediatrics*, in a published clinical report, discouraged early sports specialization and provided the following recommendations: 1) delay sports specialization until 15-16, 2) encourage participation in multiple sports, 3) take three months of the year off in one month increments and 4) take one to two days off a week from participation.[2] In addition to the AAP, organizations such as National Center for Sports Safety, Youth Sports Safety Alliance and the CDC promote injury reduction and safety by promoting education, improving medical care, and advocating for changes in policies and statues.[4,5,6]

Caring for the young athlete requires a knowledge of differential diagnosis of both childhood and adolescent injuries. Since children grow and mature at different rates and chronological ages, it is helpful to identify the athlete as having a mature or immature skeleton or closed vs. open growth plates. Growth centers close distal to proximal throughout extremities and the spine with the clavicle remaining open until the early twenties. The female athlete achieves skeletal maturation approximately eighteen to twenty-four months after menarche and the appearance of thick facial hair is one characteristic that signifies physeal closure in males. During periods of growth, bone lengthening outpaces soft tissue accommodation and leads to structures that tend to be tight. Often an increase in injuries and decrease in coordination is observed as the athlete is adjusting to his/her new body size. A child's ligaments are two to four times stronger than bone increasing the likelihood of a fracture either at the growth plate or within the bone. In general, most fractures heal rapidly without sequala due to an increase vascularity and thickened periosteum. Skeleton architecture of an immature bone consists of the epiphysis, physis, metaphysis and the diaphysis and is depicted in Figure 1. The epiphysis lies at the end of long bones adjacent to the joint, the physis is the cartilagenous growth center and is next to the epiphysis, the metaphysis is situated between the physis and the shaft of long bones called the diaphysis. The apophysis is a cartilaginous structure located near the end of long bones and is the attachment site for the musculotendinous unit; additionally, these are located throughout the spine, pelvis and extremities. Inflammation of the apophysis due to repetitive tensile forces across this interface is referred to as **apophysitis**. It is an overuse injury and is frequently observed during or after periods of rapid growth and may remain symptomatic until closure of the apophysis. Athletics participation is allowable if pain is mild and non-progressive, and the athlete can play without medication or alteration in mechanics.

Figure 1. Diagram of Immature Bone

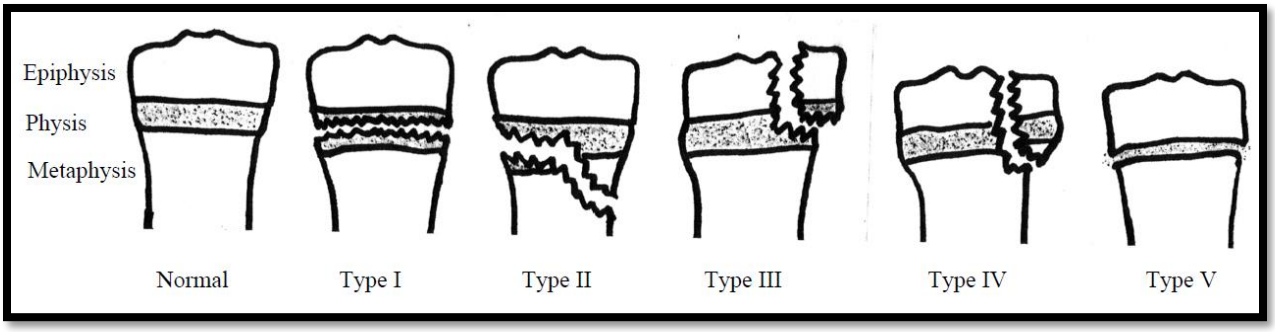


The Salter-Harris classification system is commonly used to identify different types of growth plate fractures. The original five classes are delineated by the amount of growth plate involvement and the likelihood of growth disturbance. Box 1 describes each type of fracture and Figure 2 provides a pictorial representation of the fracture line.

Box 1: Salter-Harris Classification System for Pediatric Fractures "used with permission of The International Journal of Sports Physical Therapy, In A Clinical Commentary: Recognition and Management of Traumatic Sports Injuries in the Skeletally Immature Athlete Vol 7, #6, 2012"

Type I	Fracture lines extends through the physeal plate - *Growth arrest uncommon*
Type II	Fracture lines extends through the physeal plate and metaphysis - *May or may not cause growth arrest. Outcomes favorable*
Type III	Fracture line extends from the joint surface through the epiphysis and across the physis causing a portion of the epiphysis to become displaced - *Growth arrest likely, often require open reduction internal fixation, an intra-articular injury*
Type IV	Fracture line extends from joint surface through the epiphysis, physeal plate and metaphysis causing a fracture fragment - *Growth arrest likely, almost always require open reduction internal fixation,an intra-articular injury*
Type V	Crush injury to the growth plate, not identified until after growth arrest has occurred (6-12 months) - *Rare, growth arrest certain, poor outcomes*

Figure 2. Salter-Harris Classification of Growth Plate Fractures



Since all five fracture types have the potential to cause growth arrest, identifying and managing the fracture is an important part of the differential diagnosis in the young athlete. Fifteen percent of all physeal fractures result in partial or complete growth arrest, therefore, serial monitoring of the healing fracture is indicated to identify early signs of growth disturbance.[7] Functionally, an unidentified fracture can be a source of chronic pain and instability. In addition to physeal fractures, incomplete fractures specific to the immature skeleton include greenstick, buckle or torus and plastic bowing. A disruption in the bone shaft on the tension side with an intact cortex and periosteum on the compression side is called a greenstick fracture.[7] Compression forces as seen with a fall on an outstretch hand (FOOSH), can cause a buckle or torus fracture. Upon impact, the thicker diaphysis compresses the adjoining softer metaphysis causing a buckling in the bone.[7] Plastic bowing is observed in younger children due to the malleable nature of growing bones. Excessive pressure placed on the bone cause a bowing deformity which remain when the offending forces are removed. The presence of microscopic fracture and fatigue lines within the bowing bone may cause progression of the deformation or fracture.[7] Refer to Box 2 for signs and symptoms of a fracture in the young athlete.

Box 2: Common presentation in pediatric athletes with fractures "used with permission of The International Journal of Sports Physical Therapy, In A Clinical Commentary: Recognition and Management of Traumatic Sports Injuries in the Skeletally Immature Athlete Vol 7, #6, 2012"

- Tears/crying with movement
- Limp during ambulation
- Decreased weight bearing ability
- Guarding of extremity
- Swelling
- Increased pain with palpation over bone
- Bones close to surface of skin most susceptible

In addition to susceptibility of a fracture, dislocations due to increased ligament laxity are often observed in the younger population. Ligament laxity can be measured using the Beighton-Horan joint mobility index which is outlined in Box 3.[8] Congenital ligament laxity can be idiopathic or linked to Ehrlos-Danlos or Marfans Syndromes. Young athletes with recurrent dislocations within the same joint or multiple joints throughout the body should be evaluated for an underlying ligament laxity disorder.

Box 3: Beighton-Horan Ligament Laxity Scale

- Right and left elbow hyperextension greater than 15 degrees (one point each)
- Right and left knee hyperextension greater than 15 degrees (one point each)
- Right and left thumb to wrist (one point each)
- Right and left fifth digit hyperextension greater than 90 degrees (one point each)
- Palms touch the floor with legs straight (one point)

- One point is given for each positive ligament laxity test
- Total possible score of 9 points
  0= normal
  9= significant laxity

Upper Extremity Injuries of the Immature Skeleton

Traumatic Shoulder Dislocations

Traumatic shoulder dislocations at the glenohumeral joint occur in the anterior, posterior and inferior planes. The majority of dislocations occur in the anterior plane and are more common in the adolescent athlete and young adult.[9, 10,11] Anterior dislocations are due to a blow to the upper extremity (UE) while the arm is position in abduction, extension and external rotation.[12] After dislocation, the UE is often positioned in slight abduction and internal rotation. Sideline reduction of the adolescent dislocated shoulder is discouraged due to potential vascular compromise and/or physeal involvement.[13] Splint the UE in position found using triangular bandages and a pillow/blanket to take up the space between the arm and the trunk. The

athlete should be transported to a medical facility where pre-and post-radiographs are taken, along with sensory testing, to ensure a safe and appropriate relocation.[13] Conservative management or surgical intervention following shoulder dislocation is variable depending on age, number of dislocations, concomitant structural injuries, congenital ligament laxity and future sport participation. In some cases, depending on the sport and position played, an athlete may return to sport donning a shoulder stabilizing brace that provides stability by limiting shoulder range of motion.

Little League Shoulder

Little league shoulder or a Salter-Harris Type I fracture of the proximal humeral physis is an overuse injury caused by repetitive rotational stress during overhead activities. A widening of the physis can be viewed on plain radiographs.[14,15] It is seen most often in baseball pitchers but can also be encountered by swimmers and volleyball players.[15]The young athlete reports pain in the proximal humerus while performing intense, repetitive throwing, serving or swimming activities. The onset of pain is gradual and progresses to persistent. Pain on palpation over the proximal physis is often noted. Treatment requires rest from offending activities until asymptomatic. Depending on the extent of injury, removal from sport may be recommended until the following year or closure of the physis.

Clavicle Fractures and Acromion Clavicular Joint Injuries

Both clavicle fractures and acromioclavicular (AC) joint injuries are acquired by either a direct blow to the lateral shoulder with arm by the side or an indirect fall on outstretched hand (FOOSH) mechanism.[16,17] Clavicle fractures are common in children and young adults under the age of 25.[18] AC joint injuries are less common in the developing athlete as the open growth plate of the clavicle increases its vulnerability to injury. Mid-shaft clavicular fractures are seen most often due to structural weakenss. Pain with overhead shoulder elevation and horizontal adduction are typical. Swelling, deformity, crepitus and pain on palpation over the fracture site maybe present.[8] Acute management with a sling and swath to minimize movement is recommended until radiographs can be obtained. Typically, these injuries are treated conservatively with a figure 8 brace to position the shoulder girdle in a retracted position to allow for better alignment during healing.[8,18] If increase pain and discomfort occurs in the figure eight brace, a standard UE sling maybe utilized.

Burner/Stingers

Often referred to as “dead arm syndrome,” a burner is a traumatic traction or compression injury of the brachial plexus. Although rare in athletics, brachial plexus injuries occur with some commonality in American football.[19] An athlete can sustain a burner in one of the three following ways: 1) a traction injury to the brachial plexus with the combination of shoulder depression and lateral cervical flexion to the opposite side, 2) a direct blow to the base of the

neck known as Erb's point causing and compression injury to the nerve trunks of the brachial plexus 3) another compression injury due to cervical extension with cervical lateral flexion to the same side of symptoms.[19] The incidence of injury is highest in defensive players during tackling and blocking.[19] Acutely, the athlete presents with weakness in the biceps, deltoid, supraspinatus, and infraspinatus muscles. Impaired biceps tendon reflexes and UE sensation may be present. Sideline management includes ruling out cervical spine or shoulder injuries, and symptom provocation through mechanism of injury. Same day return to play is possible if symptoms resolve within 2 minutes and full strength, range of motion (ROM), sensation, and function are restored.[19] For those athletes with longer symptoms, return to play is considered, although with caution, when the athlete demonstrates full return of strength and ROM. Athletes with persistent symptoms should seek medical follow up.

Elbow Injuries

Elbow injuries are common in the young athlete due to multiple ossification sites which develop into the mature skeleton. Fractures, dislocations and overuse injuries are all encountered by the active child and adolescent. Effusion, deformity and loss of elbow ROM in either direction are indicators of pathology.

Supracondylar Fractures

Supracondylar fractures are the most common fracture seen in the emergency department in children ages three to fourteen years of age. Approximately half of these injuries will require surgery. Supracondylar fractures are frequently caused by a FOOSH injury with the elbow positioned in hyperextension. A small percentage of fractures are caused by a direct blow to the posterior aspect of a flexed elbow.[8] The athlete who presents with significant swelling and pain is at an increased risk for neurovascular complications. Assessment and serial monitoring of symptoms for impairment of the interosseous branch of the median nerve and forearm compartment syndrome is indicated. An inability to perform the "OK" sign, with thumb's first interphalangeal joint flexed, suggests median nerve compromise. Assessment of the five "p"s (pain with passive finger extension, pallor, paresthesia, pulse, and paralysis) identifies the presence of forearm compartment syndrome. This athlete needs immediate transport to an appropriate medical facility where quick management aides in minimizing injury complications.

Elbow dislocations

Elbow dislocations are commonly seen in boys between the ages of thirteen and fourteen.[20] The mechanism of injury is typically a posterior FOOSH injury with the arm in extension and abduction. Posterior elbow dislocations are most common, and over fifty percent will have an associated fracture.[20]The athlete will present with guarding of the UE in a flexed position, significant swelling, deformity and forearm shortening. As with shoulder dislocations in this population, closed reduction should be done in a medical facility with radiographs and

examination of the neurovascular structures pre-and post-relocation. Damage and/or entrapment of the median nerve and/or brachial artery is possible. On field management immobilizes the elbow with a posterior splint and documents the neurovascular status of the UE both before and after splinting. Prompt closed reduction is advocated after pain and muscle spasms are diminished.[20] Multiple types of forearm fractures and dislocations with associated fractures are seen in this population and therefore require radiographs when suspicion of a fracture is presented. Many forearm fractures, even those with deformity, are treated non-surgically. Uncomplicated fractures of the forearm can be managed with a short arm cast, and those requiring reduction can be treated with a possible sugar-tong splint to decrease the risk of compartment syndrome, then followed by a long arm cast to minimize forearm rotation.[20]Forearm fractures which require surgery include those which are open, unstable, or significantly misaligned.[20]

Little League Elbow

The term "little league elbow" often leads to confusion among medical professionals. Initially, the phrase referred to an overuse injury to the medial epicondyle of the elbow by young baseball pitcher's due to excessive traction forces during the cocking and acceleration phases of throwing causing pain, dysfunction and loss of motion. However, in some literature, "little league elbow" refers to multiple pathologies at several locations (medial, lateral and posterior) of the elbow caused by increased traction forces medially and compression forces laterally during repetitive UE motion and weight bearing activities.[21] To avoid the above confusion, using medical terminology to describe the joint pathology is best practice. For reference, overuse injuries sustained by lateral compressive forces include Panner's disease (osteochondrosis of the capitellum), and osteochondritis dissecans (OCD) lesions of the capitellum. Injuries to the medial elbow in addition to epicondyle apophysitis, are ulnar collateral ligament injuries and avulsion fractures of the medial epicondyle. Posteriorly, the olecranon can develop stress injuries from hyperextension and valgus overload that is placed on the elbow during acceleration and deceleration of throwing. Additionally, gymnasts with a predisposition to elbow hyperextension and valgus hyperlaxity can forcefully abut the olecranon into the olecranon fossa during UE impact activities.

Acutely, the medial epicondyle can avulse following a forceful contraction of the flexor-pronator muscle group or a sudden valgus stress to the medial elbow. This injury is most often seen in teenage boys[21] during a hard throw. The athlete often feels or hears a "pop" at the medial elbow. Signs and symptoms include pain on palpation over the medial epicondyle, swelling, ecchymosis and positive valgus stress testing. The elbow is splinted above and below the joint for immobilization during transport. These fractures are classified into three types according to fracture size and involvement of the UCL. The presence of displaced or entrapped fragments, valgus instability and ulnar nerve compromise impact surgical or conservative management.

Wrist and Hand

Forearm, wrist and hand injuries are prevalent in the younger population often due to falls, tackles, and collision with balls, equipment and other players. Specific injury recognition is beyond the scope of this chapter but important for the sports medicine practitioner to understand. Clinical pearls include high suspicion for the presence of fractures prior to taping the digits and returning the athlete to play. Sideline evaluation for hand pathology encompasses both passive and active ROM of all digits with varus and valgus stress testing at each joint. A quick screen assesses normal finger alignment and hand function by having the athlete make a fist. Finger nail beds should be parallel with finger tips pointing towards the scaphoid tubercle while the hand opens and closes easily without pain.[21]

Spine Injuries to the Immature Skeleton

Spondylolysis/Spondylolisthesis

In general, young athletes will sustain different injuries to their low back than adults. Both acute and overuse low back pain lasting greater than three weeks should have a comprehensive evaluation with appropriate imaging to identify local and/or systematic pathologies. Posterior element injuries are the most common injury in this population compared to discogenic injuries in adults. Spondylolysis is a defect in the pars interarticularis and often described as a "scotty dog fracture" on radiographs. Often, plain films are negative and additional imaging may be necessary for diagnosis. The athlete may present with acute or chronic low back pain that increases with lumbar extension or rotation. Pain is often relieved by lumbar flexion or attaining a neutral spine posture. The pain is usually localized to the lumbar region but can radiate into the buttock and to the knee. Palpable pain over the pars defect maybe present but muscle spasms may cast wide spread ipsilateral pain in the lumbar area. The most common spinal level is L5 followed by L4. Sports that require repetitive lumbar hyperextension such as gymnastics, ice skating, diving and dance have some of the highest incidences of injury. Athletes who participate in contact sports and those with repetitive trunk rotation like football and ice hockey are also at risk. Thoracolumbar bracing appears beneficial in reducing pain while structures are healing.

Spondylolisthesis occurs when the lumbar vertebrae slips anteriorly to the adjacent vertebrae, also referred to as an anterolisthesis. The athlete's clinical presentation and mechanism of injury mimics spondylolysis except for a palpable positive step sign at the level of slippage and radiographic evidence of the vertebral shift. Sports participation when symptom free is variable depending on the amount of vertebral shift and the athlete's sport requirements. Participation in sports with grade three and four shifts are discouraged. Management of low back pain for these diagnoses consists of neutral spine principles, avoiding extension and rotation, rest from offending activities and addressing musculoskeletal deficits.

Lower Extremity Injuries to the Immature Skeleton

Hip Injuries

Differential diagnosis of the young acutely limping athlete ranges from systemic infections and neoplasms to focal pathology, requiring prompt and complete assessment. Immediate management indicates removal of play, assessment of both hip and knee ROM and protected weight bearing with crutches if exam findings are suggestive of serious pathology. Asymmetries and ROM limitations about the hip are concerning and therefore an important part of the exam. Additionally, it is prudent for any child complaining of nonspecific thigh or knee pain for the hip to be assessed. In the young athlete, it is helpful to use the contralateral extremity for normative reference. The age of the athlete is considered when identifying hip pathology. Table 1 categorizes hip pathology by age and provides a brief description of associated physical exam findings.

Table 1: Differential diagnoses for the limping youth athlete "used with permission of The International Journal of Sports Physical Therapy, In A Clinical Commentary: Recognition and Management of Traumatic Sports Injuries in the Skeletally Immature Athlete Vol 7, #6, 2012"

Age	Diagnosis	History	Physical Exam
4-10	Legg-Calve-Perthes	Limp with hip, groin, thigh or knee pain, insidious onset (1 to 3 mos), AVN of femoral head, Boys 3 to 5x more than girls	Limited hip abduction, flexion, and internal rotation. Positive log roll test, Conservative or surgical management
	Transient Synovitis	Fever, chills, erythema, pain	Trendelenburg gait, stiffness, guarding of movements
11-16	Slipped Capital Femoral Epiphysis (SCFE)	Hip pain, referred pain to anterior thigh or knee. Acute or chronic presentation, Boys > girls, often obese	Pain, limited internal rotation. Position of comfort hip flexion, abduction and external rotation. Surgery
	Avascular Necrosis of Femoral head	Pain in groin, lateral hip and buttock. History of steroid use, prior fracture or SCFE	Pain with ambulation, hip abduction, internal and external rotation
	Femoral Neck Stress Fracture	Endurance athlete, female athlete triad. Pain increases with weight bearing and impact. Groin pain	Pain on palpation over greater trochanter, painful ROM, positive single leg hop test
	Hip Pointer	Direct trauma to iliac crest	Pain on palpation, painful ambulation and active hip abduction
	Avulsion fractures	Sudden forceful muscle contraction or stretch. May hear/feel "pop"	Pain over involved apophysis. Pain on PROM or resisted muscle activity.
All Ages	Septic Arthritis	Chills, fatigue, fever	Decreased ROM, Pain with limb movement and Internal rotation, swelling, warmth. Preferred position (flexion, abduction, external rotation
	Osteomyelitis (bone infection)	Fever, chills, irritability, fatigue. Develops rapidly over 7 to 10 days	Pain/tenderness over hip joint, pain with movement, difficulty weight bearing
	Neoplasms	Night pain, pain that wakes the child up, pain unrelated to activity	Palpable mass, inconsistent musculoskeletal exam findings

Apophysitis about the hip and pelvis is seen in the teenage athlete whose apophysis remain open and at risk for stress injury. Six major sites include the iliac crest, ASIS, AIIS, ischial tuberosity, greater and lesser trochanter. Apophysitis can be acquired by endurance, field, and artistic athletes. Treatment includes rest and activity modification from offending forces, pain management, technique adjustment, and gradual reintroduction to play.

Avulsion fractures often occur at the apophyseal junction in the young athlete. Often, a one-time "pop" is heard or felt at the time of injury. Athletes who perform running, jumping,

sprinting, cutting and kicking motions are at risk. Common sites include the ASIS and ischial tuberosity. The mechanism of injury and specific muscular structures involved are explained in Table 2. Caution is noted with ischial tuberosity avulsion fractures as they often mimic hamstring injuries in the adolescent athlete. Radiographic evaluation is necessary for accurate diagnosis when a potential avulsion is suspected. The amount of fracture displacement indicates surgical or conservative treatment. In general, these injuries take months to heal and altered weight bearing is utilized during treatment.

Table 2: Avulsion fractures (apophyseal injuries) of the pelvis, associated muscles and mechanisms of injury "used with permission of The International Journal of Sports Physical Therapy, In A Clinical Commentary: Recognition and Management of Traumatic Sports Injuries in the Skeletally Immature Athlete Vol 7, #6, 2012"

Site	Associated Muscles	Mechanism of Injury
ASIS	Sartorius	Passive hip extension coupled with knee flexion or active hip flexion coupled with knee extension
AIIS	Rectus Femoris	Sudden contraction of Rectus Femoris such as with a vigorous kick
Ischial Tuberosity	Hamstrings and Adductor Magnus	Passive hip flexion coupled with knee extension or active hip extension coupled with knee flexion
Lesser Trochanter	Iliopsoas	Sudden active hip flexion
Iliac Crest	Abdominal Obliques	Sudden contraction of Obliques

Knee Injuries

Tibial Spine Avulsion Fracture

Tibial spine avulsion fractures often mimic an anterior cruciate ligament (ACL) injury in children ages eight to fourteen. Due to the weakness of the tibial spine at this age, it is at risk of injury, however, ACL tears and combined ACL tears with tibial spine avulsion fractures do exist. Physical exam findings include pain, effusion and reduced weight bearing.[22,23,24,25,26] The presence knee effusion in the young athlete's knee is problematic as it is often indicative of intraarticular pathology.[25]Tibial translation and knee instability may or may not be present. Both flexion and extension ranges of motion are limited by increasing pain. On field management includes, ice, immobilization and protected weight bearing. Both lateral radiographs and magnetic resonance imaging (MRI) are utilized to identify the fracture and associated injuries.[23,24,25] Cylinder casting is recommended for minimal displaced fractures. Injuries with large fracture displacements and those that cannot be reduced with casting require surgery. Diligent restoration of motion is emphasized to minimize complications of stiffness and arthrofibrosis.

Patellar Dislocations

Patellar dislocations are often seen when the athlete twists or pivots on a planted foot forcing a rotatory moment at the knee and lateral patellar displacement. Most patellar dislocations spontaneously reduce and infrequently remain laterally displaced. Athlete's with congenital ligament laxity are at risk for recurrent dislocations and may require patellar stabilizing surgery if the dislocations interfere with daily function. Acutely, the athlete may report feeling a pop or snap and a buckling of the knee. Diffuse knee pain and effusion, a positive apprehension test and decreased ability to weight bear are findings on exam. MRI is used to make an accurate diagnosis to rule out an ACL tear, and to identify concomitant injuries like osteochondral defects and cartilage damage. Uncomplicated patellar dislocations are managed conservatively with immobilization for two to four weeks. A patellar stabilizing brace may be beneficial for return to sport after rehabilitation.

MCL Tear/ Distal Femoral Physeal Fracture

The occurrence of distal femoral physeal fractures is less than one percent of all pediatric fractures.[23,27] Although rare, the potential for physeal growth disturbance and resultant angular deformity is significant; thus, warranting a thorough examination and appropriate management. The medial collateral ligament (MCL) of the knee originates on the femoral epiphysis, crosses over the tibial physis and then inserts on the tibial metaphysis. A large valgus load tethers the MCL and pulls on the physeal plate causing a distal femoral fracture instead of an MCL tear. Physical exam findings reveal medial knee pain, painful valgus stress testing, and pain on palpation over the physis with or without tenderness to the MCL. Acute management follows above recommendations. Plain radiographs and MRI are recommended to identify which type of Salter-Harris fracture was sustained. Type ll fractures are the most common with the fracture line extending through the physis and into the metaphysis.[23] All fracture types require serial monitoring of the growth plate for appropriate healing.[23]

Discoid Meniscus

A congenital malformation of the meniscus creates an abnormal disc shape. Discoid menisci are found primarily in the lateral compartment. Typical symptom progression demonstrates early sign of meniscal snapping in the preschooler, which usually fades and then reemerges in the active elementary schooler with complaints of lateral knee pain during activity or sport.[28] Tenderness of the lateral joint line, effusion, loss of end range motion, and a positive McMurray test are noted. An MRI confirms diagnosis with a bow-tie appearance of the meniscus. Surgical resection for painful, degenerated, and unstable meniscus is performed.[28]

Salter-Harris Fracture of Distal Fibula

Salter-Harris fracture of the distal fibula is often misdiagnosis as an ankle sprain. The mechanism of injury is ankle inversion and plantarflexion. The athlete may complain of lateral ankle pain, pain on palpation over ankle ligaments, and pain with range of motion testing. Differentially, the young athlete will exhibit maximal tenderness at the distal fibular physis which is located one to two finder widths above the end of the fibula. Salter-Harris Type l fractures (widening of the physis) are typical but infrequently viewed on radiographs unless a comparison view is available. A positive clinical exam suggests cast or boot immobilization for greater than three weeks. A misdiagnosis may result in chronic pain, instability and dysfunction. Return to play guidelines follow those of a lateral ankle sprain.

Sever's Disease

Sever's disease is an overuse injury of the calcaneal apophysis which can produce heel pain and limping in the young athlete. This injury is typically seen in nine to twelve-year-old athletes who compete in running and jumping sports during or just after a growth spurt. Tight gastric/soleus complex, foot pronation, an increase in training volume and playing on a hard surface are all contributing factors. Physical exam reveals heel pain, a positive calcaneal squeeze test, and pain with passive dorsiflexion. Treatment for Sever's disease encompasses avoiding offending activity, training modification, ice, and stretching. The insertion of silicone gel inserts is thought to decrease the traction stress at the Achilles tendon/calcaneal junction. The young athlete can continue to play if symptoms are mild, no limping is observed, and no pain medication is being taken. Generally, the symptoms resolve in several weeks. If pain continues, cast immobilization maybe necessary.

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Sideline Care of the Senior Athlete

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Learning Goals:

Upon completion of this section, the learner will:

1. Increase awareness of trends in sport participation of the senior athlete.
2. Recognize systemic changes with aging that may impact a senior athlete.
3. Report awareness of typical musculoskeletal injury trends in senior athletes and any special care indicated for these conditions.
4. Report awareness of potential medical emergencies that may be seen in the senior athlete.
5. Describe the signs and symptoms, risk factors, potential interventions for common medical emergencies possible with the senior athlete.
6. Report awareness of tools utilized in the physical screening of senior athletes.

Objectives:

1. Interpret the health history of a senior athlete to clear the athlete to participate in a sprint triathlon.
2. Analyze the cardiovascular changes in a 68-year-old female who reports to the aid station after completing a 10K run.

Introduction

Overall sport participation in older adults is on the rise. While many adults shy away from increased activity with advancing age, others find satisfaction in competitive and recreational sport participation. Senior athletes are increasing their involvement in all kinds of activities ranging from marathons,[1,2] to competitive swimming,[3] triathlons[4] and pickleball.[5] The National Senior Games Association[6] and the International World Games Association[7] host popular multi-sport events which attract thousands of senior athletes with a wide range of athletic experience. Age requirements vary for these events, however, for this chapter the senior athlete will be defined as any adult aged 50 or older who intentionally engages in sport or athletic competition. As this unique population continues to grow, medical providers must be ready to care for them, encourage them and educate them in order to aide in their pursuit of health and optimal sport performance.

Changes with Aging

Typical changes with aging impact every system of the human body. However, many of these systems have proven able to adapt to training stimuli[8,9] allowing athletes to overcome or delay many of these challenges. Studies of older athletes suggest that they enjoy a lower rate of all-cause mortality,[10] fewer falls,[11] better balance,[11] decreased cardiovascular disease,[12] superior strength[13,14] and overall better flexibility.[15] Yet, despite these advantages, senior athletes still experience age-related changes and collectively show a decline in performance that is significant by age 75.[16] The timing of age-related changes depends upon the health and training levels of the individual athlete. However, staying alert to the aging trends of each system will assist providers when addressing injuries or medical emergencies with senior athletes.

Cardiovascular Changes

The prevalence of cardiovascular disease in senior athletes, while lower than that of sedentary older adults[12] is still of concern when considering the impact of competition and intense training.

VO2 max. With age cardiovascular reserve declines.[17] VO2 max, a gold standard of cardiovascular fitness, shows losses of up to 20% per decade in those over age 70.[18] Maintaining high levels of training with advancing age demonstrates mild improvement in this measure[19] but even highly active senior athletes show a decline in exercise tolerance with age.[17,20]

Heart Rate. Resting heart rate doesn't change considerably with age but working heart rate decreases each year, with lower numbers needed to reach a target heart rate even in fit older adults.[20] Expect lower working heart rates for these athletes. At 80% of a calculated maximal heart rate a 75 year old will measure 116 beats per minute while a 30 year old at the same intensity will measure 152 beats per minute. Medications such as beta blockers that blunt the heart rate response to exercise are more common in older adults and could impact your findings on exam. Asking an athlete what medications they are taking may help to explain abnormalities in heart rate. Gaging exercise intensity in these cases can be achieved with a rate of perceived exertion (RPE) scale or the "talk test".[21,22] An RPE of 12-16 on a scale of 6-20 and just being able to still talk comfortably are both strongly associated with a training heart rate in older adults.[21]

Blood Pressure. Blood pressure does elevate with increased age primarily with systolic increases and a gradual lowering of diastolic values.[17] Trained athletes may demonstrate smaller increases in systolic blood pressure with aging though they are not immune to this change.[23] A systolic blood pressure greater than 200 mmHg is a contraindication to exercise and should trigger referral to a physician.[24] Due to the increased prevalence of cardiovascular

disease in aging adults, blood pressure and heart rate should be monitored more closely for abnormalities in these athletes.

Pulmonary Changes

With age, the lungs demonstrate a multitude of changes. They lose elasticity[25] and demonstrate less recoil after expanding resulting in an increased residual volume. The alveoli become larger with less functional area for gas exchange. Conducting tubules become stiff, narrow and provide more resistance to airflow. Increased calcification of the ribcage and increased thoracic kyphosis can make chest expansion and thoracic extension even less possible and further challenges the work of breathing.[26] Muscles of respiration can weaken[26] and make overcoming these challenges more difficult. Overall these changes leave reduced volume for gas exchange and less efficient transport of oxygen in an already challenged system.

In addition to oxygen transport, the number and strength of cilia in the lungs are reduced and decrease the pulmonary systems ability to defend against pathogens and foreign material thus leaving older adults more susceptible to respiratory infections[25,26] vulnerable to allergens and to pollutants in the air.

With rates of COPD and other respiratory conditions significantly higher in the aged population[26] medical providers should be alert to the possibility of respiratory distress in senior athletes. Utilizing a pulse oximeter to measure O_2 saturation may be a quick and accessible means of objectifying impairment. Normal O_2 saturation is at or above 95%. Athletes should be referred to a physician if this value drops below 90%[24] and competition should be discontinued as this could indicate systemic illness.

Musculoskeletal Changes

Cartilage and Connective Tissue. Cartilage tends to atrophy with age and becomes less hydrated and less flexible.[27] Joints as well as other connective tissue demonstrate an increased proportion of collagen with more cross-linking and less elastin creating an overall state of decreased tissue mobility. This manifests in older adults with decreased joint ROM,[28] and overall, less flexibility.[29,30] The lack of tissue extensibility leaves senior athletes at an increased risk of soft tissue injury and, when injured, a tendency toward slower recovery.

Skeletal Muscle. Aging is strongly associated with a loss of skeletal muscle mass and strength.[31,32] This loss of mass is seen most markedly in the decreased size of fast twitch (type II) muscle fibers[32] and leaves aging adults with an increased presence of intermuscular fat.[33] Maintaining higher levels of muscle mass has been associated with better function in aging

adults[33] and senior athletes do demonstrate greater preservation of strength than their sedentary peers, though a decline still occurs.[13,14] Studies of sport performance by age indicate that performance in events, such as power lifting and jumping, decline much more rapidly than events that do not demand the same skeletal muscle strength.[34] This decline can leave even healthy older athletes with less power and less ability to attenuate force, thus increasing their susceptibility to injury.

Bone. Bone loss begins in men and women in young adulthood[35] with more than 35% of total trabecular bone loss occurring before age 50 in both sexes.[35] Women further demonstrate increased trabecular and cortical bone loss during perimenopause.[35] Thus, the risk of a fracture increases with age and should be considered with all assessments,[36] particularly female athletes. Be alert to potential fractures of the spine, humerus, hip and forearm as all are more common in adults with lower bone density.[37]

Posture. Posture becomes more flexed or kyphotic with age in both men and women.[38] This becomes relevant to sport participation in older adults as increased kyphosis is linked to pulmonary disease,[38] increased difficulty with functional actvities[39] and an increased likelihood of falling.[40] Increased kyphosis can, in some cases, indicate the presence of an undiagnosed compression fractures.[41] Sport participation in a more flexed posture could also increase the risk for shoulder pain or impingement with overhead activities.

Neurological & Sensory Changes

Sensory thresholds increase in aging adults with losses in vision, hearing, taste and smell. Light touch sensation is also diminished[42] and can be more problematic in the extremities of those with peripheral vascular disease or diabetes. This loss of peripheral sensation may increase an athlete's risk of experiencing an injury from prolonged pressure due to an ill-fitting shoe or other undetected pressure. A loss in mechanoreceptors and subsequent decreased proprioception[42] as well as diminished neuromuscular control[43] can contribute to an increased fall risk. While senior athletes do enjoy a lower fall rate they still self-report an annual fall rate of approximately 10%.[11]

Integumentary Changes

Older athletes demonstrate an increased risk for skin injury and infection.[44] The skin shows a delayed and blunted response to pain and a delayed inflammatory response after age 50[45] creating an increased risk for more extensive damage to underlying tissue. When injured, older skin shows increased time needed for healing as well as an increased risk of wounds re-opening due to decreased tissue elasticity and integrity.

Other integumentary changes include decreased autonomic responses to vasoconstriction and vasodilation and overall decreased sweat production[46] contributing to poorer thermoregulation.

Permeability changes due to a change in pH, particularly after age 70 can cause difficulties when trying to anticipate a response to topical medications. Hydrocortisone, for example, absorbs at a lower rate when applied topically to older skin.[44]

Nutritional Needs

Nutrition specific guidelines for the older athlete are assumed to be unique but have yet to be formally established for many nutrients.[47] A detailed description of dietary needs is beyond the scope of this chapter but some basics can be considered for actively competing seniors. One critical component is encouraging senior athletes to consume calories adequate to support their competitive activity and exercise regimen.[48] It is recommended that athletes who regularly engage in intense training and competition are careful to consume carbohydrates during intense competition and immediately after intense bouts of exercise.[48] Recommended ranges of carbohydrate consumption include 45-65% of caloric intake[49] and are required to protect protein from being used for energy. Consuming larger amounts of protein is thought to increase and preserve strength in senior athletes.[50] Without clear guidelines in protein consumption for senior athletes the current recommendation is to follow guidelines for younger athletes with 1.2-1.7g/kg daily.[51] There are also no specific guidelines for fat intake in senior athletes though a combined position statement from the American Dietetic Association, Dietitians of Canada and ACSM for adult athletes suggests fat contribute 20-35% to an athletes diet in order to provide needed energy stores, vitamins and fatty acids.[52] Hydration needs are also an essential part of nutrition for senior athletes and will be discussed later.

Common Musculoskeletal Injuries

Up to 89% of senior athletes report an injury after age 50.[53] Aging adults are susceptible to the same injuries as younger adults and their specific injury patterns are relatively understudied, though they do show an increased prevalence of some injuries that may be less common in the younger adult.

Fractures. *Compression fractures* of the anterior vertebral body are more common in older females but occur in both genders more commonly as bone density declines.[54] These typically occur in flexion or flexed and rotated positions that put force on the vertebral body and can occur with little to no trauma in those with lower bone density.[37] An acute compression

fracture may manifest with sudden intense and local back pain that may radiate around to the front of the chest and can be confused with conditions of the heart or lungs.[55] These athletes should be kept out of flexed and rotated positions and may benefit immediately from achieving a supine position of spinal decompression with the knees bent. An off the shelf brace such as a CASH brace to protect the spine from further anterior loading can be applied immediately and may allow the athlete more mobility with less pain as they recover. Any athlete with a suspected compression fracture should be referred for imaging as treatment can be applied more effectively when these fractures are detected early.

Bony lesions common in the upper extremity include fractures of the *proximal humerus* and the *distal radius*[56] which may result from a fall onto an outstretched hand (FOOSH). In the lower extremity *hip fractures* are more common in those with decreased bone density and with advancing age[56] and are often the result of a fall.

Soft Tissue Injuries. *Rotator cuff tears*, either full or partial thickness sometimes go undetected. A random sample of 60-70 year old senior athletes showed 50% had a partial or full thickness rotator cuff tear in one shoulder and in athletes 80-99 years of age the prevalence increased to 80%.[57] This condition is frequently seen in swimmers who spend long hours training, in golfers, tennis players and other overhead athletes. However, of those found to have rotator cuff injuries very few report pain.[57] Thus it should be noted that discovery of a rotator cuff tear without pain or functional limitation should not raise alarm in this population.

Rupture of the *Achilles tendon* is common in senior athletes and has been documented in aging basketball players,[58] runners,[59] and tennis players[60] though this diagnosis is often delayed in older adults.[58] Aging runners are also likely to present with strains or tears of the *hamstring* or *gastrocnemius* and also frequently present with *plantar fasciitis*.[59] An acute injury seen more frequently in the aging tennis player is a meniscal tear[60] which may also be likely in other senior athletes but hasn't been well-documented.

Osteoarthritis. *Osteoarthritis (OA),* while a more chronic condition, is more prevalent with older adults and can certainly contribute to pain and dysfunction in senior athletes. However, OA has not been implicated as a reason to avoid physical activity or sport participation. Unless an arthritic joint is provoked by a sporting activity, senior athletes are encouraged to continue their competition and should be reassured that participation is far better than the results of sedentary behavior. Those that find joint pain worsened by their sport should seek alternative modes of exercise and sport participation that do not trigger discomfort.[61]

Common Medical Conditions of the Aging Athlete

Falls. In adults over the age of 65 more than 30% experience a fall in any given year.[62] In senior athletes that number appears to be much lower with one study showing a rate of only 10%.[11] Though lower, this number shows that falls still occur even in fit older adults. A fall is defined by coming to rest unintentionally on the ground without a medical event or external perturbation. Some individuals may not "count" a fall in which they do not suffer an injury but any fall increases the risk of a subsequent fall[63] and should be taken seriously. Factors that influence falls include a change in balance, loss of sensation and proprioception and a change in center of balance due to an increasingly flexed posture. Other factors include medication interactions and side effects, conditions such as diabetes mellitus and osteoarthritis, ill-fitting shoes, poor flexibility and visual changes. When addressing a fall-related injury in an older athlete be sure to address the risk factors above. Provide resources to the older athlete that can help them to decrease their fall risk such as evidence-based fall prevention programs. These are outlined nicely on the National Council on Aging (NCOA) website.[64] Encourage athletes that they can change their fall risk and that becoming fearful of falling is not the answer to this dilemma. Those that demonstrate fear of falling actually decrease their activity levels and further increase their risk. Thus, empowering athletes with evidence of how to decrease their risk of falls is far more effective.

Heat Related Injuries. Older adults are at an increased risk for *dehydration* and have greater needs for hydration when compared to younger athletes.[48,65] It appears that with increased age adults have decreased thirst reponses[66] and are at an increased risk for dehydration due to their decreased thermoregulation already discussed.[67] Risk factors include poor hydration before the planned event, warm weather conditions, intense exertion, diabetes, failure to hydrate due to concerns of incontinence and medications that function as diuretics. Physical signs and symptoms may prove inconsistent in many dehydrated older adults though low systolic blood pressure has proven to be a useful physical symptom.[68] Other symptoms that may be present include confusion, dizziness, headaches, dry mouth, lack of sweating, a rapid pulse, decreased urination and constipation.

The decrease in sweat production seen with aging puts these athletes at an increased risk for health complications such as heat stroke when competing on warm days as well.[46] More attention should be paid to older athletes when outdoor temperatures rise.

Also of concern with outdoor competition is the risk of sunburn. Use of sunscreen is important for athletes exercising outside.[47] With a delayed inflammatory response and delayed visible reaction to sunburn these athletes have an increased likelihood of severe burns before they are noticed. Always keep sunscreen on hand as an important preventative tool.

Hypertension (HTN). Nearly 50% of adults over the age of 60 have a diagnosis of HTN.[69] The condition typically occurs without visible signs and symptoms making it critical to take this measure when assessing an athlete. Age is a risk factor for HTN as is obesity, African American race, a family history, smoking, alcohol abuse and a diet high in sodium.[70]

Hypoglycemia. Defined as a blood glucose of <70mg/dL, hypoglycemia can cause hunger, headaches, irritability, shakiness, sweating and anxiety but can progress to confusion, slurred speech, abnormal behavior, seizures and loss of consciousness.[71] Risk factors include advanced age, a diagnosis of diabetes,[72] alcohol use, eating disorders, and increased activity in those with diabetes and inaccurate dosing of insulin. An athlete presenting with hypoglycemia may appear intoxicated but should be questioned as to whether they have diabetes. Always look for a medical bracelet indicating the disease. Those with hypoglycemia can benefit from an immediate dose of glucose via juice or another high glucose food.

Myocardial Infarction (MI). Each year 790,000 adults suffer an MI.[73] Common warning symptoms brought on by activity that may be indicative of an impending MI include pain in the chest, shoulder and back as well as dyspnea.[74] Acute symptoms in women sometimes differ from men and more commonly include shortness of breath, fatigue and weakness with acute MI with many women actually reporting an absence of the classic chest pain.[75] Staying alert to these signs and symptoms can speed identification of the problem and improve an individual's potential for survival.

Cerebrovascular Accident (CVA). Cardiovascular disease such as HTN, hypercholesterolemia, heart disease and diabetes all increase an individual's risk for a CVA[76] as do smoking, alcohol abuse and obesity.[77] Relevant to this population, CVA risk increases with increasing age.[78] The acronym FAST is often used to help recognize acute signs and symptoms[79] and can do so with a rather high sensitivity.[79] These include "F" Facial involvement as the individual may demonstrate drooping on one side. "A" Arms as one arm may not be mobile or as easily moved actively as the other. "S" Speech may be involved and either slurred, incoherent or absent. "T" addressed the time element critical in seeking medical assistance with these patients. Early diagnosis and medical treatment of a patient suffering a CVA can make a drastic difference in their recovery. These signs should not be ignored.

Peripheral Artery Disease (PAD). Lower extremity PAD is more common in the older adults[80] and goes hand in hand with systemic conditions such as diabetes, hypercholesterolemia, hypertension and obesity.[80] An athlete with bilateral pain in the buttock, thigh or calves[80] may be suffering from peripheral circulation that is insufficient to meet the demands of their sport intensity and should consult a physician as their risk for a cardiovascular incident is elevated.[81]

Screening the Senior Athlete

Health History. When assessing a senior athlete the collection of an accurate medical history can save time. If an athlete with complaints of shoulder pain previously had shoulder pain or treatment for shoulder pain you might inquire about the similarity of this pain to what they typically experience before chasing a multitude of possible diagnoses. An athlete with sudden onset knee pain requires different attention than one who has ongoing issues with knee osteoarthritis that has been aggravated by their sport participation.

Because several co-morbidities are more common even in the apparently healthy aging athlete those attending to acute emergencies and injuries should ask the athlete or those with them about any known pre-existing conditions that could manifest as or impact the athlete's current state. An athlete who has had a previous cardiovascular event such as a stroke or MI could be at risk for another event or may be on a cardiovascular medication which could blunt their heart rate. Senior athletes with diabetes should have their blood sugar tested if abnormal symptoms present. Neurological conditions such as Parkinson's disease or epilepsy may be manifest due to a missed medication dose or a change in medication metabolism due to sport competition. Cancer is an underlying diagnoses in many older adults. Some adults may be participating who are being actively treated for cancer. These athletes may be immunocompromised and may be at an increased risk for tissue injury due to active treatment. As discussed earlier in this chapter, monitoring blood pressure along with all vital signs is an important first step when evaluating a senior athlete with non-specific symptoms as variations in vitals may not be outwardly obvious and relate to a variety of possible conditions. When assessing an athlete who has fallen or even suffered mild trauma always consider the possibility of a fracture. Athletes may not be aware of their low bone density and may discount the minimal force needed for a fracture.

Always ask for a medication list when providing care to an older adult. It is not unusual for senior athletes to have a longer list of prescription medication. Medication review may assist in determining the cause or appropriate treatment of symptoms. Further, determining if the medication was taken as recommended is critical information. Medication mismanagement can often create a medical emergency on the playing field. In light of sport competitions these athletes may miss doses due to travel, anxiety or a change in routine prior to competition. This may manifest in low blood sugar, hypertension, thyroid dysfunction and a multitude of other problems treated with prescription medication.

Physical Screening. Ideally, aging athletes over that age of 40 will be screened in advance of competitive sport training with a 12-lead electrocardiogram[82] as well as stress testing if cardiovascular risk factors are present.[82,83] However, pre-participation screening is often overlooked.

Physically screening the aging athlete can be challenging as their physical function may be well above that of the typical community dweller. It is important to remember, however, that their expectations for physical activity are also much higher. Thus, the athlete who surpasses the balance typical of an older adult in a clinical setting may still be lacking the high level balance needed for their sport and even day-to-day activities. To address this, the Senior Athlete Fitness Exam (SAFE)[84] was developed with norms from National Senior Games athletes. This is a short, 15-minute screening tool to address cardiovascular risks,[12] mobility,[85,86] strength,[13,14] flexibility[15,87] and balance.[11] A SAFE form is found in Figure 1. The SAFE is commonly used at both state and national Senior Games competition by physical therapists and other health care professionals. It provides the tester with the ability to identify risk factors in each category tested and assists the athlete in determining how their training or competition preparation may need to change.

Conclusion

With an ever growing population of older adults and increased rates of sport participation, the emergency medical responder will need to be prepared to address the unique needs of senior athletes. Staying alert to potential health and injury risks and the unique trends with this population will assist with a more effective and efficient medical response.

Figure 1. Senior Athlete Fitness Exam (SAFE) Form

National Senior Games Association

UNIVERSITY OF SOUTH DAKOTA SCHOOL OF HEALTH SCIENCES

Senior Athlete Fitness Exam (SAFE)				Needs ☹ Improvement	Normal ☺	Goal
CARDIOVASCULAR						
Blood Pressure	mmHg					<120/<80 mm Hg
Oxygen Saturation	%					≥95
Heart Rate	beats/min					60-100 bpm
Waist Circumference	cm					♀ ≤ 35″ ♂ ≤ 40″
Waist to Hip Ratio						♀ ≤ .8 ♂ ≤ .9
STRENGTH **(dominant hand)**						
Grip Strength **Kg**						See chart
Chair Stand	sec					<9 seconds
FLEXIBILITY						
Shoulder (degrees)	R	L				170-180 degrees
Ankle (degrees)	R	L				10-20 degrees <5 indicates fall risk
Hip (degrees)	R	L				0 degrees
Posture (needs pillow to achieve neutral supine)	Circle yes if pillow is needed.			Yes	No	No
BALANCE All trials measures in seconds up to 30 seconds.						
Single leg eyes open Score is the BEST of 3 trials						30 seconds indicates increased fall risk in community dwelling older adults
Single leg eyes closed Score is the BEST of 3 trials						>5 sec indicates increased fall risk in senior athletes
Single leg on foam eyes open Score is the BEST of 3 trials						>15 sec indicates increased fall risk in senior athletes
Usual Gait Speed	Meters/second					1.2m/s
Fast Gait Speed	Meters/second					>1.7 m/s

Contact Becca Jordre, Becca.Jordre@usd.edu prior to conducting SAFE screening for detailed norms and instructions.

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Gender Differences in Sports Medicine

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Learning Goals:

Upon completion of this section, the learner will:

1. Understand the role that growth/development of the pre-adolescent athlete leads to sex specific differences in mortality rates, participation rates and injury patterns.
2. Understand the specific differences in the adolescent athlete as they relate to maturation patterns, mortality rates, participation rates and specific musculoskeletal, neurological and environment injury patterns.
3. Understand the role that aging plays in gender specificity as it relates to cardio/cerebral vascular disease and osteoarthritis.

Objectives:

1. Compare the injury patterns between 13 year old boy and girl soccer players.
2. Analyze the differences in concussion incidence between boys and girls.

Introduction

In his #1 best seller, *Men Are From Mars, Women Are From Venus,* psychotherapist John Gray outlined gender difference, as he saw them, in interpersonal relationships between the sexes. However, a dearth of information exists in the literature when it comes to gender specific treatment guidelines for the athletic population. The pages that follow are aimed at giving you information as it relates to three broad categories of athletes and some of the published information when it comes to treatment recommendations.

Prepubescent Athlete

Mortality Rates

From the time of conception, differences are found between males and females in the human species. These differences can be found in mortality and growth rates as well as the susceptibility to specific diseases. At birth males outnumber females, are larger in size and have a higher incidence of disease leading to a higher mortality rate.[1]

The birth rate worldwide is 1.05 male births to every female born. These numbers mirror those found at time of conception with males outnumbering females by a small 0.5% difference. From the time of early fetal development, the number of abnormal embryos is male biased leading to

an early rise in male mortality. From weeks 10 through 15, this trend reverses. By 20 weeks, this levels off with a trend toward higher male mortality. Overall, mortality rates prior to birth are higher for the female embryo/fetus.[1,2,3]

Once the infant child reaches 1 year of age, a dramatic shift has started to occur with a mortality rate of 1.2 for males. This is due to males being more likely to experience various complications at birth and other developmental conditions. This "male disadvantage" extends forward from infancy throughout the life span.[1, 4, 5, 6, 7, 8]

Sexual development

The sexual development of the embryo is determined at the time of conception with the fertilized egg containing either a XX or XY chromosomal pattern. During the initial 6 week period of development, the embryo is phenotypically indifferent with no anatomic or metabolic distinction as to its sex. At around the 7th week, the male testis begin to form with the synthesis of testosterone taking place by the 9th week. The fetus can be identified as male by the 13th week of gestation.[1, 9, 10]

In females, ovarian development begins at approximately the 11th week of gestation. Without the influence of testosterone-derived hormones, the primitive germ cells develop into the internal and external female genitalia beginning around the 13th week of development and continuing until birth.[1, 11]

Growth

At the time of birth, males trend towards being heavier and longer in length due to increased growth rates in utero.[1, 12] Soon after birth, this trend disappears with both sexes exhibiting rapid growth in the first year of life. This is followed by comparable growth rates through the prepubescent period. The growth rate increases once again at puberty from the contributions of the sex hormones estrogen and testosterone, to its highest annual rate of 8.3 cm in females and 9.5 cm in males.[13] These changes in growth rate are associated with increased growth hormone secretion in both females and males.[14] The last growth spurt during puberty typically begins earlier for females (between 10 -11 years old), and ceases at an average age of 16. Males begin their growth spurt roughly 2 years after females, around 12.5 years old, with final epiphyseal growth fusion at an average age of 18. This final action of bone growth and fusion is regulated by the sex hormones, in particular estrogen.[15]

These periods of rapid growth are most often associated with changes in mass and length in the skeletal system. At birth, the epiphyses of long bones is highly cartilaginous. As a child matures, an area of cartilage remains between the epiphysis and shaft of the bone, known as the epiphyseal plate, and is the region in which bones continue to lengthen. As puberty ends, the

growth occurring between shaft and epiphysis (cartilaginous zone) stops. The epiphyseal plate changes over time is sex and age-specific, with females typically reaching complete ossification at a younger age.[15, 16] Estimated ages of fusion for the long bones of the extremities are outlined in Table 1.

Table 1. Estimated ages of fusion for the long bones of the extremities

Bone	Estimated Age of Fusion	
	Proximal/Medial end	**Distal/Lateral end**
Humerus	10 - 15 years	9 - 15 years
Radius	14 - 19 years	16 - 22 years
Femur	15.5 - 19.5 years	14.5 - 22 years
Tibia	15.5 - 22 years	14.5 - 19.5 years
Clavicle	19 - 30 years	19 - 20 years

Forensics 101: Epiphyseal Fusion. Skeleton Keys Web Site. 2011. https://jenjdanna.com/blog/2011/12/13/forensics-101-epiphyseal-fusion.html. Published December 13, 2011. Accessed December 9, 2017.

Participation Rates

Data on youth sports participation is sparse in comparison to that of the high school and collegiate athlete. In a 2016 study done by the Physical Activity Council, it was found that 62% of Generation Z (those born in the year 2000 or later) ages 6 through 14 played an outdoor sport, and 57% played a team sport.[17] Another study by the Women's Sports Foundation found an 84% participation in an organized or team sport for youth athletes.[18] The passage of Title IX of the Education Amendments of 1972 has led to more opportunities nationwide for female athletes.[19] In 2008, the National Council of Youth Sports published data with a 10 year history of participation of youth (ages 6 through 18) in organized sporting activities. The study showed little change in overall participation rates over that period of time with boys making up 66% of those participating in youth sports. When looking at the prepubescent athletes, the gender gap is equivocal with boys making up 64% of the participants age 6 and under and 70 % of those 10 through 12 years of age. The study did show that girls were entering into sports at an earlier age and that participation at the high school level for female athletes had increased over that 10 year period of time.[20] In a retrospective study of clinical data of injured pediatric athletes by Stacciolini et al. in 2008, it was found that each boy in the study participated in an average of 2.5 sports per year with each girl averaging 2.2 per year.[21]

Injury Patterns

In an examination of injury data for the pediatric athlete (age 6 to 18), a pattern emerges as it relates to gender differences. Boys tend to participate in more team and contact/collision

sports with a higher risk of traumatic versus overuse injury.[21] These injuries are more often seen to occur to the head, upper extremities and chest regions with a higher percent of fractures overall when compared to female athletes.[22] The highest risk sport for males is football with soccer producing the greatest number of injuries for the female athlete.[23] In studies of sex comparable sports, injury patterns and locations also differ. In soccer and basketball, girls are more likely to sustain ligament tears, especially at the knee, while boys are more likely to present with fractures.[21, 24]

Adolescence

Adolescence is a time of developmental transition, in which the start of puberty marks the beginning of adolescence. Currently, the onset of puberty is happening earlier compared to years prior. With the onset on puberty comes an adolescent growth spurt, changes in organs directly related to reproduction and the development of secondary sex characteristics. The Tanner scale is often used to stage the progression of development from prepubescence through adolescence.[25]

The onset of puberty begins earlier in females beginning around 10 years of age marked by the development of breast buds. The onset of the first menstrual cycle occurs at a mean age of 12. In males, the beginning of puberty is marked by testicular enlargement at a mean age of 12.[26, 27]

Accelerated growth during puberty occurs in both sexes with males reaching their peak growth spurt at a later age, with it lasting 2-3 years longer compared to females, leading to a greater average height and weight.[26, 28, 29] The adolescent growth spurt ends around 18 years of age for females with the males maturing at around 21. Prior to puberty, the male and female body look very similar. During the adolescent growth period, males develop greater muscle mass and strength, especially in upper body musculature, as compared to females.[30,31,32] In females, there is a significant increase in body fat with distribution more readily in the areas of the hips and thighs, as opposed to the abdomen in males. This increase leads to an average percent body fat of 20-30% in female and 10-15% in males at early adulthood.[31, 32, 33] As mentioned earlier, males tend to be taller than females which is due to greater elongation of long bones. One other skeletal difference is the widening of the female pelvis, creating a larger pelvic outlet needed for the process of childbirth.[34]

These changes seen during development are driven by hormones, specifically estrogen and testosterone. Both hormones are available in males and females in differing concentrations. Hormone levels are similar between the sexes during the pre-pubescent period. At the time of puberty, estrogen levels rise in both sexes leading to the physical growth changes associated with adolescence. During this same period, girls experience a minor rise in testosterone levels while boys see a significant surge leading to the characteristic virilisation associated with males.[35,36] Growth hormone levels are influenced by sleep deprivation; however, younger individuals tend to be less affected.[37] Following puberty and prior to around age 50, women

exhibit a fall in estrogen levels, linked to menopause, with levels being relatively equal in both sexes.[38] Testosterone levels remain consistent throughout adulthood in males with a decline starting in the seventh decade of life.[39]

Mortality rates

As with the pre-pubescent athlete, male mortality rates far outpace those of females, often times more than twice the number, as males tend to experience greater rates of homicide, suicide, and unintentional injury.[40] Unintentional injury is the leading cause of death for both sexes during the adolescent period and includes motor vehicle crashes and drug overdoses.

According to data from the National Center for Catastrophic Injury Research[41] during a 33-year period (1982-2015), 2,372 catastrophic sport-related injuries/illnesses were reported at the high school and college levels. The majority of these injuries were not fatal (60%), were from a direct mechanism of injury (66%), and occurred more often among high school participants (80%). When evaluating those injuries that were fatal and related to a direct mechanism of injury, there was no significant difference in the number reported between high school and collegiate athletes.

The total number of fatalities for high school athletes during that time period was 721 (male 666, female 55). For male sports, football had the highest number of fatalities at 354 with basketball reporting 118. For female athletes, the most deadly sports were cheerleading and cross country with 9 deaths each followed by soccer with 7 deaths.

When examining cause of death in both the secondary and collegiate athlete, cardiovascular issues were the leading cause of fatalities (arrest, arrhythmia, myopathy, congenital defect) followed by fractures and traumatic brain injury.

Participation Rates

Yearly participation estimates for high school athletes for 2014/15 included over 7.5 million athletes (over 4.5 million males and 3 million females) according to the National Federation of State High School Associations participation reports.[41] Yearly participation estimates for collegiate level athletes over that same time period as reported by the NCAA sports were nearly 500,000 athletes (over 270,000 males and 200,000 females). There were also over 3,500 males competing in non-championship sports (archery, badminton, bowling, equestrian, rowing, rugby, sailing, and squash) and over 3,000 females who competed in emerging sports (archery, badminton, equestrian, rugby, sand volleyball, squash, synchronized swimming, and team handball).

Injury Patterns

As outlined earlier, males participate more often in high risk sports such as football and wrestling; thus, males exhibit higher traumatic injury rates. When looking at injury data which takes into account athletic exposures, males have a higher incidence of injury at 0.45 severe injuries per 1000 athletic exposures as compared to 0.26 in female athletes. However, when comparing sex-comparable sports, the reverse is true with female athletes showing 0.29 injuries per 1000 athletic exposures and males 0.23.[23] Injuries in both sexes occurred most often in competition and involved fractures and ligament injuries.

The opposite patterns are found when examining overuse injury data. Females are at a much higher risk of developing overuse injury, especially when it comes to patellofemoral pain syndrome and stress fractures.[42,43] Just as in males who sustain more traumatic injury due to the type of sports in which they typically participate, the same is true with female athletes and overuse injury. Girls tend to show a greater participation rate in track and field, dance, and gymnastics - all of which show higher overuse verses traumatic injury rates.[24]

Concussion

When examining the data on prevalence of concussion in the adolescent athlete, it is reported that males have a higher overall rate of concussion, again related to their greater participation numbers and propensity to participate in contact/collision sports.[44] However, when looking at sex comparable sports, girls are more than twice as likely to sustain a concussion as boys with the most common mechanism of injury being player to ground or player to equipment contact (as opposed to player to player contact for males).[45] Girls are also more likely to sustain a recurrent concussion, have more symptoms, require more interventions, and take longer to recover.[46] In general, females are more likely to report their concussion[47] and follow return to play guidelines.[48] In high school and collegiate athletics in the U.S., the highest rates of concussion for males occur in football and soccer with female athletes being concussed most often in soccer and basketball.[45, 46]

Exertional Heat Injury

Exertional heat injury (EHI) is a leading cause of death among athletes, following closely behind injury to the head/spine and fatal cardiovascular events. When heat stroke does occur, it has been reported to result in mortality 10% of the time.[49] It is reported that more than 9,000 high school athletes are treated for EHI annually, most often during the month of August, which typically marks the beginning of the fall sports season. It is at this time that athletes have yet to adapt to exercising in the heat, thus making them more vulnerable to injury.[50] The bulk of EHI deaths (sports-related) in U.S. adolescents occurred during varsity football, wrestling, and cross-country/track- leading to a higher overall rate in male athletes.[51] In a report by Kerr et al.,

boys accounted for 87.7% of all EHI events. When excluding football, boys made up 50.9% of EHI events. Further, participating in gender-comparable athletic events resulted in proportional EHI occurrences among all injuries/events for girls versus boys.[52]

Adolescents are believed to be at an elevated risk for EHI compared to older age groups, as adolescents are more likely to participate in strenuous exercise during warmer months.[53] Even though the study above showed no significant gender specific difference in EHI, studies on tolerance have shown that women were 3.7 times more likely to be heat intolerant when compared to men. Compared to men in the study, women had significantly higher body fat percentage, and lower body surface area, waist circumference, and VO_{2max}. When assessing all participants, the heat intolerant participants had lower VO_{2max} and higher body fat percentage than those who were classified as heat tolerant. However, when VO_{2max} and body fat percentage were entered into regression equations to predict heat tolerance, sex became nonsignificant.[54]

Asthma

It is estimated that over 7.8% of the U.S. population currently suffers from asthma with 25% of those being children and adolescents.[55] In the pre-pubescent athlete, asthma shows a higher prevalence in males with the reversal being true during adolescence when females are more at risk. After puberty, asthma prevalence is remarkably uniform across both genders.[56,57] Adolescent females are at an increased likelihood to have more severe symptoms,[58] require more medication[59] and emergency room visits,[60] and have a higher incidence of relapse.[61]

When evaluating exercise induced asthma (EIA) rates in athletes, certain trends emerge. Endurance athletes, those athletes exercising in cold weather, and those involved in indoor sports such as swimming show higher rates of symptoms exacerbation.[62-65] 25% of US Olympic winter athletes in 1998 were affected by EIA, in which cross-country skiing reported the highest incidence (50%), with women being slightly more affected.[66] Competitive swimmers had prevalence rates approaching 50%, while distance track and field athletes were at 17%.[65] Some have proposed these increased rates are due to the inhalation of cold, dry air in the case of cold weather activities, and in the case of swimming from the presence of chemical gases used to treat the water at those venues.[65]

Musculoskeletal

As mentioned earlier, there were approximately 7,807,047 high school athletes and an additional 482,533 collegiate athletes who participated in sports for the 2014-15 academic year.[41] When assessing overall injury data, musculoskeletal injury makes up a bulk of the data reported by these athletes.[67] There were an estimated 1.4 million athletic injuries during the 2015-16 academic year with the majority of those injuries for males occurring in football, with

96% having at least one day lost from practice/competition. These athlete were most often from the senior class with the highest percentage of injury occurring to the head/face with sprains/strains of the knee ranking second in the rate of occurrence.[67] Soccer was the most injurious for female athletes with a similar percentage of lost days from practice/competition and site/types of injury reported. As opposed to males, female freshman comprised the greatest percentage of injured athletes.[67]

When assessing sex-comparable sports, gender differences can be found as they related to musculoskeletal injury. In soccer, basketball and softball/baseball, females are injured more often. The head/neck area remains the most common region of injury for both genders with the knee ranking second. Also ranking high for female athletes is injury to the ankle, and for males injury to the hip/upper thigh. Sprain/strains were the most commonly diagnosed injury. Mechanism of injury for males was most often contact with another player, and for females rotation on a planted foot and contact with the ball. Injury most often occurred during competition for both groups.[67]

When examining basketball, injury to the head/face, knee, and ankle ranked high for both genders with head/facial injury most common for females and injury to the ankle highest for males. Sprains/strains were again the most common diagnosis, with injury to the ankle most common for both sexes and a higher incidence of knee injury in females. A common mechanism of injury involving contact with another player ranked highest for both groups with injury occurring most often during general play for females and during rebounding for males.[67]

Softball/baseball injury data closely mirrors that of the two prior sports with females being injured more often with a similar injury pattern involving the head/face and the knee as well as the ankle. For males, the elbow/arm ranked ahead of the head/face followed by the shoulder as the most commonly injured body region. Sprains/strains were the most common diagnosis for both sexes with the ankle ranking highest for females and the arm/elbow for males. The mechanism of injury most associated with these diagnoses in females was contact with bases and for males it was the act of pitching.[67]

In examination of the above mentioned injury data, trends can be found. Injury to the head/face ranked number one in all three sex-comparable sports and has been covered previously in the concussion section. When assessing the remaining injury patterns, a trend can be seen in the lower extremity (injury to the knee and ankle) and upper extremity (injury to the elbow and shoulder). A more thorough assessment of the regions, their injury patterns, and the associated gender differences will be discussed in the next section.

Knee

When assessing data on injury to the knee, it is often divided into traumatic (ligament/meniscal injuries, fractures, dislocations) and non-traumatic (patellofemoral syndrome and

osteoarthritis). Much has been written on injury to the anterior cruciate ligament (ACL) including gender-specific differences. Females are between 2 and 8 times greater risk of tearing their ACL as compared to their male counterparts.[68-71] This is true for the high school and collegiate athlete with similar injury rates for males and females at the professional level.[72-73] Females are more likely to tear their contralateral ACL after ipsilateral reconstruction[74,75] and to have associated collateral ligament injury.[76, 77] Females are also less likely to undergo ACL reconstruction[78] with a decreased rate of return to their prior level of sport.[79]

The hypothesized reasons behind this increased rate of ACL injury are both anatomical and neuromuscular. From an anatomical perspective, females exhibit an increased posterior tibial slope[80, 81] and a smaller and weaker native ligament.[82, 83] The neuromuscular data suggests greater peak knee abduction angles with a quadriceps dominant landing pattern as well as poor trunk control.[82-89]

When looking at isolated meniscal tears, males are much more likely to sustain this type of injury, especially to the medial meniscus with an increased incidence as they age. Studies show a 3 to 4 times greater risk of tears in those under 40 years of age.[90-93]

Acute patellar dislocation in the adolescent population is more likely to occur in the female athlete. One study suggests that females in this age group are 33% more likely to dislocate as compared to their male counter parts, especially if they have a prior history of subluxation and/or dislocation.[94] Reasons for this may be increased prevalence of hypermobility, increased femoral torsion, or greater extensor mechanism misalignment, i.e. greater Q angle.[95]

The non-traumatic condition of patellofemoral pain syndrome has mixed results when looking at the gender specific rates of occurrence, with a leaning towards a greater prevalence in the female athlete.[96-102] When examining the likely contributors, there is equally mixed information particularly pertaining to Q angles, hypermobility, decreased strength, and decreased neuromuscular control as they relate to females.[103-113]

Ankle

As mentioned earlier, the ankle is vulnerable to injury, especially in the sport of basketball. When looking at the data on injury patterns in the adolescent athlete, the rate of injury is 3.1 per 10,000 athletic exposures.[114,115] In the overall population, women are more likely to suffer an ankle injury.[116] However, in the adolescent athletic population, males exhibit a higher rate of injury,[117,118] have more residual symptoms following injury,[119] and have a higher rate of medial and high ankle sprains.[120] Females have a higher incidence of grade I injury with grade II and III injury rates being similar for both sexes.[121] Males tend to injure their ankle most often during competition whereas females sustain ankle sprains more often during practice.[122] Females have an increased risk of subsequent ankle sprains as they exhibit greater rates of ongoing

ankle instability.[123] Like ankle sprains, ankle fractures are more likely to occur in the adolescent male and to be of a more complex nature than those of their female counterparts.[124]

Shoulder/Elbow

The majority of shoulder and elbow injuries in the adolescent athlete occur during softball/baseball and are a result of the act of throwing. When looking at the gender differences as they relate to the throwing motion, males tend to throw with greater velocity, distance, and accuracy.[125] The is due in large part to males being taller, with longer lever arms, and have a larger mass both of which lead to increased force delivery to the ball. This ability to develop great amounts of force coupled with increased participation rates in throwing sports leads to a higher number of injuries to the shoulder/elbow in males.

In the general population, females report a higher incidence of shoulder pain as well as concurrent cervicalgia.[126] In the athletic population, high school males are more likely to injure the shoulder and elbow, with no appreciable difference in injury rates for the collegiate athlete.[127-130] When examining shoulder data unrelated to throwing, it is seen that males suffer from higher rates of first time and recurrent shoulder dislocation,[131,132] fractures about the shoulder,[133-135] and superior labrum, anterior to posterior (SLAP) tears.[136] Females on the other hand are more likely to exhibit multidirectional instability,[137,138] a propensity towards adhesive capsulitis,[139] and myofascial pain syndrome.[140]

Injuries about the elbow in the adolescent athletic population show greater rates in the male population. These conditions include injury to the ulnar collateral ligament and ulnar neuropathies,[141] valgus extension overload,[142] and olecranon bursitis.[143] No gender differences were observed in the incidence of both medial and lateral epicondylitis.[144,145]

Masters Athlete

The masters athlete is often defined as an athlete who is older than 35 years of age who either trains for or continues to take part in athletic competition.[146] Currently, 15 % of the 300 million person population of the United States is 65 years or older, with this percentage increasing each year.[147] Within this group, there has been an increased emphasis on staying healthy and living an active life style. In a Gallup compilation of polls between 2003 and 2005, 32% of those 65 years and older took part in vigorous exercise. This was defined as "vigorous sports or physical activities for at least 20 minutes that cause large increases in breathing or heart rate" or in "moderate sports or recreational activities that cause slight increases in breathing or heart rate, such as walking, gardening, or other similar activities."[148] In addition, 23% of males and 15% of females in this group continue to remain in the work force.[149] Within the realm of sports, there has been an explosion in the number of older adults who are continuing to compete. In a period of just under 25 years, the National Senior Games has seen a participation

rate more than quadruple to over 10,000 participants[150] with a similar trend seen in the New York City marathon where participation rates for those 50 years and older increased 119% from 1,983 to 1,999[151,152] with 2,398 participants over the age of 60 finishing the event in 2017.[151,152]

Mortality Rates

The average life expectancy for those living in the United States in the year 2014 was 84.3 years of age with women out living men by an average of 2.5 years. 21.7% of those who were noninstitutionalized were classified with fair to poor health, with the leading causes of death being heart disease, cancer and chronic lower respiratory disease.[153]

Injury Patterns

When assessing the overall concerns for injury in the masters athlete, pre-participation physical examination plays an important role with subsequent yearly health assessments. Special attention should be given to those exams focusing on cardiac disease, diabetes, and hypertension.[154] The American Heart Association recommends that a 12-lead electrocardiogram (ECG) should be part of a routine evaluation for all senior athletes, focusing on assessing exertional symptom. In addition, a physical examination emphasizing the cardiovascular system should be completed, with special attention given to cardiovascular risk factors including hypertension, hyperlipidemia, and diabetes.

Cardiovascular

Gender specific anatomical and physiological differences exist in the cardiovascular system. Women tend to have smaller hearts with lower left ventricular mass, both of which are established during puberty and related to differences in body size.[155, 156] This difference in size means less volume expelled from the heart with each beat. The smaller female heart, pumping less blood with each beat, needs to beat at a faster rate to match the larger male heart's output. These factors have been shown to influence the training response and contribute to lower maximal aerobic power in women. However, there is no difference in left ventral wall thickness (when accounting for body size); therefore, no difference in the physiological hypertrophic effect on the heart due to exercise.[157] During the aging process, women better preserve myocardial mass versus men.[158] Additionally, with smaller heart size comes smaller coronary arteries - leading to poorer outcomes following coronary artery bypass surgery.[159,160,161]

Additional physiological differences also exist between the sexes. In general, women have a preponderance of vagal parasympathetic responsiveness, which is regulated through vagal nerve input at the sinoatrial (SA) node.[162, 163,164] They are therefore able to better adapt to

stressors placed on the cardiovascular system when compared to their male counterparts.[165,166] Women are more predisposed to ectopic beats and arrhythmias due to estrogen based hormonal shifts. During the luteal phase of the menstrual cycle, women may tend to report increased occurrence of arrhythmias and premature beats.[167]

As outlined earlier, the leading cause of death in the senior athlete is coronary artery disease (CAD).[153] On average, for men this occurs by 45 years of age and for women by age 65. Although there is a 20 year difference, the facts can be misleading. Once women develop overt CAD, they have a more unfavorable prognosis compared to men. Moreover, 64% of women (50% of men) who died suddenly from CAD were previously asymptomatic for this disease. At the time women are diagnosed, the disease tends to be more advanced. Although there has been a decline in heart disease mortality at younger ages for men, this trend has not been seen in the female population due in part due to greater delays from MI symptom onset to diagnosis, and less aggressive treatment strategies.[168]

When evaluating the top risk factors associated with CAD, many are comparable for both genders. Smoking, hypertension, and hypercholesterolemia have a similar gender-specific association as they relate to CAD.[168] However, diabetes is a far more crucial coronary risk factor for women. Hypertension and diabetes will be addressed later in this section.

Men and women may also present with differing signs and symptoms when it comes to acute myocardial infarction (MI). Although each MI may present differently some trends have been identified.[168]

*Symptoms of a heart attack in males:[168]

- Chest pain, described as an "an elephant" sitting on one's chest, a squeezing sensation (can be intermittent or constant/intense)
- Upper body pain or discomfort (arms, left shoulder, back, neck, jaw, or stomach)
- Increased or irregular heart rate
- Stomach discomfort that feels like indigestion
- Shortness of breath, even at a resting state
- Dizziness or feeling like you're going to pass out
- Breaking out in a cold sweat

*Symptoms of heart attack in females:[168]

- Unusual fatigue lasting for several days or sudden severe fatigue
- Lightheadedness
- Shortness of breath
- Sleep disturbances
- Anxiety
- Indigestion or gas-like pain
- Upper back, shoulder, or throat pain
- Jaw pain or pain that spreads up to your jaw
- Pressure or pain in the center of the chest, which may spread to the arm

*Story, C. Symptoms of a Heart Attack. Healthline website. Retrieved from https://www.healthline.com/health/heart-disease/heart-attack-symptoms. Accessed May 29, 2018.

For cardiac related deaths in the masters athlete, a majority of the literature comes from the endurance community. In a study by Webner et al., surveys were sent to 400 US marathon race directors. Surveys from 88 (22%) marathons run were returned from 1976 to 2009 from over 1.7 million participants. The risks for sudden cardiac arrest (SCA) and sudden cardiac death were calculated, which were reported as 1 in 57,002 and 1 in 171,005, respectively. Men represented a greater number of those affected by SCA at 93%, with coronary artery disease being the primary cause of death.[169] Hart examined data on long distance running and found that among the 10.9 million registered race participants from 2001 to 2010, 40 cardiac arrests occurred in marathons and 19 in half marathons.[170] In a 2016 systemic review, Waite et al. reaffirmed prior studies showing that a proportion of those suffering SCD were male (ranged from 57.1% to 100%) with an age range from 37 to 48 years of age.[171] The potential explanations for lower incidence rates in women may be due to lower participation rates in marathons, as well as women tend to develop atherosclerosis about 10 years later than men.[172] There remains debate as to whether the predominant mechanism for SCD in these studies was due to plaque rupture leading to a thromboembolic event or supply/demand mismatch in the context of exercise intensity.[172]

Hypertension

Hypertension is relatively common in the US among men and women, which is defined as a measured systolic blood pressure of 140 mmHg or more or diastolic blood pressure of 90

mmHg or more, or includes current use of blood pressure medication. Hypertension is less prevalent among women compared to men in middle adulthood, with a reversal later life. By the age of 70, 79% of women and 63% of men have been diagnosed with high blood pressure. For those Americans of African descent in the same age demographic, those percentages reach 83% for both men and women.[173]

Hypertension functions as an independent risk factor for cardiovascular disease (CVD) and cerebral vascular accident (CVA) incidence and mortality in men and women.[174, 175] In a study evaluating risk for CVD in women, a 10 mmHg higher level of systolic pressure was linked to a 30% increased risk of CVD. In men, this same 10 mmHg higher level led to only a 14% increased risk of CVD.[176]

When comparing cardiovascular disease with cerebrovascular disease across the life span, a true gender difference exists. Men tend to have a higher incidence of cardiovascular associated coronary artery disease, specifically atherosclerosis, whereas women have an increased incidence of cerebrovascular disease associated with stroke.[1]

It has been estimated that one in five women (one in six men) will have a stroke in her lifetime. The increase in risk is thought to be due to women living longer, risk associated with pregnancy and delivery, and from oral contraception.[177] When women do experience a stroke, they are generally more severe with a less likely outcome for independent living.[178] Risk factors associated with stroke are hypertension, hyperlipidemia, diabetes, and obesity. Control of these factors is the most effective treatment for stroke prevention. Standard goal values have been set for each of these factors (Table 2).[179]

Table 2. Standardized goals

Risk Factor	Assessment Tool	Goal Value
Hypertension	Resting systolic blood pressure	≤ 140 mmHg
Diabetes	Resting blood sugar level	108 mg/dL
Hyperlipidemia	Resting lipoprotein profile	< 160 mg/dL
Obesity	Body mass index	18.5-24.9

In the past, women have been less frequently treated according to these standards.[180, 181] With treatment of hypertension with antihypertensive medication, both men and women have a similar reductions in stroke risk, with one study reporting a 38% reduction in stroke for women and a 34% reduction for men.[182]

Women tend be at greater stroke risk due to atrial fibrillation.[184, 185] In a study by Renfrew and Paisley, 30% of women suffering from atrial fibrillation had a stroke, while only 17% of men experienced the same result.[183] This is thought to be due to under treatment of these women with proper medications prior to their stroke.[184, 185] When assessing women who were not on

anticoagulation medication for their arrhythmia, women were at a 1.6 times higher risk of stroke than their male counterparts.[186]

When assessing extra- and intracranial vascular disease, men tend to show a greater prevalence of carotid and cerebral artery stenosis.[187, 188] Carotid stenosis treatment recommendations differ between sexes. Men had the maximum surgical benefit when over 50% of the artery was blocked, with a significant reduction in stroke risk. Whereas women showed a reduction only when the blockage had reached greater that 70%.[189] In regards to carotid artery surgery, females demonstrated 50% higher rates of perioperative stroke and death.[190]

Gender differences have been found with assessment, treatment, and outcome following an acute stroke. Stroke evaluation tends to be less comprehensive in women,[191,192] women are less likely to be given tissue plasminogen activator (tPA),[193] women are less likely to accept thrombolytic therapy,[195] women more often have cardio-embolic strokes (as opposed to lacunar),[191] have a higher likelihood of heritability (primarily maternal),[195] have more episodes of aphasia,[196] and have more disability following stroke[191,197] with a lower rate of return to independence.[198]

Another factor putting women more at increased risk for stroke is the presence of estrogen in their system, either endogenous or exogenous. Endogenous levels increase during pregnancy or during menopause when estradiol levels drop.[199] In addition, exogenous estrogen (oral contraceptives or hormone replacement therapy) has been linked to increased stroke risk.[200, 201]

Hyperlipidemia

The standard pharmacological treatment of hyperlipidemia in recent years has been the use of statins. These drugs have shown promise in reducing stroke risk as well as coronary artery disease in both sexes, but the literature is not as clear regarding its effectiveness for women. This is mainly due to the limited sample size of females utilized in the testing of the effects of these medications. Current evidence supports the use of statins for stroke prevention overall, specifically in males, as well as cardiovascular disease prevention in women. In terms of stroke prevention in females, there is no clear evidence supporting the use of statins.[202]

With exercise comes the increased risk of both cardiovascular and cerebrovascular events. Mittleman et al.[203] reported an overall increased relative risk of myocardial infarction during exercise of 5.9 with Siscovick et al.[204] showing similar results with a five-fold increased risk of sudden cardiac death. Similar results were found for the increased risk of stroke with Mostofsky et al. finding a 2.3 fold increase in risk up to 60 minutes following vigorous activity.[205]

Diabetes

Even though women are at an overall lower risk for developing diabetes, it has been found that when developed it is a more powerful predictor of overall cardiovascular and cerebrovascular disease risk in women than it is in men, with both an increased risk of stroke[206] and an increased risk of coronary artery disease.[207] In a meta-analysis of 37 prospective cohort studies, the risk of fatal coronary artery disease is 50% higher in women with diabetes compared to male diabetics.[208]

Central obesity increases risk of cardiovascular events in both men and women. However, post-menopausal women are at increased risk with a greater number of comorbid risk factors associated with metabolic syndrome compared with aging men.[209]

Osteoarthritis

Osteoarthritis (OA) is the most common cause of musculoskeletal disability in the masters athlete.[210] Men and women exhibit differing pattern as they relate to prevalence, location, and severity. Women are more prone to develop OA in the knee, ankle, and feet whereas men show a greater prevalence in the hip, wrist, and spine.[210, 211] When it comes to OA at the knee, women are more likely to develop the disease sooner in life,[210] have more severe clinical symptoms,[211] have thinner femoral and patellar cartilage,[212] have greater annual cartilage loss,[213] are more likely to have complaints of pain not linked to radiographic OA,[214] and are less likely to undergo surgical interventions.[214] Higher BMI has been found to be an independent predictor of knee OA and its speed of progression, with a stronger effect in women than in men.[215,216] Rehabilitation programs have shown a similar effect in both men and women.[217]

Conclusion

Throughout the life span, athletes exhibit sex specific differences in growth/aging patterns, mortality rate, participation rates, and injury patterns. The better the understanding of these gender specific variabilities, the better the sports medicine provider will be at assessing and treating these specific patient populations.

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Injuries & Emergent Conditions: Athletes in Adaptive Sports

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Learning Goals:

Upon completion of this section, the learner will:

1. Recognize different groupings and sports available to athletes in adaptive sports.
2. Explain the reasoning and process of classification for athletes in adaptive sports.
3. Compare and contrast injury patterns for athletes in adaptive sports to able-bodied athletes.
4. Describe common injury patterns in athletes participating in adaptive sports based on the athlete's type of disability.
5. Discuss measures of prevention for and the appropriate emergency management of the following conditions for an athlete in adaptive sports:
    a. Autonomic Dysreflexia
    b. Seizure
    c. Thermoregulatory condition
    d. Concussion
    e. Behavioral issue
6. Recall sports medicine considerations and issues relating to travel for an athlete in adaptive sports.
7. Identify sports medicine considerations as they relate to the equipment and adaptations used by an athlete in adaptive sports.

Objectives:

1. Explain autonomic dysreflexia in spinal cord injured athletes.
2. Given a physically challenged athlete, propose the athlete's classification level.

Introduction

Sporting events for athletes in adaptive sports have grown over the last 30 years and the Paralympics is currently the second largest sporting event in the world.[1] Currently, a variety of different disability groups compete in adaptive sports. These groups include: athletes with spinal cord injury (or other wheelchair users such as those with diseases with at least 10% loss of lower extremity function such as polio); athletes with cerebral palsy (or other damage to the brain that influences movement and posture such as cerebrovascular accident or cerebral

trauma); athletes with amputation/limb deficiency; athletes with visual impairment; athletes with intellectual disability; and a category known as les autres ("the others") such as those with dwarfism, osteogenesis imperfecta, muscular dystrophy, and other disorders that are not categorized elsewhere.[2,3] In order to ensure fairness in competition, athletes in adaptive sports undergo a classification process in which athletes are classified based on their abilities in order to ensure fairness among classification groups.[2] These classification groups are sport specific.[2,3] A variety of sports exist within adaptive sports and not all sports are open to all disability groups. A list of current Paralympic sports can be found at http://www.teamusa.org/us-paralympics/sports.

Epidemiology of Sports Related Injury

Sports participation is accompanied by an inherent risk of injury. This is no different for athletes in adaptive sports. However, true incidence rates for injury within adaptive sports have proven difficult to determine.[4,5] This is mostly due to a variety of factors that includes variation in sports, variation in disabilities, athletes competing in multiple sports, and variations in research study designs.[4] Generally, there is a popular belief that these individuals are at a greater risk of sports-related injury compared to their able-bodied counterparts. However, most studies have demonstrated that the injury rate for athletes in adaptive sports is similar to able-bodied.[3,6] It is of note though that injury in athletes participating in adaptive sports may present with more significant consequences than that in an able-bodied athlete as injury may lead to not only dysfunction and disability as it relates to sports participation, but also to dysfunction and further disability in activities of daily living and mobility.[6,7]

Sports-related injuries for those competing in adaptive sports are sport and disability specific. Approximately 55% of injuries are acute while 45% are chronic in nature.[4] Summer Paralympic sports more commonly result in sprains and strains while winter Paralympic sports result in more impact related injuries such as contusions, fractures, and concussions.[4] Ambulatory athletes within adaptive sports experience acute injury patterns similar to able-bodied athletes with sprains, strains, contusions, abrasions, and blisters being most common. Due to the nature of their disability, wheelchair athletes are at a greater risk for acute injury in the upper extremity as well as the cervical/thoracic spine compared to the lower extremity.[3,4] Contusions, abrasions, fractures, and dislocations are most common in contact/collision sports. In the 2012 Summer Paralympic games, the sports that produced the highest injury rates were 5-a-side soccer, wheelchair fencing, powerlifting, goalball, wheelchair rugby, and track/field.[4]

Like able-bodied sports, adaptive sports have made variations to rules and equipment to combat some of the most common injury patterns. For instance, sled/sledge hockey athletes typically have a cage that covers their feet to help avoid fractures and 5-a-side soccer requires that athletes verbalize when they are defending a specific athlete in order to avoid collisions that may result in concussion. Additionally, the rules of cycling prevent athletes from securing

a hand to their cycle in order to avoid injury if a crash occurs. As in all sports, rules and equipment are constantly evolving to protect the health and well-being of the athletes and it is important for the emergency medical responder to be aware of these rules and equipment to ensure they meet their purpose.

Specific Emergent Conditions for Athletes in Adaptive Sports

In addition to typical emergent conditions that occur in both able-bodied and those in adaptive sports, athletes in adaptive sports may have special emergent conditions to consider.

Autonomic Dysreflexia

Autonomic Dysreflexia is a condition potentially experienced by individuals with a spinal cord injury above the T6 spinal level.[2,3] In this condition, an external or internal noxious stimulus below the level of spinal cord injury such as an insect sting, injury, wheelchair straps, bladder distension, etc. creates a loss of autonomic nervous system control.[3] This results in vasoconstriction and variability in normal heart rate leading to bradycardia/tachycardia, an inability for heart rate to respond normally to physical activity, and a rapid and dangerous increase in blood pressure. Additionally, in attempt to gain an edge in performance, some athletes with disabilities will intentionally create this noxious stimulus- a condition known as boosting.[2] Although banned by the International Paralympic Committee, boosting may result from self-initiated stimuli such as clamping of their urinary catheter, excessive tightening of straps, twisting &/or sitting on the scrotum, self-inducing a small fracture such as a toe, or use of an external object such as sitting on a tack. Autonomic dysreflexia is a life-threatening condition that has the potential to result in stroke, intracranial hemorrhage, &/or death.

The most common symptom in athletes with autonomic dysreflexia is headache, but diaphoresis above the level of spinal cord injury, piloerection, blurred vision, and/or nausea are all also likely.[2,3]

Like most emergent conditions, prevention and awareness are key in autonomic dysreflexia.[3,8] Educating athletes about the dangers of the condition as well as inspecting for potential noxious stimuli is paramount.[3] Acute management of autonomic dysreflexia involves activating the emergency medical response system, monitoring vital signs, sitting the patient upright to encourage an orthostatic decrease in blood pressure, loosening any tight fitting clothing, searching for and removing the noxious stimulus, and assisting with any prescribed medication for the condition.[3]

Seizures

Seizures are common for those competing in adaptive sports, particularly those with motor dysfunction of cerebral origin such as those with traumatic brain injury, cerebral palsy, and/or

cerebrovascular accident. The seizures may vary in severity from mild (petit mal) to more severe (grand mal) depending on the patient and the individual seizure. Usually in this population, the athlete will be aware of known "triggers" for their seizures. These "triggers" may include dehydration, stress, chaotic environments, hypoglycemia, hyperventilation, electrolyte imbalance, heat, and/or fluorescent lighting.[2,9] Unfortunately, these "triggers" are usually prevalent in the environment(s) surrounding athletic competition.

Signs and symptoms of a seizure may include altered mental status, uncontrolled muscle spasms throughout the body, drooling, convulsions, etc. Although seizures present as a medical emergency in a majority of people, athletes in adaptive sports typically have a long-standing history of the disorder with known origin and known management. Therefore, following an extensive SAMPLE history, it may be up to the discretion of the emergency medical responder to alert further emergency medical personnel or not.[9] Acute management of a seizure for an athlete in adaptive sports should begin by maintaining the safety of the patient. This may include assisting with stability so the athlete does not fall or their wheelchair does not tip over and/or removing any potentially harmful objects that are surrounding the patient. Like any seizure you will need to maintain an open airway as best as possible and document the time the seizure begins and ends. Additionally, for those competing in adaptive sports, you should also do your best to remove or eliminate the "trigger" following the seizure event. This may require cooling the patient, removing them from a particular environment, or helping them eat or drink as needed.[9] However, food and drink should never be given during the seizure and you should exercise caution when assisting with food or drink following the seizure as this may create an airway obstruction if another seizure begins. Finally, assist the athlete with any prescribed anti-seizure medication. Make sure to follow your general rules: right patient, right medication, right route, right dose, and right date. It is recommended that if possible, you continue to monitor the athlete every 2 hours for the 24 hour period following a seizure.[9]

Thermoregulatory Issues

Another potential emergent condition for those competing in adaptive sports is issues related to appropriate and normal thermoregulation. This is particularly true in athletes with spinal cord injuries at the T8 level or higher. This injury creates a dysfunction of the sympathetic nervous system that results in difficulty in internally self-regulating core body temperature.[3] These athletes have altered ability to sweat effectively and have alterations in their bodies' ability to dilate peripheral vasculature in response to rising core body temperature and activity.

Additionally, certain other characteristics related to athletes in adaptive sports may make them prone to thermoregulation issues as well. These characteristics include athletes with decreased overall body surface such as those with amputation which gives them less surface area from which to sweat[2], those athletes that demonstrate dysphagia and thus lose excessive fluid and become dehydrated more quickly, athletes who demonstrate poor motor efficiency such as

those with cerebral palsy[2], athletes who are on medications that induce a diuretic response, and those athletes that need assistance to ingest fluids. Certain sports also put athletes in adaptive sports at greater risk for heat-related problems. These sports include track/field, cycling, equestrian, soccer, and wheelchair tennis.

Thermoregulation is another area in which education and prevention are of the utmost importance.[8] Awareness of environmental conditions, monitoring of hydration availability/status, access to shade, awareness of proper clothing, and type of physical activity all play a role in preventing thermoregulation problems.[9] External sources of cooling such as fans, ice towels, or spray bottles of cool water may assist athletes with external cooling.[9]

Acute management of a heat-related event does not differ from that of able-bodied athletes. Quick notification of the emergency medical system along with rapid cooling are the treatments of choice for a heat stroke related event. However, particular attention to core body temperature is necessary to prevent cooling core body temperature below normal levels.

Other Emergent Conditions

Other emergent conditions are similar for those in adaptive sports compared to the able-bodied population. Management of these conditions does not change. However, athletes in adaptive sports may provide a more extensive medical history when dealing with such issues. It is not uncommon for athletes in adaptive sports to have an extensive cardiac, neurologic, endocrine, and/or integumentary history. A thorough SAMPLE history may be crucial in appropriate management of emergent conditions.

Additionally, athletes in adaptive sports have a higher percentage of allergies that lead to anaphylaxis than able-bodied athletes. Triggers commonly include foods, insect stings, and/or latex. When caring for athletes in adaptive sports it is critical to be aware of these allergies and know if the athlete carries an auto-injector for such anaphylactic events.

Finally, approximately 90% of individuals with spina bifida have hydrocephalus. Most of these individuals have surgically placed shunts to help relieve pressure build-up. However, if a shunt malfunctions, the athlete will experience a headache, blurred vision, nausea/vomiting, altered level of consciousness, or other neurologic signs. This is a medical emergency and warrants activation of the emergency response system.

Other Considerations in the Medical Management of Athletes in Adaptive Sports

Although injury rates and patterns for athletes in adaptive sports are similar to those in able-bodied sports, several other special considerations are needed for the overall medical management of athletes with disabilities.

Skin Considerations

Lacerations, abrasions, blisters, and contusions are common in sports for athletes in adaptive sports.[9] This is especially true for sports that are high speed and have the potential to result in falls or crashes such as track/field and cycling. In managing these skin conditions in those competing in adaptive sports, it is necessary to provide a thorough secondary assessment as the athlete may not have complete sensation to an area of the body and these skin conditions may represent a more extensive injury such as an underlying closed fracture.[9] Additionally, use caution with topical ointments and dressings as the athlete may have an extensive list of allergies and the products may contain an allergen for the athlete. Always use non-latex gloves when working with athletes in adaptive sports.

Pressure ulcers are common in athletes with spinal cord injury.[3] These result from shearing forces and friction along with pressure from prolonged positioning. The sacrum along with the buttocks, hips, and heels are the most common areas for this to occur.[3] This is a disqualifying medical condition for many athletic competitions and due to the athlete's altered sensation they may require assistance in inspecting and monitoring for pressure sores. Again, prevention is the key.[8]

Head, Neck, and Concussion Management

Although there is little evidence to support any altered or different approach to head, neck, and concussion assessment and management in athletes in adaptive sports, the emergency medical responder needs to consider a few special circumstances in this population. First, athletes in adaptive sports may have loss of sensation or cognitive deficits that may interfere with palpatory assessment of tenderness and/or subjective questioning. Additionally, many athletes in adaptive sports have existing neurologic signs, symptoms, and deficits. This creates difficulty in assessing for any new or different neurologic signs and symptoms such as altered extremity sensation, pupillary response, cognitive processing, memory, and balance difficulties as well as symptoms such as headache, fogginess, or visual disturbances. Finally, athletes may have decreased active or passive range of motion of their neck, head, and/or spine that makes full assessment challenging. Although athletes in adaptive sports may have grown accustomed to neurologic phenomenon and "write-off" the potential seriousness of such conditions, it is necessary to take a conservative approach when considering potential head, neck, or concussion related injuries.

Psychosocial/Behavioral Issues

Just as with any emergency situation, behavioral issues may present as an issue that makes a scene permanently or temporarily unsafe. This is no different in athletes within adaptive sports. In addition to their extensive medical histories, these athletes may have extensive psychologic histories related to their medical condition or the mechanism of injury that led to their condition. Post-traumatic stress disorder (PTSD) may be common in those competing in adaptive sports and may lead to difficulties following an acute, traumatic injury or event.

Travel

From a medical standpoint, travelling for those in adaptive sports is more difficult than their able-bodied counterparts. Athletes need to consider all of the equipment, supplies, and medications that they may need during their time away.[9] This can create a cumbersome and exhaustive task for these athletes. Additionally, travelling across time zones can create alterations in sleep/wake schedules, hydration status, nutrition status, and/or adherence to medication regimes.[9] This can lead to issues with athletic performance and/or medical related issues.

Equipment & Athlete Assistance

Another consideration for the medical management of an athlete in adaptive sports compared to an able-bodied athlete is the equipment and surrounding assistance that they have.[2] Athletes may have multiple types of wheelchairs, prosthetic devices, throwing chair(s), etc. that are necessary to compete in their sport or a variety of different sports. This equipment then becomes crucial for both performance as well as medical management. It is necessary for an emergency medical responder who is covering adaptive sports events to be aware of the different types of equipment as well as the management of such equipment. This is necessary in order to ensure that athletes have not made any unsafe adaptations to the equipment as well as understanding how the equipment can either assist or get in the way of appropriate emergent care.

Athletes in adaptive sports may have an extensive social support system around them. These caregivers may assist with everything from carrying equipment to coaching to medical management. In addition to people, service dogs may also provide support to an athlete in adaptive sports. Although they are generally not allowed to help the athlete directly compete, these caregivers and service dogs can provide valuable information and alerts to the emergency medical responder and may be able to provide assistance with emergent care. However, be aware that some service dogs will become protective during emergent situations and may make the scene unsafe for further medical assessment and intervention.

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Performance Enhancement Issues in Athletes

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Learning Goals:

Upon completion of this section, the learner will:

1. Identify four major areas of concern to performance enhancement that can lead to health/medical emergencies.
2. Define and explain the nature of the processes of each of the four performance enhancing areas of concern that can cause health and medical emergencies.
3. Identify common medical emergencies and disorders with specific performance enhancing behaviors and procedures.
4. Recognize possible signs and symptoms of athletes engaging in these behaviors in order to properly identify medical emergencies and/or prevent a medical emergency.

Objectives:

Recognize the signs and symptoms of an athlete engaging in the use of diuretics.

Introduction

As Sports Physical Therapists, there are a variety of performance enhancing issues that we may encounter. Athletes may choose to use an array of legal, illegal and/or banned substances and methods all while unannounced to their healthcare providers. The increasing pressure for athletes to perform at their peak performance may cause some athletes to do whatever it takes and at any cost.

Given the pressure to excel and perform at peak levels, athletes may take any substance or combination thereof, known or unknown, to create improvements in their physical, psychological, and cognitive abilities. As healthcare providers, the consequences of each athlete's decision may lead to emergency situations that we need to be able to identify in order to care for the athlete appropriately in an expedited manner.

Some of the most popular areas of consideration regarding performance enhancement are performance enhancing drugs, blood doping, and gene doping. These three areas will be covered in the following sections of this chapter.

Regulation

For US athletes, there are two major organizations for performance enhancement regulation, the World Anti-Doping Agency (WADA) and U.S. Anti-Doping Agency (USADA). For athletes who are subject to drug testing by their organization for banned substances, WADA has defined prohibited performance enhancing substances**.** As stated by WADA, their purpose since 1999 is to be an "international independent agency composed and funded equally by the sport movement and governments of the world. Its key activities include scientific research, education, development of anti-doping capacities, and monitoring of the World Anti-Doping Code (Code) – the document harmonizing anti-doping policies in all sports and all countries."[1] "The U.S. Anti-Doping Agency (USADA) is the national anti-doping organization (NADO) in the United States for Olympic, Paralympic, Pan American, and Parapan American sport. The organization is charged with managing the anti-doping program, including in-competition and out of competition testing, results management processes, drug reference resources, and athlete education for all United States Olympic Committee (USOC) recognized sport national governing bodies, their athletes, and events. Additionally, USADA contributes to the advancement of clean sport through scientific research and education & outreach initiatives focused on awareness and prevention."[2] Both organizations are in agreement regarding which substances are banned. USADA references WADA's list of banned substances to determine which substances USADA will classify as banned for U.S. athletes. A prohibited substance, as defined by WADA, is if "1) It has the potential to enhance or enhances sport performance 2) It represents an actual or potential health risk to the athlete 3) It violates the spirit of sport."[3]

USADA also educates athletes about dietary supplements and therapeutic exemptions. Therapeutic exemptions are when an athlete may need a medical exemption to take a prohibited substance, for example, insulin for the diabetic athlete. Together, both organizations provide guidance for U.S. sport organizations and athletes regarding banned performance enhancing drugs and methods.

Performance Enhancing Drugs

Commonly abused performance enhancing drugs can include the following:

Anabolic Agents
Human Growth Hormone
Beta2-agonists
Diuretics
Stimulants
Narcotics and Cannaboids
Glucocorticosteroids
Beta Blockers
Insulin

Anabolic steroids, or androgens, include exogenous testosterone and various forms of androgen.[4] Athletes can administer anabolic steroids or androgens orally, injected steroids, topicals, and transdermal patches. Anabolic steroids can improve an athlete's overall physical performance because it has been shown to enhance muscle mass and strength. However, it also has been proven to have detrimental effects such as cardiovascular disease, heart attacks, coronary artery disease, high cholesterol, carcinogenic effects, liver damage, kidney scarring, acne, high blood pressure, left ventricular heart changes, aggression, violence, mania and suicide.

Human Growth Hormone (HGH) or somatotropin can be administered via injection, although it has been marketed via sprays and pills. This is believed to improve an athlete's overall performance by building muscle mass and decreasing adipose tissue. However, the evidence does not strongly support an increase in muscle mass and decrease in adipose tissue in those who naturally produce it on their own. Further, it has also been shown to have hazardous side effects such as muscular and neuromuscular pain, edema, high cholesterol levels, diabetes and cancerous tumors.

Some consider Beta2-adrenergic agonists to be ergogenic. Athletes may administer beta2-agonists via inhalers. Some examples are albuterol, formoterol, and salmeterol. Although there is little to no supportive evidence,[5] some believe that beta2-agonists may increase skeletal muscle, suppress the breakdown of protein, encourage smooth muscle relaxation, and decrease body fat. However, beta2-agonists may contribute to experiencing adverse effects such as dizziness, lightheadedness, fatigue, shortness of breath, reproductive health issues (impotence and decreased sex drive), and cardiovascular side effects. Other side effects may also include tremors, headache, insomnia, anxiety and nervousness.

Diuretics can result in rapid weight loss (because it increases production of urine), and thus applied with the intent of performance enhancement in sports with weight classes or are weight-centered sports such as wrestling, weightlifting, horse racing, gymnastics, cheerleading, cycling and rowing. An example of a diuretic includes caffeine. Diuretics can be taken in pill or liquid form. Side effects of diuretics include dehydration, hypovolemia, hypokalemia, hyperkalemia, and hyponatremia. Diuretics are also an abused and banned substance in sport because they are masking agents and assist in hiding other banned performance enhancing drugs by diluting the urine for urine analysis tests.

Stimulants, or amphetamines, come in many forms and compounds.[6] Some more popular stimulants include "amphetamine, D-methamphetamine, methylphenidate, ephedrine, pseudoephedrine, caffeine, dimethylamylamine, cocaine, fenfluramine, pemoline, selegiline, sibutramine, strychnine, and modafinil."[4] It is important to mention that most, if not all sports, allow athletes to have some level of caffeine. Athletes can administer stimulants in various forms such as liquid, powder, pill, injection, or smoked. Athletic performance gains have been noted to include improving stamina, enhancing anaerobic performance and reaction time, and weight reduction.[4] However, evidence has shown that stimulant use has grown substantially in the past few years, especially in the college athlete population. One popular way that athletes

are now commonly consuming stimulants is through energy drinks. The rise in energy drink consumption for performance could be due to the drinks socially acceptable availability, product marketing, and encouraged use for particular sports. For example, ultra-endurance triathlons provide energy drinks at aide stations for athletes to consume at specific distance markers. Although stimulants may help athletes improve their performance, they too have been shown to contribute to chronic health issues such as dyskinesia, compulsive/repetitive disorders, paranoia, blood vessel necrosis, and nerve damage. Acute side effects include weight loss, increased heart rate and blood pressure, headaches, insomnia, convulsions, hallucinations, paranoia, and death secondary to a ruptured blood vessel, heart attacks, arrhythmias, and heat stroke. Stimulants are detected via a urine sample.

Narcotics and cannaboids can be used by athletes with the intent to reduce anxiety and decrease pain, which may be a form of performance enhancement. There is minimal research investigating performance enhancement from these substances. Athletes can administer narcotics via pill form such as opioid pain killers that are commonly prescribed for injured athletes. Athletes also can administer cannaboids in an edible or smoked, or vaping form. Cannabis' acute physiological side effects may include tachycardia, vasodilation, dry mouth, increased appetite, bronchodilations, and dizziness. Chronic respiratory problems may result from inhalation. Narcotics have been shown to have acute side effects such as constipation, sedation, dizziness, nausea, vomiting, and respiratory depression. Chronic side effects of narcotic use can include addiction, diarrhea, muscle pain, anxiety and irritability. Accessibility and care of sports medicine injuries may have been partly to blame for the rise in narcotic use in athletes; however, a recent awareness of this topic may allow for decreased accessibility. On the other hand, with legalization of marijuana in certain states within the US, we may now see a more socially accepted rise in athletes utilizing cannabis for performance enhancement. Detection of cannabis and narcotics are tested via a urine analysis.

Glucocorticoids such as cortisone, dexamethasone, hydrocortisone, prednisone, and methylprednisone are proposed to enhance performance because of their anti-inflammatory and analgesic effects. However, there is minimal research to support any performance enhancements associated with these drugs. Side effects of long term use may include delayed healing, diabetes, osteoporosis, increase cholesterol, and gastric ulcers.

Beta blockers such as propranolol, atenolol and metoprolol help to decrease heart rate, reduce hand tremor, and anxiolysis (anxiety reduction). Performance-enhancement can be obtained in sports in which steadiness is required such as baseball, golfing, archery, shooting, and billiards. Athletes can administer beta blockers via a pill form or intravenously. However, it also has been proven to have an acute side effect of an excessively slowed heart rate because beta blockers counter the effects of epinephrine. Hypoglycemia, hyponatremia, dizziness, fainting or light headedness, diarrhea and nausea may result acutely when taking beta blockers. Long term effects can range from disordered sleep and impotence.

Insulin in sport has been noted to slow down muscle degradation, which is enticing for body builders and powerlifters and, given that insulin feeds muscles, it has shown to be abused by

endurance athletes. However, there is minimal evidence supporting these performance enhancements. Athletes can administer insulin via an injection. However, it also has been shown that side effects of using insulin can cause acute symptoms of rapid heartbeat, sweating, paleness, hunger, weakness diabetes, coma, death, or insulin shock. An insulin doping athlete can be detected via urine analysis.

Blood Doping

Blood doping is a performance enhancing method to which an athlete's blood is modified to help transport more oxygen to an athlete's muscles. Modifying an athlete's blood is done by adding more hemoglobin to his/her blood, which is the oxygen carrying protein in the blood. More hemoglobin contributes to higher amounts of oxygen delivered to the athlete's muscles for fuel. This is done by one of three methods: blood transfusions, injections of Erythropoietin (EPO), and injections of synthetic carriers.

Blood transfusions can come from the athlete's own blood that was previously drawn and stored for use, or a donor of the same blood type. EPO injections are administered by injecting a synthetic EPO hormone, which stimulates the body to produce increased amounts of red blood cells, hence increasing hemoglobin. Synthetic carriers are injectable which carry oxygen. Synthetic oxygen carriers are used in emergency medical situations when human blood is not available or there is a high risk of blood infection. When used for performance enhancement, it is used to increase oxygenation to the muscles, similar to the two previously described blood doping methods. Common sports that have athletes who engage in blood doping are those that require endurance, such as cycling and running. Recognition is directly unachievable for blood doping that uses an autologous transfusion (a transfusion of the athletes own blood). However, indirect methods, such as testing the athlete's blood at different times throughout the season for comparison, is carried out to ensure hemoglobin levels are not greatly enhanced. Blood doping methods that use synthetic carries and EPO can be detected via urine analysis. Side effects of blood doping can occur largely because of the thickening of blood. For example, these athletes can be at risk for a stroke, heart attack, or a blood clot. Blood transfusion from another donor can put an athlete in danger of HIV/AIDs, hepatitis B, and hepatitis C. Significant side effects of EPO injections include high blood pressure, hyperkalemia, and flu-like symptoms.[7] Synthetic oxygen carriers can also cause heart disease, stroke, heart attack, and blood clots.

Gene Doping

Newer to the world of performance enhancing drugs is the concept of gene doping. This method became more known in the early 2000's. The technique is similar to Gene Therapy techniques which are used commonly in contemporary medicine to treat and/or prevent illnesses, except with the purpose of enhancing one's performance.

The method involves athletes being injected with DNA, in order to allow athletes to alter their DNA. Athletes may choose to add excess genes to their existing DNA, or may manipulate

expression of their own DNA.[8] The transfer of genes can be performed in vivo and ex vivo. Ex vivo techniques are when the athlete's cells are taken, DNA is added to additional genes in order to be genetically modified in a cell culture, then injected back into the athlete. This approach allows for labs to sort and screen the genetically modified cells before returning them to the donor athlete. In vivo gene doping is when excess genes are injected directly into the athlete in hopes to genetically modify the DNA with the host, or the athlete. This technique does not allow for selection of screening and may lead to "dirty doses," to which athletes receive viruses, toxicities, or contaminated injections. However, it is more cost effective for the athlete.

Athletes may be enticed to use gene doping because it is known to enhance performance in many ways.[8] Gene doping can increase endurance if a gene is alerted to block the action of myostatin which increases hematocrit levels, thus increasing oxygen uptake. Additionally, over expression of insulin-like growth factor can be created - promoting muscle health and function. As mentioned prior, added genes of erythropoietin can also increase red blood cell count, thereby increasing endurance. Muscle hypertrophy and hyperplasia can be induced by genetically increasing follistatin. Genes can also be modified to increase growth hormone to improve muscle mass and decreased adipose tissue as well as increase endorphins to reduce pain perception.

Although advances have been made in testing and recognition of athletes, identification of gene doping proves to be difficult and inefficient at this time.[8] Testing involves analyzing sample cells looking for additional or extra genes, whose sequence differs from the athlete's.[9] Cells with extra genes may lead to suspicion of a doping athlete. Some gene doping techniques can and have been tested via analyzing blood samples. Red blood cell and hematocrit count can certainly identify dopers using additional gene copies. In addition to the extra copies of the erythropoietin, genes themselves can be identified in blood cell samples. However, if the genes are injected specifically to an organ, (muscle or lung tissue), biopsies of the tissue will show positive results for gene doping. Additionally, a new technique identified as the CRISPR method (Clustered Regularly Interspaced Short Palindromic Repeats), alters gene activity without changing the DNA's sequence. This method only alters the chemical tags (epigenomes), meaning detection would be almost impossible to occur. *Epigenome editing*, as this technique has been referred, is still in its very early stages in medicine; however, it can lead to abuse issues in doping.

Health risks that would be of concern when caring for these athletes that perform gene doping are of the following, but not limited to serious cardiovascular events, increases in systolic blood pressure, autoimmune anemia, cancer and tumors, viruses, toxicity and contamination.[8,10] Most of the cardiovascular risks are from the increase in erythropoietin and hematocrit as well as red blood cells. Viruses, toxicity and contamination risks are from receiving "dirty doses."

Conclusion

In the competitive environment of sports, it is no secret that athletes may do whatever it takes to get an edge on their competition. As healthcare providers, it is important to be aware of the methods and substances available to athletes, as well as the potential health risks imposed on the athlete. Proper working knowledge of performance enhancing drugs and methods will allow clinicians to quickly respond to an athlete in need.

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Sport Variations & Rules for Sideline Care

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Objectives:

Upon completion of this section, the learner will:

1. Gain a greater understanding of sport venue coverage and the rules that guide care for the injured athlete and protect other athletes.

****Please refer to corresponding course lectures for content.**

Environmental Considerations

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Learning Goals:

Upon completion of this section, the learner will:

1. Identify risk factors, signs and symptoms associated with cold injuries, and discuss both prevention and management strategies.
2. Identify risk factors, signs and symptoms associated with exertional heat illness, and discuss both prevention and management strategies.
3. Identify signs and symptoms of dehydration, its effect on the athlete and performance, and provide recommendations for fluid replacement.
4. Discuss the body's response to altitude, and identify the benefits and effects of high altitude training.
5. Identify common etiologies of anaphylaxis, manifestations, and the management of anaphylaxis from an emergency response perspective.
6. Identify causes of asthma exacerbations, major signs and symptoms of asthma, and describe pharmacologic and nonpharmacologic management strategies.
7. Identify detrimental dermatologic environmental elements, and discuss their signs, symptoms and management.
8. Discuss the hazards of lightening, management of a lightening victim, and prevention measures.

Objectives:

1. Discuss the athlete's bodily response to altitude.
2. Distinguish between the symptoms of heat cramps, dehydration, heat exhaustion and heat stroke in a football player presenting to you on the sideline during practice.
3. Design a lightning plan for your summer softball league.

Part I: Heat, Cold, & Altitude Considerations

Introduction

Participation in sport, structured exercise, and general physical activity frequently take place in uncontrolled environments where individuals must be able to effectively respond to the effects of heat, cold, and altitude. In some cases, the body is capable of chronic adaptations to these exposures. In others, we must prepare for and protect our athletes from the impact of the environmental factors that may degrade performance and increase risk of illness.

Thermal stress is caused by any environmental condition that causes a change in body temperature threatening homeostasis away from the thermoregulatory set point of 37 °C. Hyperthermia occurs when the core temperature exceeds 39 °C,[1] while hypothermia occurs when the core temperature falls below 35 °C.[2] In response to core temperature away from the thermoregulatory set point, acute adaptations occur that work to return to 37 °C through modifications in heat transfer.

Heat Transfer Mechanisms

Core temperature regulation is reliant upon the body's ability to adapt energy exchange and is conceptually expressed through the following equation:

$$S = M - Wk \pm K \pm R \pm C \pm C_{res} - E_{res} - E_{sk}$$

The law of energy conservation states that the rate of body heat storage (S) is equivalent to the difference between the metabolic rate (M) and the energy utilized to perform exertional work (Wk) in addition to the heat exchanged from the skin by conduction (K), radiation (R), convection (C), convection from respiration (C_{res}), evaporation from respiration (E_{res}), and evaporation from the skin (E_{sk}). This is typically expressed in Watts (W), but may be normalized for total body mass or body surface area and expressed as W/kg^2 and W/m^2.[3]

Most weight bearing activities result in a negligible portion of the energy produced converted to external work,[4] while some non-weight bearing exercises (e.g. cycling, rowing) may result in up to 25% of the metabolic energy production converted.[5,6] Hence, most, if not nearly all of the energy produced from increasing metabolic rate is stored as heat energy. Several studies have evaluated the actual rate of heat production with various activities:[7-12]

Sleeping	1.0 W/kg
Standing	1.3 W/kg
Walking	4.0 W/kg
Heavy Work	8.0 W/kg
Running 5 mph	10.0 W/kg
Running 10 mph	20.0 W/kg

The metabolic demand of these activities exposes athletes to large increases in heat storage, and factors such as morphology[13], health status[14-16], ambient temperature and humidity[17] greatly impact factors related to heat transfer out of the body via conduction, radiation, convection and evaporation.

Conduction is the transfer of heat between two solid surfaces. Generally, conduction with the external environment is negligible. However, actions taken to warm athletes with blankets or the use of ice packs or immersion to cool the body as a preventive measure, performance optimization effort, or treatment for heat illness are examples of conductive heat transfer in athletes.[18-20]

Heat exchange through radiation takes place through radiant heat exchange between two bodies that are radiating electromagnetic waves. Heat is gained or lost via radiant transfer based on the mean radiant temperature of the two bodies in question.[3]

Convection is a transfer of heat between a solid surface and moving air or fluid. The direction of heat transfer is dependent on the temperature of the solid and air or fluid medium and its effectiveness is based on the temperature difference and velocity of movement of the air or fluid medium. An added benefit of convection is that the movement of air also enhances the impact of evaporation as a heat transfer mechanism.[21]

Evaporation is the primary mechanism for heat transfer away from the body in hot environments and is the only mechanism for heat transfer away from the body when ambient temperatures exceed skin temperature. Evaporation is impacted by the surface area of the body where skin is wet and available for vaporization and the environmental elements that limit the amount of evaporative heat transfer that can take place (e.g. humidity, clothing).[3]

Heat dissipation results when heat is transferred from the core to the external environment through the skin. Peripheral vasodilation diverts blood to the skin, while the vital organs and active skeletal muscles continue to compete for sufficient blood flow to maintain function. At rest, the majority of heat dissipation occurs via radiation and convection, and increasing humidity elevates their relative contribution for maintaining the thermoregulatory set point. During strenuous exercise, nearly all heat dissipation occurs via evaporation. However, as humidity increases, radiation and convection play a larger role (e.g. 20% contribution at 32 °C and 70% relative humidity).[22]

When the body is exposed to cold temperatures, thermoregulatory mechanisms that preserve core temperature include peripheral vasoconstriction, and shivering/non-shivering thermogenesis. The initial reduction in peripheral blood flow is initiated when the entire body skin temperature falls below 35 °C and is maximized at 31 °C. Vasoconstriction also occurs with smaller, localized exposures when skin temperature reaches 26-28 °C. This response is sympathetically driven and results in a reduction in convective heat transfer and maximizes the effectiveness of subcutaneous fat and skeletal muscle to act as insulators. Two negative impacts of this response are a reduction in manual dexterity and an increase in risk of cold injury of the extremities. To reduce this effect, cold-induced vasodilation produces periodic oscillations that increase blood flow to these areas.[23]

Shivering thermogenesis is a process that produces involuntary, rhythmic muscle contractions that increase in intensity with increasing cold stress that begin in the torso and work their way to the extremities.[24] During cold water immersion, there is potential for a six-fold increase in resting metabolic rate. Non-shivering thermogenesis is another form of sympathetic induced

muscle tensing and heat generation that is associated with the presence of brown adipose tissue. There is some evidence that enhanced recruitment of brown adipose tissue may result in a very small acclimatization effect to cold exposure.[25]

Exertional Heat Injury

Exertional heat injuries (EHI) impact an estimated 9000 high school athletes every year and are one of the leading causes of preventable morbidity and mortality seen in sport.[26] Heat related illness claims up to 600 lives annually in the U.S.[27], with 123 deaths in American football from 1960-2009.[28] Typical heat related illnesses observed by the sports physical therapist include exercise associated muscle cramps (EAMC), heat syncope, heat exhaustion, and heat stroke.

EAMC's are sudden and progressive involuntary, painful contractions that occur during or after activity. These cramps are not associated with elevated body temperature but appear to be associated with a combination of dehydration, electrolyte imbalances, altered neuromuscular control, and fatigue. They can be divided into incipient cramps, which are painless and do not demonstrate muscular activity on electromyography. Fully progressed cramps are painful, may be debilitating, and demonstrate clear activity on electromyography.[29]

Heat syncope can occur with normal or mildly elevated temperatures. Athletes who are unfit or not acclimatized often suffer from heat-related syncope or orthostatic intolerance, typically appear pale, and may exhibit transient loss of consciousness after extended periods of activities in standing and just after stopping activity. These symptoms are frequently seen in athletes when wearing a uniform or insulated clothing. Athletes with heat syncope typically experience dehydration, venous pooling, reduced cardiac filling, and low blood pressure. Syncope occurs when cerebral ischemia occurs in response to these impairments.[30]

Heat exhaustion is the most common heat injury seen in sport. Patients typically present with core temperature below 40.5 °C. In addition, high skin temperatures can result in shunting blood flow to the periphery, resulting in reduced venous return and cardiac performance. Profuse sweating and mental status changes are common and can occur in both non-acclimated and acclimated athletes and present with central fatigue related symptoms. Care must be taken to protect athletes from further exposure to prevent the transition to heat stroke.[31,32]

Heat stroke is a true medical emergency and is a sign of thermoregulatory failure in the athlete with a core temperature that is typically, but not always ≥ 40.5 °C. Patients may additionally present with altered mental status, vomiting, and diarrhea. Athletes may also be hot and dry, but the presence of profuse sweating should not be a factor that rules out a diagnosis of heat stroke. Typically, the first sign of heat stroke is CNS dysfunction and mental status changes. This condition requires the activation of the emergency medical response system; however, active and immediate cooling should occur prior to transport as the risk of morbidity and mortality increase with prolonged core temperature above 40.5 °C.[33-35]

Risk Factors for Exertional Heat Injuries

EHI's are typically multi-faceted with both environmental and non-environmental risk factors. Additionally, the cause of each injury is a unique subset of these risk factors, so the sports physical therapist must be aware of their environment and know the athletes that they are working with to ensure safe participation in hot and humid conditions.

Military and NCAA data indicate that up to 80% of EHI nationally occur in the southeast United States.[36,37] While injuries are seen at wet bulb globe temperatures below 82 °F, risk of heat injury is substantially higher at temperatures above 90 °F and is considered an "extreme risk" condition by the American College of Sports Medicine.[35] Additionally, these data indicate that risk increases by at least two-fold in military recruits and football players during the first three training days, indicating poorly acclimatized individuals are at higher risk.[37]

Non-environmental risk factors for EHI include those that are beyond the control of the athlete, such as age and gender. Modifiable factors, such as fitness level, previous exposure, illnesses and skin conditions, hydration and nutritional status, medications and supplements, and the impact of clothing and gear are all considered when assessing injury risk.

There is no epidemiological data that indicates there is a higher incidence of heat related injury in children. However, there are metabolic, morphologic and cardiovascular differences between children and adults that impact heat production, tolerance, and dissipation. Reduced economy of the gait cycle (running or walking) results in 10-15% greater oxygen consumption and heat production in children, leading to higher heat stress in equivalent activity when compared to adults. Body surface area to mass ratios in children are about 20% higher than adults, resulting in greater reliance on evaporation for heat dissipation.[38-40] In low and moderate temperatures and humidity, the latter actually benefits children. However, when ambient temperatures exceed core temperature and humidity increases, greater heat absorption occurs through non-evaporative mechanisms. This difference in body surface area also results in more blood shunted to the skin and the presence of fewer sweat glands. As muscular workload increases, this results in relatively lower cardiac outputs and sweat rates which negatively effects both exercise capacity and heat injury risk.[3]

Female reproductive hormones have central impacts on the hypothalamus and peripheral impacts on the vasculature and autonomic nervous system that trigger heat dissipation responses, vasodilation of cutaneous vessels, and sweating.[41] However, these responses appear to "reset" the thermoregulatory set point higher and do not change the sensitivity of the hypothalamus or peripheral receptors when responding to thermal stress.[42] Therefore, these differences do not appear to appreciably change the manner in which women respond to heat stress or expose them to additional risk of heat injury. To further support this assertion, heat injury risk and incidence rates in studies that were controlled for body morphology, fitness level, and acclimatization status demonstrated no difference between men and women.[43]

Patients who have suffered heat stroke that is not related to dehydration or febrile illness have an increased risk of suffering another heat injury, even at heat and humidity levels that would not increase risk in normal individuals. However, this reduction in heat tolerance appears to be

a preexisting condition, not related to the heat injury itself. Heat tolerance (and risk of heat injury) is transiently impacted in cases of heat stroke that are related to hydration status and acute illness, and for those who performed heavy work in the heat. In these individuals, there is also an increased risk associated with exposure on consecutive days. Additionally, cardiovascular and neurological diseases, as well as conditions that impact the ability to sweat, reduce tolerance to heat.[44] Heat tolerance testing protocols have been developed to assess those who have suffered previous heat stroke or have conditions that may increase risk. These tests expose patients to a standardized treadmill exercise protocol in a heat chamber for two hours at 40 °C and 40% humidity. Patients must maintain their core temperature at or below 38.5 °C, their heart rate below 145 beats per minute, and a sweat rate above 620 g/h to be considered "heat tolerant" for unrestricted activity.[45]

Hypohydration leads to reduced circulatory function and negatively impacts thermoregulation.[46] When plasma volume is reduced by greater than three percent, cardiac output and stroke volume are reduced along with sweat sensitivity and skin blood flow responses.[47,48] Fluid management should be based on percent body weight loss after activity with rehydration for those who have less than a three percent reduction in body weight. Rehydration in combination with 24 hours rest in a cool environment should be planned for those with body weight loss between three and five percent. Medical referral is required for those with a body weight loss of five percent or greater.[49]

Caloric intake prior to exercise should attempt to meet the caloric demands of the planned activity. For those exercising for over one hour, have a sweat loss of greater than 7.6 L, have an insufficient caloric intake or experience diarrhea, should ensure that they obtain sufficient carbohydrates, protein, and electrolytes after activity. Primarily, athletes should focus electrolyte intake on dietary sodium. Currently, it is unclear how much dietary sodium is required to maintain an adequate level of sweat sodium concentration. But, rehydration is significantly improved by immediately replacing sodium losses during post-exercise hydration.[49,50]

Heat injury risk is also impacted by prescribed medications, supplements, and illicit drug use. Frequently prescribed medications that are associated with heat intolerance include beta-blockers, diuretics, laxatives, anticholinergics, antihistamines, MAO inhibitors, tricyclic antidepressants, antipsychotics, and vasoconstrictors.[51] Additionally, illicit drug and alcohol use may also expose athletes to additional heat stress. For example, amphetamines, which stimulate the central nervous system, are the most abused drug amongst healthy, active people. Overdoses of amphetamines are associated with hyperpyrexia and fatal heat strokes with acute poisoning incidents.[52,53] Unlike other stimulants, caffeine use in commercial beverages do not appear to increase risk of heat injury or negatively impact hydration status in otherwise healthy people.[54]

Clothing and associated gear may have a negative impact on heat dissipation. This in prominently seen in American football players and military members. The American football uniform covers about 70% of the body surface area and greatly impacts evaporative heat loss, resulting in heat storage while worn. Similarly, military uniforms, particularly combat uniforms, and additional required gear result in more strenuous heat loads. Early studies of the football

uniform demonstrate core temperatures of 39 °C during summer practices and a longer time to recover to normal when compared to those in shorts and a shirt. Additionally, these athletes were unable to perceive a greater heat strain. These findings eventually led to work/rest exposure limits and acclimatization schedules recognized by the American College of Sports Medicine and the NCAA.[42]

Prevention of Exertional Heat Injury

Prevention of EHI is a vital year-round effort to protect the health and welfare of athletes. This begins with a published policy on the prevention of EHI that includes screening for athletes susceptible for heat injury, heat acclimatization policies, actions to minimize risk and exposure, and an Emergency Action Plan that ensures a fast and seamless response when EHI's occur. Medical staff are responsible to ensure that all stakeholders are educated in these policies.[50]

All athletes should participate in a physician-supervised pre-participation medical screening each year. This screening should include questions regarding previous diagnosis of EHI, subjective questions regarding heat tolerance, current level of fitness, hydration, and nutritional status.[50]

Athletes should also have a plan to acclimatize to the heat for an 8-14-day period to allow for physiologic adaptations that lower heart rate, increase plasma volume, lower core temperature, and increase sweating rate and volume with reduced sodium concentration. As this is the time where EHI is most likely to occur, a progressive increase in activity and clothing/equipment burden should be implemented.[50]

Specific work/rest cycles involve rest cycles in shaded and cool environments with equipment removed and occur during the hottest part of the day. Due to the cumulative nature of heat exposure, athletes should obtain at least 7 hours of rest each night in a cool environment, allow 2-3 hours for meal breaks and ensure proper hydration and nutritional digestion and absorption before the next exposure.[50]

Hydration and nutritional status must be maintained with active replenishment of fluids and electrolytes during rest breaks and between exposures. Athletes should have unrestricted access to fluids during practice and be encouraged to eat foods containing sodium to replace electrolytes and enhance hydration. Body weight loss from sweating should be limited to two percent per day, otherwise activity restriction should occur the following day. Athletes can self-monitor by observing urine color as well. Additionally, athletes should avoid supplements, medications and drugs that have a dehydrating effect, increase basal metabolic rate, or affect thermoregulation and body temperature. Consumption of caffeine should not be advised. However, it should not be discouraged if that is the only source of hydration.[50]

Finally, athletes who present with a viral infection, other illnesses, fever or a skin rash should not participate in activities until the condition has resolved. After the athlete returns to activity, they should be slowly integrated back to full intensity work and monitored.[50]

Heat Injury Management

Management of EHI requires a specific and immediate response based on clinical symptoms and differential diagnosis. Response to symptoms may include removing patients from exposure to thermal stress, active cooling, and activation of the emergency medical system.[50]

The immediate treatment for the acute onset of EAMC's is rest and passive static stretching until symptoms abate. The addition of ice and massage may provide additional symptomatic relief. Additionally, it is recommended that athletes consume fluids and foods containing sodium and carbohydrates to enhance hydration and electrolyte balance at a concentration level that does not induce nausea or stomach fullness. In cases where patients cannot or will not be compliant with fluid replacement, intravenous fluids should be considered. In cases where athletes present with recurring EAMC's, further medical evaluation should be pursued to rule out other neuromuscular conditions.[50]

Athletes who present with heat syncope should be moved into the shade, discontinue activity that increases thermal loading, and remove any clothing or gear that impedes the transmission of heat from the body. The athlete should be placed in supine with the legs elevated above the level of the heart. Skin cooling and rehydration with fluids containing sodium and carbohydrates should begin as soon as possible. Patients who lose consciousness should be placed in the recovery position and directly monitored.[50]

Athletes who present with exertional heat exhaustion should be immediately removed from the heat, remove equipment and clothing that impede heat transfer away from the body, and begin active cooling with fans and ice towels or massage with ice bags. Rectal temperature should be obtained, patients should be placed supine with the legs above the heart, and fluid replacement containing sodium and carbohydrates to enhance hydration. If symptoms do not improve after 30 minutes, care should be transferred to a physician and if rectal temperature exceeds 40.5 °C, the athlete should be immediately treated for exertional heat stroke.[50]

Treatment for athletes who sustain exertional heat stroke should be specifically outlined in an Emergency Action Plan (EAP) that is shared with all stakeholders to include medical, administrative, and coaching staff that includes EMS activation. The goal for intervention is to reduce core temperature to 38.9 °C within 30 minutes of collapse to minimize risk of morbidity and mortality. The gold standard intervention for EHS is to remove clothing and gear to maximize cooling, obtain a rectal core temperature, and fully immerse the patient up to the neck in water that is 1.7°-15 °C. An acceptable alternate method is partial-body immersion in combination with ice packs applied to vital areas and the skin to enhance cooling when full body immersion is not available, safe, or practical. During active cooling, the patient's core temperature and other vital signs should be monitored every five to 10 minutes. Overcooling should be avoided to prevent hypothermia. If a physician is present, transportation may be unnecessary if the goals of active cooling are met within 30 minutes and the patient is asymptomatic for one hour after cessation of cooling. When managed by other personnel, transport via EMS should occur after the goals of cooling have been achieved. Non-medical staff should initiate cooling immediately until medical help arrives.[50]

Injuries Due to Exposure to the Cold

A core temperature below 35 °C is required to diagnose clinical hypothermia and is divided into mild, moderate and severe categories. These subdivisions are separated from each other by core temperature, observed physiological changes, and other observed impairments.[2] Common injuries due to cold exposure include frostbite, trenchfoot, and chilblains.

Mild hypothermia occurs between 33-35 °C. Initially, athletes will reach the point of maximal shivering as they progress into this stage, with an increase in blood pressure. As core temperature declines, behavioral changes are noticed, and the athlete may display poor judgement, amnesia, and dysarthria. As core temperature reaches 33 °C, the athlete may become apathetic and ataxia may be observed.[2,55]

Moderate hypothermia occurs between 29-32 °C. The first measurable objective sign in this stage is pupil dilation. Additionally, the patient may be in a stupor and shivering is typically not present. As the patient reaches 30 °C, cardiac function is impacted, and arrhythmias may be detectable. Patients become unconscious at 29 °C.[2,55]

Severe hypothermia is defined as a core temperature below 28 °C. This phase presents with life threatening symptoms to include ventricular arrhythmias, acid-base disturbances, reduced cerebral blood flow, and asystole. Absence of reflexes will also occur.[2,55] It should be noted that patients found in severe hypothermia should be rescued and warmed, even if presumed dead, as the lowest adult survival recorded was a core temperature of 13.7 °C.[56]

The freezing point of skin is negative 2-5 °C [57,58] and wet skin cools faster and at a lower temperature than dry skin.[59] Frostbite is most commonly seen in skin that is directly exposed to cold and can happen within 30 minutes of direct exposure. Instantaneous or contact frostbite can occur when skin is exposed to liquids that can become super cooled (e.g. fuel, alcohol) and when touching highly conductive objects (e.g. stone, metal). Athletes will typically sense cooling of the skin at 28 °C, with pain reported at 20 °C and numbness at 10 °C. Skin may be firm or hard to the touch and may initially be red, but will progress to a waxy, yellow or white appearance, with increased discoloration and blistering present in more severe cases. Pain will be significant upon rewarming and may take on a purple or black appearance.[60] Also note that surface temperatures of the hands and feet are highly correlated with core temperature. Care should be taken to treat patients with suspected frostbite for general hypothermia as well.[61]

Trench foot is a non-freezing cold injury that typically occurs at temperatures of 0-15 °C when wet footwear is worn for extended periods of time. In athletics and military populations, incidence is low except in those who spend 12 hours to four days performing winter hiking, camping, and expeditionary activity. Patients with trench foot present initially with swelling, edema and numbness in a red foot that eventually becomes pale and cyanotic. Pain sensitivity increases, but typically presents as aching sensations. Care must be taken to observe for infection in the affected areas.[62]

Chilblain occurs after one to five hours of exposure in wet conditions at temperatures below 16 °C. There are no lasting effects from chilblains; however, they present as small erythematous papules on exposed skin that are swollen, itchy, and painful with a burning sensation. Upon rewarming, symptoms may worsen for several hours after exposure.[62]

Risk Factors for Cold Injuries

Risk factors for cold-related injuries are primarily environmental. Non-environmental factors include body composition, age, nutritional status, and fitness level. While the factors discussed below have some impact, the effect of these risk factors is small when considering the short amount of time it takes to experience dangerous levels of hypothermia when exposed to cold temperatures. Therefore, careful risk assessment and mitigation are essential prior to activities in cold weather.[63]

In addition to exposure to the cold, risk increases when exercising while immersed in water and activity in rainy and windy conditions. The convective heat transfer coefficient is 70 times greater in water when compared to air.[64] Swimmers and athletes performing activity in rainy or wet conditions should expect significant cooling to take place even in relatively mild water and air temperatures.

Athletes with lower levels of subcutaneous body fat and muscle mass are at higher risk of cold injuries and explains the gender difference for risk of injury related to cold exposure.[65] Body fat has relatively high thermal resistance to heat transfer from the body. Unperfused muscle also insulates from cold external temperatures, and in combination with fat, provides up to 85% of the limb insulation provided by body tissue.[66] However, once a muscle begins to work to maintain buoyancy or perform physical activity, this advantage is lost.

Children and those over 60 years of age are also at higher risk for cold injury. This is primarily due to the greater body surface area to mass ratio in children[67] and those above 60 years old display blunted acute physiological[68] and behavioral responses[69] to cold conditions.

Those who are fasting, poorly fed, or experiencing hypoglycemia are at a higher risk for cold injury. Underfeeding and hypoglycemia impairs the centrally mediated shivering response[70] and low levels of carbohydrate stores may reduce the ability to maintain shivering thermogenesis during cold exposure.[71]

Physical fitness and training level does not appreciably change the thermoregulatory response to cold or reduce risk for cold injury.[72] While those that are more fit are able to perform more activity over a given amount of time, they are not able to maintain their level of activity longer than a less fit person of the same body mass and composition when hypothermic.[73]

Prevention of Cold Injuries

Because the impact of non-environmental risk factors is relatively low, prevention of cold-related injuries must be the main consideration for all athletes. Medical staff play a vital role in

risk management, use of appropriate clothing, and ensuring appropriate hydration and nutritional intake for athletes who are expected to perform in cold, cool, and wet weather conditions.[63]

Following this, the sports medicine and coaching staff should analyze their participants and identify contributing factors that may further increase risk for hypothermia (e.g. nutrition, hydration, body composition, training level). Identifying those who are at greatest risk ensures that all participants, medical staff, and coaches are aware of risk factors that may require additional mitigation or that may exclude the athlete from participation.[63]

Once risk factors have been identified, athletes, coaches and medical staff should work together to implement controls that mitigate risk to an acceptable level. These may include increased training in the cold, identification and use of proper clothing and equipment, and providing warming stations along an event route. These must be adopted and supported by all levels to include participants, medical staff, coaches, and leaders. Additionally, supervision to ensure compliance with required controls must be conducted.[63]

As any acclimatization to cold is minimal at best, use of proper clothing is the most important control that protects athletes from hypothermia and other cold related injuries. Clothing ensembles contain layers with various layers of insulation. The first layer is characterized by a base layer of light weight silk, wool or synthetic fabrics that wick water away from the skin. The middle insulating layer is made from fleece, merino wool or goose down. This layer also has wicking qualities and provides insulation to maintain core temperature. Finally, a third layer is breathable to allow perspiration to leave the clothing ensemble. This outer layer should block wind and repel rain or snow. The amount of insulation required is dependent upon ambient temperature and the intensity of the activity and care must be taken not to overdress. The goal when outfitting an athlete should be to feel mildly cold at the beginning of the event, but work at a comfortable temperature once metabolic rate increases to a steady state. Use of middle layer vests or outer shells with convenient zipper mechanisms can aid athletes in maintaining an effective core temperature.[63]

Food and fluid intake may need to be increased 10-40% due to increased energy requirements from workload changes associated with the effect of heavy clothing and effort of movement in the snow or mud. Additionally, shivering will increase energy expenditure in the cold. Athletes should eat normal meals, supplemented with frequent daily snacks and carbohydrate supplementation with beverages containing 6-12% carbohydrates throughout the day to sustain the shivering response and to avoid fatigue during activity.[63,74]

Dehydration may occur if athletes are too warm from overdressing or if they become cold and experience cold-induced diuresis. However, the impact of mild dehydration in the cold does not impact vasoconstriction or shivering, nor is performance significantly impacted. It is recommended that athletes continue normal hydration practices prior to activity to avoid dehydration.[63]

Management of Cold Injuries

When athletes present with hypothermia, immediately find shelter from cold and wind exposure and get the athlete into dry clothing. Once this has been achieved, begin gradually warming the athlete to minimize the risk of cardiac arrhythmia with warm non-alcoholic drinks and avoid the use of tobacco or other vasoconstrictors.[75]

In patients with frostbite, treatment for hypothermia should begin immediately. In addition, prompt transportation to definitive treatment should take place prior to rewarming affected tissues to lessen the risk of refreezing during transport. Effected extremities should be elevated and constricting clothing and jewelry removed. Dress the affected areas with dry, sterile gauze with cotton between the fingers and toes. Avoid rubbing the area, as friction may increase damage to the tissues.[75]

Illness from Exercise at High Altitude

The physiological effects of altitude on health and performance generally occur at elevations greater than 5000 feet and risk of illness and performance degradation increase substantially at higher levels of elevation.[76] In addition to the effects on health, athletes who are active at altitude must plan for its effects on oxygen utilization, ambient temperature and wind chill, humidity, and solar radiation.

Physiological Effects of Altitude

Increasing altitude negatively impacts maximal oxygen uptake primarily due to reduced atmospheric pressure and decreased oxygen diffusion or pressure gradient in the pulmonary capillaries. This results in diminished oxygen transport due to decreased hemoglobin saturation. To demonstrate this, when comparing athletes at 8,000 feet with those at sea level, the oxygen diffusion gradient is decreased by 70% and hemoglobin saturation is 92%. This not only reduces oxygen availability to vital organs, it diminishes oxygenation of muscles required for physical activity.[77] Additionally, dehydration in response to reduced atmospheric pressure occurs via plasma dumping over the first two days of altitude exposure. This results in reduced cardiac output and maximal oxygen uptake primarily due to decreased stroke volume. In response to these conditions, heart rate and respiration rate are increased.[78-80]

Chronic cardiopulmonary and muscular adaptations assist to maintain health and improve physical performance at altitude. Stabilization of plasma volume begins after 72 hours, hemoglobin levels increase, and erythropoiesis is maximized to enhance red blood cell production and concentration in the plasma. These actions partially make up for the decreased oxygen diffusion gradient that is experienced acutely.[78-81]

Muscle tissue cross sectional area is decreased with chronic altitude exposure. This may be related to reduced appetite, dehydration, muscle wasting, or reduced metabolic activity.

However, over time, muscular performance will be enhanced from increased capillary density in the remaining muscle.[81]

Additionally, hypoxia results in neurohormonal and hemodynamic responses in the brain and lungs to maintain adequate levels of oxygen. This results in over perfusion of microvascular beds and elevates local capillary pressures, resulting in capillary leakage and edema. Evidence suggests that all people have some level of swelling of the brain when they ascend to altitudes greater than 5000 feet and likely contributes to the symptoms of altitude related illnesses.[82]

Illnesses Associated with Acute Altitude Exposure

As altitude increases, risk for illness and performance are increasingly affected. Between 5,000-8,000 feet, some athletes may demonstrate symptoms consistent with mild acute mountain sickness (AMS) and begin to complain of headache, earlier shortness of breath, sleep disturbances, and diminished coordination. Onset typically occurs within 6-24 hours of exposure and will vary between individuals, but is more prevalent in children.[83] Typically, symptoms will dissipate within 72 hours if the athlete does not ascend to greater altitudes. Between 8,000-14,000 feet, symptoms of AMS become a common occurrence and the medical team should expect most athletes to be impacted to some degree from symptoms of AMS and reduction in physical performance. At altitudes between 14,000 and 18,000 feet, these symptoms and performance reductions are the rule for all athletes. Altitudes above 18,000 feet should not be attempted without structured acclimatization and monitoring for short periods of physical activity with an immediate return to a base camp below 18,000 feet.[84-87]

Athletes who ascend to altitude too quickly, perform activity too aggressively or continue to ascend in the presence of symptoms of mild AMS will likely have worsening symptoms. Symptoms indicative of worsening illness, progressing to moderate and severe AMS include complaints of a worsening headache and shortness of breath, nausea and vomiting, weakness and decreased activity levels, and clinically observable coordination deficits with ataxic gait. Athletes suspected of progressing to this level of illness should be evaluated with a Tandem Walk Test. If ataxia is observed, immediate descent is required until symptoms resolve before resuming a gradual ascent. This may take as long as three days.[85-87]

High altitude pulmonary edema (HAPE) and high altitude cerebral edema (HACE) are life threatening illnesses related to altitude exposure with unknown etiology. HAPE appears to be associated with rapid ascents above 9,000 feet and is seen more commonly in children and young adults. Athletes will present with shortness of breath, mental status changes to include loss of consciousness. HAPE's unique characteristic is observable cyanosis. HACE is defined as the end stage of AMS and typically occurs at altitude above 14,000 feet and patients who present with AMS and HAPE will progress to HACE at a faster rate. Patients with HACE have elevated intracranial pressures that may result in findings consistent with global encephalopathy rather than focal neurologic findings on clinical exam. An eye exam may show papilledema and retinal hemorrhage. Both conditions require supplemental oxygen and immediate supervised descent for definitive care.[85-87]

Other Health Related Considerations for Performance at Altitude

Decreased air temperatures and wind chill work to increase the risk of hypothermia in athletes performing at altitude. Typically, temperature decreases 1 °C for every 500-foot increase in elevation. Adding to this, wind speeds are typically higher at greater altitude and there are fewer wind breaks available in the contour of the landscape.[88]

Colder temperatures also result in decreased humidity. Because respiratory rate is increased, risk of dehydration is increased due to increased levels of water evaporation in expired air. This adds to dehydration risk beyond plasma losses that are observed due to changes in atmospheric pressure alone.[88]

Solar radiation injury risk is also increased at altitude. Light travels through a less dense and less humid atmosphere at higher altitudes, resulting in less radiation absorption. This increased density of UV rays increases potential for sunburn and eye injuries. This risk is increased further due to reflection of UV radiation from snow and light-colored terrain in areas with little vegetation. Sunscreen and polarized sunglasses should be part of the risk mitigation plan.[89,90]

Prevention and Treatment of Altitude Related Illness

To minimize the risk of AMS and HACE, athletes should ascend to altitude slowly, avoid same day ascents of more than 8,000-9000 feet, and avoid overexertion for 24 hours after arrival. Once above 8,000 feet, athletes should not ascend greater than 2,000 feet per day, with a 24-hour acclimation period between ascents. These gradual ascents reduce AMS risk by up to 41 percent. For those with a history of AMS, athletes should receive prophylactic doses of acetazolamide and dexamethasone. An alternative intervention is the use of ginkgo biloba when making gradual ascents up to 16,000 feet. Overhydrating prior to ascent does not appear to be preventive.[85-87]

For patients experiencing mild AMS, the standard management is to descend 1,500-2000 feet and acclimate to the lower altitude while treating symptoms with analgesics and antiemetics. The time to acclimatize can be reduced by prescribing acetazolamide.[85-87]

Moderate and severe symptoms of AMS, to include HACE, are managed similarly with supplemental oxygen at a rate of 1-4 L/min, but descent is primarily an evacuation to lower altitudes for medical management and monitoring. When descent is not possible, use of portable hyperbaric chambers in combination with acetazolamide and dexamethasone is indicated while awaiting medical evacuation.[85-87]

Prevention measures for HAPE, beyond those for AMS and HACE in healthy patients who have not previously experienced it is not typically considered. However, there is evidence that the use of inhaled β-agonists to increase the clearance of fluid from the alveolar space and to lower pulmonary arterial pressure may be of value and is safe to use. For those athletes who have

experienced HAPE or may have medical conditions that increase concern for developing the condition, prophylactic use of nifedipine should be considered with medical consultation.[85-87]

In athletes who develop symptoms of HAPE, supplemental oxygen should be administered at 4-6 L/min until symptoms decrease and then 2-4 L/min to conserve supplies. An immediate descent or portable hyperbaric chamber should be used until evacuation is possible. Descent should be performed in a manner that minimizes exertion levels to the patient. If supplemental oxygen is not available, nifedipine should be administered. Dexamethasone should be utilized in patients who display neurologic deficits.[85-87]

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Part II: Anaphylaxis

Anaphylaxis is a systemic allergic reaction that is severe and life-threatening. Delay in diagnosis and treatment may result in death due to airway obstruction or vascular collapse.[1] Anaphylaxis is a systemic response to an allergen; of which many cases are immunoglobulin E (IgE)-mediated. This leads to mast cell and basophil activation, resulting in manifestations/symptoms in multiple body systems.[1] Signs and symptoms typically develop within five to 60 minutes of exposure to the allergen, but may take several hours to develop.[1,2] The most frequent signs and symptoms include upper airway edema, dyspnea, wheezing, urticaria/ angioedema, flushing, dizziness, hypotension, syncope, nausea/vomiting/diarrhea, abdominal pain, rhinitis, and headache.[2] Other general symptoms can include anxiety, paresthesias in the extremities, weakness, and irritability.[1] Common triggers include food, such as nuts, milk, and shellfish (this is not an all-inclusive list). Other common triggers include medications, insect venom, animal dander, latex, radiographic contrast media, and physical factors/exercise.[2] Anaphylaxis can also be idiopathic, where no factor is identified.

The initial emergency management of anaphylaxis includes sizing up the scene, and performing a primary assessment and supportive care of the patient's airway, breathing, and circulation. If the patient is unconscious, has difficulty breathing, or is experiencing other symptoms of a severe allergic reaction, call for more advanced medical personnel. Provide care for the life threating conditions, including prompt administration of epinephrine. Epinephrine autoinjectors are often the preferred method for delivery of this therapy.[1] If the patient is conscious, obtain a SAMPLE history. Monitor the patient's condition by performing an ongoing assessment and observe the patient's response to the epinephrine.[3] Providing oxygen, when available, and placing the patient in the recumbent position with the lower extremities raised is also appropriate.[2] Current practice guidelines identify the timely administration of epinephrine, as the most important treatment for anaphylaxis.[1] Side effects of epinephrine can include tremor, increased heart rate, nausea, anxiety, headache, anxiousness, dizziness, and pallor.[4]

Again, the preferred route of administration is through the use of an epinephrine intramuscular autoinjector.[1] When assisting with an epinephrine autoinjector, there are precautions to follow. First, check local protocols before carrying or using an epinephrine autoinjector. Second, check the label to confirm the prescription of the epinephrine autoinjector is for the patient. Next, check the expiration date, and also confirm the liquid is clear, not cloudy. Always follow medical direction and the manufacturer's instructions for the device.[3] Always obtain consent when assisting with an epinephrine autoinjector. To administer an epinephrine autoinjector, first remove the device from the storage tube by opening the cap of the carrying case. Grasp the device with the orange tip facing down and remove the safety release. Aim the autoinjector at a 90- degree angle toward the outer thigh - jabbing the device into the outer thigh until the device clicks. Firmly hold the device against the thigh for 10 seconds, for full dose delivery. Remove the autoinjector from the thigh and gently massage the thigh for 10 seconds.[3] The used device should be given to more advanced medical personnel when they arrive. Document that epinephrine was given, the dosage, as well as the time of administration.[4]

The onset of action is typically three to five minutes. A second dose can be administered when more advanced medical personnel are not present and if anaphylactic symptoms persist.[3] It can be given every five to 15 minutes, up to three times, until the patient is without respiratory or vascular compromise symptoms.[1,2] Once anaphylaxis symptoms abate, 10-24 hours of observation is recommended, as biphasic reactions may sometimes occur.[1] Allergen avoidance is the primary prevention method, and all patients who have experienced anaphylactic reactions should carry an epinephrine autoinjector.

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Part III: Asthma

Asthma is a chronic inflammatory disorder of the airways, with associated airway obstruction and bronchial hyperresponsiveness.[1] Asthma has multiple triggers, which can include environmental factors such as allergens, pollutants such as smoke, inhaled irritants such as tobacco smoke, respiratory infections, medications, cold air temperature, and exercise.[1] The symptoms of asthma that manifest are the result of the airway obstruction, and include coughing, wheezing, breathlessness, and chest tightness.[2] Other signs of an asthma attack can include sweating, difficulty speaking, bent posture with shoulders elevated and lips pursed, and feelings of anxiousness/fear.[3] The symptoms due to the airway obstruction often reverse spontaneously or with treatment.[2] Appropriate symptom management is imperative, as severe asthma attacks can result in irreversible airflow obstruction, leading to death.[1]

A detailed medical history, exam, and lung function tests are essential to aid in the diagnosis and appropriate patient specific management of asthma attacks. There are multiple methods utilized to control asthma attacks, to include avoiding the environmental triggers, exercise techniques, and pharmacotherapy. Strategies such as using masks or using a technique called nose breathing to warm and moisturize inhaled air may decrease the frequency and intensity of exercise induced asthma.[1] After exercise, a refractory period can be utilized, which is when the airway response is temporarily inhibited (upwards of 2-3 hours).

Medications used in the management of asthma symptoms can be categorized as either controller or rescue.[1] Controller medications are typically used daily over a long-term timeframe, and administered prophylactically in order to manage asthma. Controller medications generally are not used to address acute asthma symptoms.[3] Examples of controller medications include systemic corticosteroids, inhaled corticosteroids, and long-acting β2-agonists.[2] Rescue medications are used during acute attacks to rapidly treat acute

bronchoconstriction and its associated symptoms. These medications include inhalers that are rapid-acting β2-agonists, short-acting theophylline, and inhaled anticholinergics.[1] The most commonly administered reliever medication for chronic asthma includes rapid acting inhaled β2-agonists.

There are multiple delivery systems for asthma medication. A metered-dose inhaler is a hand-held aerosol canister with mouthpiece, which is designed to allow a patient to inhale a specific amount of medication into the lungs in one puff.[3] In some cases, a spacer may be attached to an inhaler to serve as a medication reservoir to assist appropriate administration of the medication. A dry powder inhaler is also a hand-held medication device. It delivers a dry powder medication inside a compartment, where the inhaler is activated by a rapid inhalation.[3] A small-volume nebulizer administers a medication mist over a few minutes. Asthma medication can also be taken in pill form.

When assisting a patient with the use of an asthma medication, always know and follow local protocols, and obtain consent. Ensure that the inhaler prescription is in the patient's name, is not expired, and is intended as a rescue inhaler. Shake the inhaler and then proceed to remove the cover.[3] If using a spacer, attach it to the inhaler. Instruct the patient to exhale fully through the mouth, then place lips tightly around the mouthpiece of the inhaler. The patient should slowly and deeply inhale as they depress the inhaler. The medication will be released and inhaled into the lungs. The patient should then hold their breath for a count of 10 seconds. If the patient is using a spacer, instead of holding their breath, they should be instructed to take five to six deep breaths with the spacer in their mouth. Follow with the patient rinsing their mouth out with water to reduce side effects. Note the time of administration. Monitor the patient's breathing. The medication may be repeated again after one to two minutes if symptoms are not improving, and every five to 10 minutes thereafter. Of note, rescue medications may take five to 15 minutes to reach full effectiveness.

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Part IV: Dermatologic Conditions

The environment poses dermatologic threats to the athlete. The skin is often times exposed and therefore subject to insects, the sun, and allergens. One of the more common environmental dermatologic disorders is sunburn. It occurs when the melanin in the skin

becomes damaged from UV light exposure. They can be classified as superficial, superficial partial-thickness, and in severe cases deep partial-thickness.[1] The extent of a sunburn, similar to other burns, depends upon the length of exposure to and distance from the source (sun), and medical conditions/medication use; as NSAIDS and tetracycline antibiotics can increase sensitivity to the sun.[2] The onset of symptoms is typically hours after the sun exposure event. The symptoms include redness, warmth, sensitivity, and days later may demonstrate peeling of the skin or blisters. Management first includes prevention. Prevention techniques include applying and reapplying sunscreen with and SPF of 30 while outside, even if cloudy, staying hydrated, staying in the shade when possible, and wearing large brim hats.[3] Once the sunburn has occurred, symptom relief can include topical lotions with aloe, pain relievers, and cool compresses.[2]

A second common dermatologic threat includes insect bites/stings. When an insect stings, it injects a venom through the stinger. With a bee sting, the venom sac may still be attached to the stinger and will continue to release venom. To remove the stinger scrape the stinger away from the skin with a plastic card or tongue depressor. If using tweezers, grasp the base of the stinger, not the venom sac.[1] The area will typically demonstrate a circular area of redness, warmth, and be sensitive to the touch. Clean the site and cover it with a dressing. A cool compress/cold pack my help to reduce pain and inflammation, and a local anesthetic may assist with the associated pain. Ask the individual if they have any know allergies to insect stings, and always monitor for signs of an allergic reaction. This reaction may be localized and minor, or as severe as anaphylaxis.

Mosquito bites are also a relatively common occurrence. When mosquitoes bite, they draw out blood while injecting some of their saliva. Their saliva contains an anticoagulant and proteins. These proteins trigger the body's immune system to release histamine, resulting in the itchiness, inflammation and swelling.[4] Their symptoms may be managed with topical antihistamines and Benadryl. They less commonly can result in mosquito borne illnesses such as West Nile Virus, Zika Virus, Yellow Fever, Malaria, and encephalitis.

Ticks can also produce a dermatologic threat, through a tick bite. They may spread serious diseases to humans such as Rocky Mountain Spotted Fever, Lyme Disease, and Ehrlichiosis.[1] If a tick is embedded in the skin, it is important to correctly remove it. To properly remove a tick, with a gloved hand, grasp the tick with tweezers, with the tweezers placed as close to the skin as possible. Then, pull slowly and firmly. Clean the bite area with soap and water. The individual should then be monitored for signs of infection, illness, and neurological symptoms.[2]

A third type of bite that can occur is a spider bite. In the United States, most spiders have a bite that is harmless. They may result in in a small bump on the skin that is red, itchy and tender for a short duration of time. Their symptoms can be managed similar to an insect sting. However, the bites of recluse spiders and black widows can cause serious injury or death. The venom of black widow spiders contain a neurotoxin that affects neuromuscular function.[1] The black widow spider bite usually feels like a pinprick, followed by redness, dull pain, and swelling. Pain

typically increases within an hour, and may spread. Other symptoms may develop, such as sweating, dizziness, headache, stomach cramps, weakness, nausea and vomiting, and fast heart rate.[5] The recluse spider venom is necrotizing. Its bite may produce zero to little pain initially, however pain will increase over the next few hours. A blister will form under the surface of the skin with a red ring around it. With time, the blister will increase in size, then rupture, leading to tissue necrosis.[1] Some individuals may develop symptoms of fever, chills, rash, and stomach upset.[5] Advanced medical care should be sought.

Due to the skin's exposure to the environment, dermatitis may develop as a result of the exposure to allergens, chemicals, and heat. Allergic contact dermatitis is the result of an allergen coming in contact with the skin and triggering a hypersensitivity reaction.[2] An example is coming in contact with poison ivy or poison oak. Irritant contact dermatitis is the result of the skin's exposure to a chemical that results in skin inflammation.[2] Examples of substances that can cause irritant contact dermatitis are detergents and cleaners. Contact dermatitis symptoms may not manifest until up to 48 hours after the exposure. Symptoms of allergic contact dermatitis can include pruritus, hives, blisters, redness, burning, and swelling.[6] Symptoms of irritant contact dermatitis can include, erythematous plaque lesions, scaling, and vesicles.[2] Management begins with identifying the causal agent and discontinuing its exposure/use. Treatment also includes cleaning the skin with mild soap and water, use of topical corticosteroids treatments, and if needed oral corticosteroids.[2]

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Part V: Lightning Safety

Lightning is the most common weather hazard encountered, and on average results in more weather related deaths annually than any other weather hazard.[1] Lightning is a transient, high-current electric discharge in the air.[2] It is a danger to the outdoor recreational and athletic

population, in addition to event spectators, with most lightning casualties occurring from May to September between 10:00am and 7:00pm, consistent with popular times for athletic and recreational events.[2] Education on the danger of lightning, and precautions to reduce the likelihood of being struck by lightning, are critical steps in lightning safety.

There are six mechanisms of a lightning injury. A direct strike is described when a lightning bolt hits a person as the first point of contact.[2] A contact injury occurs when an object is being touched that is in the path of the lightning current. A side flash is when lightning strikes an object and some of the energy jumps from the object to a person in close proximity. A ground surface arc occurs when a lightning current from a ground strike is intercepted by a person. An upward leader is a lightning channel developed from the ground toward the cloud. Lastly, blunt injury is when lightning current throws an individual from the strike point.[2] As a result of these lightning injuries, multiple body systems are effected. Most lightening deaths are due to cardiac or respiratory arrest.[2] If an individual does survive a lightning injury, they may suffer both temporary and permanent effects, including brain injury, hearing and visual deficits, pain syndromes, temporary paralysis, and burns.

To provide emergency care to an individual with a lightning injury, it is first imperative to activate EMS and to size up the scene. While it is safe to touch the patient and provide care, personal safety should be ensured if active thunderstorms are occurring. Once both the victim and rescuer are in a safe location, a primary assessment should be performed, as it is imperative to initiate CPR quickly and safely if the victim is in cardiac or respirator arrest.

Lightning safety strategies should be practiced by all individuals involved in outdoor events. An Emergency Action Plan (EAP) for lightning should be in place, and previously practiced, before the season begins. A lightning specific EAP should include an established chain of command, reliable weather monitoring, outlined safe structures, activity continuation/discontinuation criteria, and maintenance of certifications and equipment.[1] If there is a threat of thunderstorm, keep in mind lightning can strike in the absence of rain, therefore activities should be promptly postponed. Lightning safe buildings should be identified, and include fully enclosed buildings. Keep a safe distance from electrical equipment, plumbing, and wiring in these buildings, and keep away from windows.[1] Structures with open areas, such as carports, gazebos, and dugouts are not considered lightning safe. If a safe building is not accessible, a fully enclosed vehicle is a recommended option for safety. If an individual is unable to reach a safe location, they should avoid water, high ground, open spaces, metal objects, trees, and other tall isolated objects.[1] If a lightning strike is nearby, the individual should crouch down with feet together with weight on the balls of their feet. Maintain a minimum distance of 15 feet between people in this situation.[1] Criteria should be established to both discontinue and resume outdoor activity. Common criteria utilized includes the flash to bang theory. A measure of five seconds from flash of lightning to sound of thunder indicates the lightning is one mile away. When flash to bang equals 30 seconds, the lightning is six miles away, and individuals must seek a lightning

safe location immediately. To resume activity, a minimum of 30 minutes should elapse after the last sound of thunder, before leaving the lightning safe location.[1]

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Legal & Ethical Concerns for the Athletic Venue

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Learning Goals:

Upon completion of this section, the learner will:

1. Identify the legal duties of both an EMR and sports medicine clinician.
2. Recognize the importance of consent, refusal of care and confidentiality.
3. Describe the components of mandatory reporting.
4. Understand the properties of negligence.
5. Define and explain the Good Samaritan Law.
6. Describe the legal difference between various roles as a care provider EMR, PT, volunteer, paid practitioner.
7. Understanding the basic components of direct access.
8. Identify medical support requirements for venue coverage.
9. Explain the role of governing associations on laws, ethics and practice procedures.

Objectives:

1. Articulate the Good Samaritan Law as it applies to your volunteers at your 10K race.
2. Defend "Life First" application in regards to using an EpiPen®.

Introduction

Medical laws and ethics shape and define how healthcare practitioners deliver care, whether you are an emergency medical responder, physical therapist, physician, athletic trainer or any other provider. Laws, policies and position statements are living documents which are created and amended according to the latest research and standards of care. Regulations are enacted to protect the public, assure the competence of the provider and hold those who fall short of adhering to the established laws and ethics accountable.[1] Additionally, laws are written to protect the medical provider from liability unless there is negligence.[1]

Ethics are the moral codes by which we conduct ourselves as professionals. Sometimes, conflicts arise between what is legal and what is moral and require an individual to make a choice, often quickly, to the best of their knowledge and ability. Over the years, as athletic participation numbers rise, healthcare practitioners are becoming more liable for the athlete's injuries and career.[2] This chapter is designed to clarify legal terms, identify challenges in practice regulations, define liability during the coverage of sporting events and provide helpful hints to the medical practitioner who is summoned to administer emergency care or who chooses to volunteer at an athletic competition.

Scope of Practice

Every licensed medical professional's scope of practice is defined by law in the form of a Practice Act. Each state has the authority to adopt or modify a profession's practice act. The professional scope of practice is developed based on a unique body of knowledge which is gained through education, evidence based research and competence in skill delivery.[3] It identifies the skills and duties which are appropriate for a specific medical practitioner to render to the public in a safe, beneficial and effective way.[1] Additionally, everyone should hold him/herself accountable to a personal scope of practice which matches the individual skill set that the healthcare provider is competent to perform.[3] At times, what is advocated in a professional's scope of practice may differ from what is legally allowed in state's Practice Act. For example, the administration of Oxygen is allowed in a physical therapist's scope of practice but according to state law it is only acceptable with a physician's prescription. However, as an emergency medical responder, the use of Oxygen is advocated for many emergency situations. The above example illustrates how conflicts can arise when a medical provider possesses multiple degrees or certifications. Because each state's laws vary, it is very important as a medical provider to know the details of the state Practice Act in which you are residing and/or practicing.

Standard of Care

A professional's scope of practice identifies what services are appropriate to be delivered to the public, while the standard of care holds the provider accountable for the way these services are implemented. They are the accepted practices and norms of the profession. Individuals are responsible for practicing at the level of their peers in a specific specialty.[4] For instance, if you are a sports clinical specialist, (SCS) the care you provide must be equal to that of other SCS practitioners, not just a general physical therapist.[4,5] The designation of SCS identifies a physical therapist as possessing an expertise in the treatment of athletic injuries and therefore is held to a higher standard of care.[4] Currently, there are no national standards of care for the coverage of athletic events.[5] Often the framework for developing standards of care arise from common law statues in individual states, policies/position statements, and recommendations from governing medical organizations. In a malpractice lawsuit of an injured athlete, the actions of the defendant will be compared to the standards of sports medicine care: "what is reasonable and acceptable under similar circumstances".[4] Often expert witnesses, those with the same credentials, are consulted to assess the care that was delivered.

Duty to act

The legal responsibility to render care in an emergency is called the duty to act.[6] An individual or organization's relationship with the injured person and/or athlete determines the

accountability. Tort (civil) law in the United States upholds that any given person does not have a legal duty to assist, rescue or protect another individual from harm unless the aforementioned person was responsible for the accident or is the guardian of a minor.[7] Most states encourage a duty to act rather than have official mandates to the public.[8] In addition to state laws, there are specific situations that require a duty of act: contractual agreements, formal obligations, and continual assistance once medical care is initiated. A medical provider may be liable for abandonment if he/she stops the delivery of care or leaves the scene of an emergency.[6] Contractual agreements between sports medicine providers and athletic institutions by nature enforce a legal duty to act. An emergency medical responder, EMT, or paramedic have a formal obligation to provide services when their job requires them to be "on duty". Conflict may arise during an "off duty" emergency between legal duties and moral obligation. When a relationship has been established between a provider and an athlete, a formal duty to act also applies. Institutions like colleges, public and private high schools have a legal duty to act and provide reasonable care to their students.[5] The duties owed to an athlete include: adequate instruction, standard safety equipment, appropriate selection of participants, knowledgeable supervision, and proper post injury management.[4] High school personnel have a duty to obtain timely emergency care to the injured student athlete.[4] In order to ensure safe and effective management of athletic injuries, an emergency action plan (EAP) is developed prior to the beginning of the school year and maybe adjusted for each individual sport.

Consent

Prior to initiation of any type of care, informed consent must be obtained from the patient. The patient has a right to know the level of expertise of the provider and the benefits and risks of the care that will be implemented.[9] The patient responds to the request by giving expressed consent by verbalizing or gesturing he/she agrees to care.[9] If the patient is deemed unconscious, disoriented, or has impaired competence, implied consent is assumed based on the premise that most people in this situation would accept the assistance/care.[9,10] Impaired competence includes being under the influence of drugs or alcohol, diminishing level of consciousness and mental illness rendering an individual incapable of providing an appropriate answer. Typically, a state's informed consent laws are inapplicable if a delay in care while obtaining consent could cause an increased risk of harm or death.[8] Additionally, individuals also have the right to refuse care.[9,10] A refusal of care is dynamic and can change throughout the interaction.[9] If at any point the patient voices for care to stop, the provider must honor the request but is responsible for informing the person of the risks and consequences for cessation of care. EMS should still be contacted and notified of the events. Withholding of emergency care is warranted in the presence of a legal document such as an advance directive or do not resuscitate order. A verbal consent by a family member to withhold treatment without a legal document is insufficient.

When assessing or treating a minor, as defined by each state, a good faith effort is necessary to obtain consent from the legal guardian. Documentation of the effort is important. It is also recommended, when appropriate, to ask the child and/or adolescent for permission. If obtaining permission from the legal guardian would delay the implementation of care for a serious or life-threatening illness and/or injury, implied consent is enacted.[10] The American Academy of Pediatrics position statement supports that "all pediatric patients who are presented to the emergency department or emergency medical services for an evaluation and treatment receive a medical screening examination (MSE) regardless of the ability to pay or the presence of a legally authorized decision-maker who can provide consent."[10] The MSE is performed to identify serious medical illnesses or injuries which left untreated could result in death or disability. Federal Law under the Emergency Medical Treatment and Active Labor Act (EMTALA) "mandates an MSE for every patient seeking treatment in an ED of any hospital that participates in programs that receive federal funding, regardless of consent or reimbursement issues."[10] Therefore, healthcare professionals have the authority to provide emergency medical evaluations, care and transport to an appropriate medical facility to a minor without guardian consent.[10] Emergency medical care includes, but is not limited to. life saving measures, the treatment of fractures, infections, shock and pain.[10] Non-urgent and preventatives procedures should be withheld until given consent.

There are three exceptions in which consent is not warranted for a minor. They include: 1. emancipated minor, 2. mature minor exception, and 3. specific medical conditions.[11]A minor who is emancipated has proven to the state that one of these conditions applies: he/she is married, independent and economically self-sufficient, is active in the military and/or in some states is a parent or pregnant. The mature minor exception is implemented by the court when a teenager has proven the capacity and maturity to make appropriate decisions. Lastly, most states allow minors control of specific medical conditions like reproductive health and mental illness.[10,11] During either a natural disaster or a terrorist attack, attempts should still be made to obtain consent; however, as above, if delaying consent places the minor at increased risk or harm, implied consent is recognized.[10]

The Good Samaritan Law

The Good Samaritan law exists in all fifty states, District of Columbia and in many other countries.[8,12] Although the basic tenants are the same, the law varies greatly state to state. The law encourages aide to a fellow citizen in an emergency by limiting liability of the provider who acts in a reasonable manner, within their scope of practice and with the best interests of the injured or sick.[8,12,13] Practitioners who act with malicious intent, in a reckless or negligent manner are not immune from liability under this law. In some jurisdictions, the sports medicine provider who is not compensated for services rendered is covered under the Good Samaritan law.[13] The federal government has extended this law to cover domestic airline travel. To qualify as a Good Samaritan law, the intervention must occur during an emergency, outside a hospital

or medical facility and without compensation to the provider.[8] In addition to monetary gains, compensation could be viewed as any gift, food or self-promotion that is received by a volunteer for his/her services.[5] Items not covered under the Good Samaritan law may include a first aide booth, non-emergency treatment, routine care, pre-participation physicals, and return to sports evaluations.[13] Repairs of lacerations, treatment of sprains/strains and simple fracture care may be considered non-emergent.[13]

Negligence, Confidentiality and Liability

The legal tort of negligence requires the proof of four elements: 1. Duty to Act 2. Breach of Duty 3. Causation 4. Damages.[7,9]A breach of duty occurs when a provider who has a legal duty to assist, fails to act, or acts inappropriately outside the norms of standard of care.[7,9] A sports medicine clinician may demonstrate a breach in duty with the performance of an inadequate PPE, inappropriate advice regarding the nature and severity of the injury, withholding of information or negligent return to play decisions.[2] Causation is proven when a direct correlation between the breach of duty and the subsequent injury is established. Damages are both short and long-term consequences of the injury that result in harm, disability or death. In addition to being responsible for providing appropriate care, the emergency provider needs to be diligent in the management of confidential information and patient privacy. Confidential information includes a person's medical history, as well as the assessment and treatment performed. A signed release of information is often necessary, especially when communicating to parties outside the medical team. In circumstances of abuse, gun shots and certain infections and diseases, mandatory reporting of these incidences is required.[9] When practicing as an emergency responder or medical volunteer, there are personal steps each provider can take to minimize liability. Staying current with your professional knowledge base as well as federal and state laws is paramount. Understanding ever changing laws that govern the treatment of athletes which have had heart or heat illnesses is important for the sports medicine provider.[14, 15] Volunteering at events within your area of expertise is optimal. Take proactive steps and establish policies and procedures that protect the health and safety of the athletes in the form of an EAP. Ensure that appropriate staffing, venue safety and ample medical supplies are available.[2] Be cognizant, even in an emergency, to only perform interventions within your scope of practice. As a volunteer or paid provider, knowing how the event is organized and the role in which you are participating is important for identifying what type of insurance coverage is needed. Event liability insurance is purchased by the event organizers, but may not provide coverage against medical liability. Understanding and purchasing personal liability insurance may be necessary as a medical provider working/ volunteering outside his/her normal medical practice.[13] Currently, there are no federal provisions allowing licensed medical providers to cross state lines and practice or volunteer without restrictions. When practicing or volunteering out of state, investigate the state provisions that permit or deny your ability to provide care. Some states require a temporary or emergency license, while others required supervision from

an in-state licensed practitioner and strict state regulations only allowing emergency treatment to be performed that would qualify under the Good Samaritan law.[13] Most importantly, document everything and maintain a personal copy of the records. Document from the beginning of the emergency scene with the time of the event, details of the situation, consent or refusal to treat, assessment findings, intervention, response to treatment, and the condition of the individual during transition to the next provider.

Abuse, Assault and Sexual Violence

The International Olympic Committee, in its Consensus statement on harassment and abuse, defines "Safe Sport" as the "athletic environment that is respectful, equitable and free from all forms of non-accidental violence to athletes."[16] Unfortunately, the prevalence of various forms of abuse (psychological, physical and sexual) is too common in the sports culture of today requiring federal, state and institutional laws and policies to address its presence. Athletes of all ages, sport, ethnicity and culture are susceptible, with a noted increase in incidence among the young, disabled, elite and LGBT players.[16] Various governing bodies including but not limited to the International Olympic Committee (IOC), National Collegiate Athletic Association (NCAA), and US department of Health and Human services support and enforce the mandatory reporting of suspected abuse and neglect to the appropriate authorities. Mandatory reporters vary by state but generally include: teachers, athletic personnel and administrators, coaches, physicians and other healthcare practitioners who interact regularly with athletes. These mandatory reporters, in addition to EMS responders, are also responsible for recognizing the signs and symptoms of abuse and sexual violence outside the athletic environment. Many states have an anonymous tip line for reporting of child and elder abuse and neglect.[17] Institutions such as schools and health care facilities are also responsible to report suspected incidences to their respective state. Sexual violence is an umbrella term used to describe any type of unwanted, nonconsensual imposed acts of a sexual nature. It can include sexual assault, abuse, harassment or misconduct. The IOC defines sexual abuse as "any conduct of a sexual nature, whether non-contact, contact or penetrative, where consent is coerced/manipulated or is not or cannot be given."[16] Assault and battery is the unlawful touching of a person without given consent resulting in intentional physical arm and is also a reportable offense.

In 2014, the NCAA adopted the handbook *Addressing Sexual Assault and Interpersonal Violence: Athletics' Role in Support of Health and Safe Campuses* to promote a safe and hostile free environment for collegiate sports participants. The basic tenants are prevention, response, accountability and recovery for acts of sexual assault and interpersonal violence.[18] Prevention through yearly education on sexual violence is required for all athletes, coaches, administrators, medical staff and athletic personnel.[18] These participants are responsible for 1) complying with campus authorities and immediate reporting of suspected offenses 2) knowing and complying with federal and state statues regarding abuse, assault and neglect, etc. 3) cooperate but not interfere with investigations into suspected violations and 4) acknowledgement of established resources on campus for reporting incidents.[18] As health care practitioners practicing in the

athletic environment or in the community, it is important to recognize the signs and symptoms of abuse and neglect of the individuals in our care and know the appropriate channels for reporting according to individual institution and state statues.

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