

# Selected Issues in Injury and Illness Prevention and the Team Physician: A Consensus Statement

## DEFINITION

Prevention of injury and illness associated with athletic activity is one of the roles of the team physician (10,15). This process involves understanding the pathophysiology of the injury or illness, evaluating the known risk factors that influence the incidence of injury or illness, implementing interventions to minimize the influence of the risk factors, and recording the outcomes of the interventions.

## GOAL

The goal of this document is to help the team physician improve the care of the athlete by understanding and practicing methods of injury and illness prevention in specific sports medicine problems. To accomplish this goal, the team physician should have knowledge of general strategies of injury and illness prevention and implement these strategies for the following:

- Musculoskeletal injuries to the ankle, knee, elbow, and shoulder
- Concussion and cervical spine injuries
- Cardiovascular issues
- Heat-related illness
- Skin infection
- Equipment issues

## SUMMARY

This document provides an overview of selected medical issues that are important to team physicians who are responsible for the care and treatment of athletes. It is not intended as a standard of care and should not be interpreted as such. This document is only a guide and, as such, is of a general nature, consistent with the reasonable, objective practice of the health-care profession. Adequate insurance should be in place to help protect the physician, the athlete, and the sponsoring organization. This statement was

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developed by a collaboration of six major professional associations concerned about clinical sports medicine issues. They have committed to forming an ongoing project-based alliance to bring together sports medicine organizations to best serve active people and athletes. The organizations are the American Academy of Family Physicians, American Academy of Orthopaedic Surgeons, American College of Sports Medicine, American Medical Society for Sports Medicine, American Orthopaedic Society for Sports Medicine, and the American Osteopathic Academy of Sports Medicine.

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## GENERAL CONCEPTS IN RISK FACTORS AND PREVENTION STRATEGIES

The incidence of injury in sports medicine may be influenced by the presence of risk factors. Intrinsic factors may be physiological, biomechanical, anatomical, or genetic and may include previous injury, muscle weakness, inflexibility, imbalance, or kinetic chain breakage (injuries or other alterations in distant parts of the body, which affect function

in the local joint). They may also include psychological factors, which have been addressed in the Team Physician Consensus Conference series (13).

Extrinsic risk factors may be related to the inherent demands of the sport, such as the intensity and duration of play, or factors, such as environmental, conditioning, or equipment issues. They may influence the process of chronic injury or illness development, or they may influence the occurrence of an acute injury or illness. Specific programs that affect the intrinsic and extrinsic risk factors to alter or prevent illness and injury are limited. Of the programs that do exist, implementation is often a challenge. However, current studies have shown that a strategy of risk factor identification and process implementation to modify risk factors before athletic competition may reduce the incidence of some injuries or illnesses. These studies show that the prevention strategies should be as specific as possible to the injury or illness, athletic activity, or sport and need to be continued as long as the athlete is competing. A general format of prevention and risk factor modification strategies includes the following:

- Understanding the pathophysiology of the injury or illness.
- Understanding and implementing procedures for identifying risk factors.
- Implementing interventional processes to modify the risk factors to improve outcome.

Assessing medical history, family history, and exertional symptoms is relevant in developing prevention strategies in medical conditions

It is essential the team physician

- Understand basic concepts of injury and illness prevention.

It is desirable the team physician

- Set up policies and procedures to identify risk factors, implement intervention strategies, and quantify outcomes.
- Work with the athletic care network (see [15]) to educate athletes, parents, and coaches on the principles and practices of injury and illness prevention.

## EPIDEMIOLOGY

### Injuries

The type of injury and its related risk factors present various opportunities and methods of prevention. The National Collegiate Athletic Association (NCAA) Injury Surveillance Program (ISP) defines a reportable injury as one that occurs as a result of participation in an organized intercollegiate practice or competition and requires medical attention by a team athletic trainer or physician regardless of time loss (23).

At the high school level, the National Athletic Trainer Injury and Outcomes Network provides injury data that uses the same definition of injury as the NCAA (21). Additional high school data are available from High School Reporting Information Online, which defines injury as that which results in

restriction of the athletes' participation for one or more days (24) although concussions, dental injuries, fractures, and heat-related events are included regardless of time loss.

A source of consistent and systematic data of injuries sustained in collegiate sports from September 2008 to 2013/2014 is from ISP (23). High school data are available from June 2005 through 2013/2014 (24).

From these data, the following issues have been identified:

- Across most sports, reported injury rates continue to be significantly higher in competition than in practice.
- Non-time loss injuries account for more than half of all injuries.
- Lower-extremity injuries account for 49% and 46% of all practice and game injuries at the collegiate level and 51% and 48% at the high school level (21)
  - Ankle sprains account for 21% of lower-extremity injuries at the collegiate level and 16% at the high school level (21)
  - Anterior cruciate ligament (ACL) injuries are relatively infrequent (3% of all reported injuries) but are associated with significant loss of time from play.
    - At both high school and collegiate level, women's soccer, women's basketball, and men's football had the highest rates of ACL injury, with football reporting the greatest absolute number (24).
    - Patellofemoral pain and tendinopathy are frequent injuries, particularly in women.
- Upper-extremity injuries account for approximately 19% and 24% of all practice and game injuries at the collegiate level and 26% and 27% of all practice and game injuries at the high school level (21)
  - Shoulder injuries account for 27% of upper-extremity injuries at the collegiate level and 24% at the high school level (21).
- Head and neck injuries account for approximately 8% and 12% of all practice and game injuries at the collegiate level and 8% and 14% of all practice and game injuries at the high school level (21)
  - Concussions account for 6% of all injuries at the collegiate level and 4% of all injuries at the high school level (21). Overall, rates have increased during the sample period.
  - At the collegiate level, men's wrestling, men's ice hockey, men's football, women's soccer, and women's basketball had the highest rates of concussion. At the high school level, boys' football and ice hockey and girls' soccer and lacrosse had the highest rates of concussion (24).
  - Both the number and the rate of concussions have increased over the last 3 years. This may be due to improved diagnostic strategies and increased disclosure by student athletes.

- Caution must be taken when interpreting differences between the collegiate and high school data as study periods and distributions of reporting sports programs vary.
- Most head, neck, and spine injuries do not have catastrophic consequences.
  - Reported concussion rates are increasing at all levels of participation.
  - Twelve thousand spinal cord injuries occur each year in the United States; 10% are related to athletic events.
- According to the National Center for Catastrophic Sports Injury Research, football, gymnastics, ice hockey, wrestling, and cheerleading have the highest risk of catastrophic injury.
  - Forty-one total catastrophic injuries occurred in high school and collegiate sports in 2012/2013 (29 high school; 12 college) representing 0.53/100,000 participants.
  - Over a period of 31 years (Fall 1982–Spring 2013), 2101 catastrophic sports-related injury and illnesses were recorded; 80.8% occurred at the high school level and were directly attributed to activities of the sport (22).
- Ruptured aortic aneurysm (Marfan’s syndrome) (3% of athletes)
- Myocarditis
- Arrhythmias

Heat illness is sport- and environment-specific, most commonly occurring during preseason practices with the highest prevalence in football.

- Milder forms of heat illness are more common but may be underreported; more serious forms of heat-related illness are less common.
- One of the leading causes of death in the high school and college athlete.
- Race and ethnicity appear to be risk factors.

### Skin Infections

- Skin infections account for 21% of health conditions and injuries in collegiate sports and 8.5% in high school sports.
- In collegiate athletics, skin infections account for 1% to 2% of all time-loss injuries.
  - In college wrestling, the most common skin infections are Herpes gladiatorum (41%), fungal (22%), impetigo (14%), and bacterial, including methacillin-resistant *Staphylococcus aureus* (MRSA) (11%) (23).

### Medical Conditions

Sudden cardiac death (SCD) is a rare occurrence.

- Responsible for 16% of death among college athletes (8). Other causes of death included accidents (51%), suicide (9%), cancer (7%), homicide (6%), sickle cell (2%), and heat stroke (1%).
- Incidence of SCD in exercising high school and collegiate athletes is 2.3 to 4.4/100,000 per year in the United States.
  - The highest rate of SCD occurs in Division 1 men’s basketball (8,9).
  - Men and African American and Caribbean athletes are most at risk.
- Causes in young athletes include the following:
  - Hypertrophic cardiomyopathy (HCM) is the most common cause of sudden death in high school and college athletes and occurs more frequently in men and all African American athletes.
  - Commotio cordis is the second most common cause of sudden death in the youth athlete.
    - Most commonly occurs in baseball, lacrosse, ice hockey, softball, and other sports, as well as recreational activities involving projectile or direct blows to the chest.
    - Most commonly reported in boys between ages 7 and 16 years.
    - Fifty-three percent occur in competitive sports; 24% occur in recreational sports/activities.
- Other causes of SCD include the following:
  - Coronary artery anomalies (12% to 33% of athletes)

### MUSCULOSKELETAL INJURY PREVENTION

#### Inversion Ankle Sprains

Pathophysiology, including risk factors:

- Traumatic inversion injury upon landing (variable amount of injury to all structures)
- Although inversion ankle sprains are well recognized to cause injury to the anterior talofibular and calcaneofibular ligaments (ATFL and CFL), other injuries may occur and require particular attention, including the following:
  - Lateral or medial malleolus fracture, especially at the physis in the young athlete
  - Peroneal tendons dislocation and/or retinaculum tear
  - Talar dome osteochondral injury
  - Anterior tibio-fibular ligament injury
  - Fifth metatarsal avulsion injury
- High rate of recurrent injury
- Risk factors include the following:
  - Previous ankle injury
    - Ligamentous instability
    - Incomplete rehabilitation, decreased ankle dorsiflexion, and/or poor proprioception
  - Peroneal muscle weakness in injured or noninjured ankles.
  - Heel varus
  - Increased body mass index (BMI)

#### Injury Risk Reduction and Modification Evaluation:

- Athletes in running, landing, and cutting sports should have an evaluation, including the following:
  - History of previous ankle injury
  - Ankle ligament evaluation
  - Heel alignment
  - Ankle muscle strength and flexibility testing
  - Balance and core muscle control
  - Body mass index (BMI)

#### Injury Risk Reduction and Modification Interventions:

- Implement an education program and sport/activity conditioning program with periodization (10,17), including the following:
  - Local muscle strengthening with eccentric emphasis
  - Improve dorsiflexion range of motion
  - Motor control (including balance and core muscle control)
- Ankle bracing is effective for both primary and secondary prevention (19).
  - Ankle bracing is superior to and more cost effective than neuromuscular training for secondary prevention (18).
  - Ankle taping is effective for secondary prevention but may be less effective for primary prevention.
- Proprioceptive training is effective for both primary and secondary prevention of ankle sprain (27) and recommended in combination with ankle bracing or taping.

It is essential the team physician understand the following:

- Mechanism of inversion ankle sprains
- Structures other than ATFL and CFL may be injured.
- The usefulness of taping or bracing as well as proprioceptive training in primary and secondary prevention.
- The role of rehabilitation to decrease the risk of subsequent ankle sprains.

It is desirable the team physician

- Identify previous ankle injury and assess status of rehabilitation (10,17).
- Coordinate the implementation of a preseason conditioning program including balance training for all athletes in running, landing, and cutting sports (10,17).
  - Risk awareness education (e.g., increased BMI as a modifiable risk factor)
- Work with the athletic care network to educate players, parents, and coaches on the principles and practices of ankle injury prevention.

#### Knee Injuries: ACL

Pathophysiology, including risk factors:

- ACL injuries may occur in contact or noncontact injuries. Risk reduction and intervention strategies are more effective for noncontact injuries.

- In high school sports, football has the highest rate of ACL injury. In collegiate sports, women's soccer has the highest rate of ACL injury.
- In sports with the same rules, female subjects have a higher incidence of ACL injury than their male counterparts.
- Causes of noncontact ACL injuries are multifactorial (11).
- Risk factors include the following:
  - Neuromuscular variables (e.g., core and lower extremity strength, balance, flexibility, and muscle activation patterns)
  - Biomechanics (landing position)
  - Environment (e.g., playing surface, shoe interface)
  - Female
  - Anatomy
  - Family history
  - Increased BMI
- Noncontact ACL injuries occur commonly during deceleration, landing, or cutting. At-risk body positions during these maneuvers include the following:
  - Hip adduction and extension
  - Knee extension
  - Knee valgus position
  - Flat foot landing
  - Off-balance body position

#### Injury Reduction and Modification Evaluation

- Athletes in running, landing, and cutting sports should have an evaluation (10), including the following:
  - History of previous personal or family ACL injury
  - Lower extremity alignment (e.g., knee valgus)
  - Motor control (including core and lower extremity strength, balance, and flexibility)
- Other evaluation techniques may include the following:
  - Review of training surface and shoe type
  - Screening biomechanical analysis of jumping and landing

#### Injury Reduction and Modification Interventions

- Implement a sport-specific conditioning program with periodization (10), including these elements that have been shown to have efficacy in specific populations:
  - Motor control (including core and lower extremity strength, balance, and flexibility)
  - Technique training to include landing and sport-specific athletic skills programs
  - Risk awareness education
- Knee bracing is ineffective for primary and secondary prevention of ACL injury.
- Proper care of playing surfaces
- Sport- and surface-specific selection of shoe type

It is essential the team physician understand the following:

- The multifactorial nature of ACL injury mechanisms.

- Neuromuscular and educational interventions decrease risk of ACL injury.
- Female subjects are more at risk than male subjects in soccer and basketball.
- In high school sports, football has the highest risk of ACL injury.

It is desirable the team physician

- Identify previous ACL injury and assess status of rehabilitation.
- Evaluate for core stability, lower extremity strength, and motor control.
- Coordinate the implementation of a sport-specific conditioning program, including the following:
  - Motor control (including core and lower extremity strength, balance, and flexibility)
  - Technique training to include landing and sport-specific athletic skill programs
  - Risk awareness education (e.g., increased BMI as a modifiable risk factor)
- Coordinate the evaluation of the playing surface
- Advise on the selection of shoe type
- Work with the athletic care network to educate athletes, parents, and coaches on the principles and practices of ACL injury prevention.

## Other Knee Injuries

**Patellofemoral Pain.** Patellofemoral pain and dysfunction are multifactorial including malalignment, articular cartilage lesions, instability, soft tissue factors, and psychosocial issues (13). Few intervention programs for alteration and prevention have been shown to be effective.

Pathophysiology:

- Patellofemoral pain may occur in what seems to be an anatomically normal knee.
- Chondromalacia means degenerative cartilage and may have no relationship to symptoms of anterior knee pain.
- Structures in the anterior knee that may be involved include the following:
  - Patellar subchondral bone
  - Fat pad and synovium
  - Medial plica
  - Retinaculum
- Other structures that may cause anterior knee pain:
  - Patellar tendon
  - Apophyses (e.g., tibial tubercle, inferior patella)
  - Hip pathology
- Risk factors include the following:
  - Muscle weakness and/or imbalance and inflexibility, including hamstrings, quadriceps hip abductors, and iliotibial band
  - Trauma, overuse, training errors, and/or previous injury

- Patellar hypermobility
- Early sport-specific specialization
- Abnormal kinematics with jumping and landing
- Patellofemoral hypoplasia
- Increased femoral anteversion

- The contribution of static and/or dynamic malalignment of the pelvis, hip, knee, ankle, and foot to anterior knee pain is less clear.

Injury Reduction and Modification Evaluation:

- Athletes should have an evaluation (10), including the following:
  - History of previous lower extremity injury and rehabilitation
  - Present and anticipated volume of training and participation
  - Patellar and peri-patellar examination
  - Lower extremity alignment (e.g., femoral anteversion, knee valgus, and foot pronation)
  - Hip abduction, quadriceps, and hamstring strength
  - Quadriceps, hamstring, and iliotibial band flexibility
- Other evaluation techniques may include the following:
  - Review of training surface and shoe type
  - Screening biomechanical analysis of jumping and landing

Injury Reduction and Modifications Interventions:

- Implement sport- and activity-specific conditioning program with periodization (10), emphasizing hip abduction; quadriceps and hamstring strengthening; and quadriceps, hamstring, and iliotibial band flexibility.
- Other interventions include evaluation of playing surfaces and shoe type.
- As a secondary prevention strategy, avoid patellofemoral compression exercises (e.g., lunges, deep squats)

It is essential the team physician

- Understand the role of multiple risk factors and possible sites of pain in athletes with patellofemoral pain.
- Perform an examination that includes evaluation of quadriceps, hamstrings, hip abductors, and iliotibial band.

It is desirable the team physician

- Identify history of patellofemoral pain and assess status of rehabilitation.
- Evaluate for core stability and lower-extremity strength, flexibility, and alignment.
- Coordinate the implementation of a strength and conditioning program (10) for the core and lower extremity.
- Recommend shoe type for anticipated activity.
- Discuss surface selection for training and conditioning.
- Work with the athletic care network to educate athletes, parents, and coaches on the principles and practices of patellofemoral prevention.

## NONCONTACT SHOULDER INJURIES IN THROWERS AND OTHER OVERHEAD ATHLETES

Few intervention programs for the alteration and prevention of specific shoulder injuries have been shown to be effective.

### The “Disabled Throwing Shoulder” (DTS)

Pathophysiology, including risk factors

- DTS is a concept that describes findings associated with injury, pain, and/or decreased function in throwers and other overhead athletes. These findings include the following:
  - Anatomical injuries
    - Superior labral anterior to posterior (SLAP) tears and biceps tendon pathology
    - Other labral injuries
    - Rotator cuff pathology
    - Capsular injuries
  - Physiological deficits
    - Posterior rotator cuff weakness or fatigue
    - Altered shoulder rotation: isolated loss of internal rotation (glenohumeral internal rotation deficit or loss of total range of internal/external rotation)
    - Pectoralis minor inflexibility
    - Scapular muscle weakness inhibition or injury
    - Kinetic chain changes in core strength or flexibility
  - Alterations of biomechanical motions
    - Abnormal arm position in the overhead motion sequence
    - Scapular dyskinesis: alteration of scapular static position or dynamic motion
    - Alteration in coordinated kinetic chain segment motion, including altered timing of coordinated activation
  - Volume and intensity of overhead activity and throwing
  - Lack of adequate rest between throwing episodes
  - Previous injury in the shoulder or other parts of the kinetic chain
  - Shoulder muscle imbalance, most commonly posterior shoulder, muscle weakness, fatigue, or inflexibility
  - Alteration of hip motion, especially the loss of internal rotation
  - In youth baseball, increased number of pitches per game, innings pitched per season, months pitched per year.
  - In youth baseball, pitching while fatigued

#### Injury Reduction and Modification Evaluation

- History of any previous injury in the shoulder and relevant parts of the kinetic chain.
- Volume and intensity of training

- Examination of shoulder, including the scapula and kinetic chain
- When possible, coordinate the evaluation of the throwing, hitting, or serving mechanics, including the kinetic chain.

#### Injury Reduction and Modification Interventions:

- Educate athletes, coaches, and parents of the importance of the cause of overload injury and rest (10).
- Address identified deficits in the glenohumeral joint, scapula, and kinetic chain.
- In youth baseball, emphasize recommended pitch volume per game and per season and oversight of number of games played.
- Assessment for and encouragement of proper throwing or serving mechanics

It is essential the team physician understand the following:

- The importance of overload as a risk factor in shoulder injury and addressing load and rest in injury reduction and modification
- The importance of altered shoulder rotation and scapular dyskinesis as most prominent risk factors for DTS.
- Youth baseball players and other overhead athletes require specific oversight, including pitch volume.

It is desirable the team physician

- Identify previous shoulder injury and assess status of rehabilitation.
- Recognize multiple anatomic, physiologic and biomechanical factors may exist and contribute to DTS.
- Assess shoulder rotation, scapular function, and kinetic chain status.
- Assess throwing, hitting, or serving mechanics and interact with coaches to optimize the motion.
- Implement a program for evaluation and conditioning.
- Work with the athletic care network to educate athletes, parents, and coaches on the principles and best practices of shoulder injury reduction and modification.

### Elbow

Elbow injuries are becoming more recognized, especially in youth/adolescent overhead athletes. A point of specific concern is the increasing recognition of valgus overload injuries, resulting in ulnar collateral ligament (UCL) tears and subsequent reconstructions. Few intervention programs for the alteration and prevention of UCL injuries have been shown to be effective.

#### Pathophysiology:

- Partial or complete disruption of the anterior band of the UCL
- Clinical presentation may be an acute injury or an acute exacerbation of a chronic injury
- Other important causes of elbow pain:
  - Medial epicondylitis, apophysitis, and avulsion
  - Osteochondritis dissecans of the capitellum

- Risk factors include the following:
  - Volume and intensity of overhead activity
    - Pitches, hits, or serves
    - Events, games, or tournaments
    - Multiple leagues and/or teams
    - Length of season
  - Poor throwing, hitting, or serving mechanics
  - Tight or weak pronator and elbow flexor muscles
  - Shoulder and scapular dysfunction
  - Kinetic chain deficits, including hip muscle weakness and hamstring or quadriceps muscle tightness
  - Performing while fatigued
  - Early single-sport specialization

#### Injury Reduction and Modification Evaluation:

- Review of playing and throwing history to determine risk factors
- History of elbow, shoulder, and kinetic chain injury and rehabilitation status
- Examination of the elbow, including the shoulder and kinetic chain
- When possible, coordinate the evaluation of the throwing, hitting, or serving mechanics, including the kinetic chain.

#### Injury Reduction and Modification Interventions:

- Educate athletes, coaches, and parents of the importance of the cause of overload injury and the importance of rest (10).
- Address elbow flexibility and strength deficits
- Address identified deficits in the glenohumeral joint, scapula and kinetic chain.
- Implement a sport/activity-specific conditioning program with periodization of activity and incorporating rest intervals (10)
- In youth baseball, emphasize recommended pitch volume per game and per season as well as oversight of number of games played.
- In youth baseball, monitor fatigue.
- Assessment for and encouragement of proper throwing or serving mechanics

#### It is essential the team physician understand the following:

- Overload as a risk factor in UCL injury and addressing load and rest in injury reduction and modification.
- Other common injuries associated with valgus overload in the young athlete.
- Altered shoulder rotation and scapular dyskinesis as common risk factors for UCL injury.
- Avoidance of throwing, pitching or serving while fatigued.
- Youth baseball players and other overhead athletes require specific oversight.

#### It is desirable the team physician

- Identify previous elbow injury and assess status of rehabilitation.

- Assess shoulder rotation, scapular function, and kinetic chain status.
- Assess throwing, hitting, or serving mechanics and interact with coaches to optimize the motion.
- Implement a program for evaluation and conditioning.
- Work with the athletic care network to educate athletes, parents, and coaches on the principles and best practices of elbow injury reduction and modification.

## MEDICAL INJURY PREVENTION

### Cardiovascular Issues

#### Hypertrophic cardiomyopathy

##### Pathophysiology:

- Genetic mutations in beta-myosin heavy chain gene, cardiac troponin gene, or alpha-tropomyosin gene
- Autosomal dominant pattern of inheritance
- Characterized by left ventricular hypertrophy (LVH)
  - With or without left ventricle (LV) outflow tract obstruction
- Myocardial disarray on histology
- Sudden death most often secondary to arrhythmia is usually ventricular tachycardia (VT) or ventricular fibrillation (VF)
- Diagnosis made by electrocardiography (ECG) and echocardiography, cardiac magnetic resonance imaging (MRI). More than 90% demonstrate abnormal resting ECG.

##### Risk factors for sudden death:

- Family history of one or more HCM-related sudden cardiac deaths
- One or more episodes of unexplained syncope
- LVH greater than 30 mm
- Nonsustained VT on Holter ECGs.
- Hypotensive or attenuated blood pressure response to exercise.
- Other possible risk factors:
  - Akinetic thin-wall LV apical aneurysms
  - Delayed enhancement
  - Large ventricular septal scars

#### Arrhythmogenic right ventricular cardiomyopathy.

Five-fold risk of sudden cardiac death with arrhythmogenic right ventricular cardiomyopathy in competitive sports

##### Pathophysiology:

- Inherited myocardial disease due to gene mutations encoding cardiac desmosomal proteins
- Focal myocarditis with healing leads to fibrofatty replacement of myocardium and predisposition to VT or VF

##### Risk factors for sudden death:

- Previous cardiac arrest
- Unexplained syncope
- VT with hemodynamic compromise
- Extensive structural disease including LV involvement

## Coronary artery anomalies

Pathophysiology:

- Ischemia and/or arrhythmia, secondary to abnormal anatomy
- Most common in SCD are left coronary artery origins in the right sinus of Valsalva and right coronary artery origins in the left sinus of Valsalva
- Screening EKG is usually normal

Risk factors for sudden death:

- Vigorous exercise

## Ruptured aortic aneurysm (Marfan's syndrome)

Pathophysiology:

- Autosomal dominant disease of collagen due to genetic mutation encoding fibrillin causing weakening of the aortic wall (cystic medial necrosis), leading ultimately to aortic dissection/rupture.
- Physical stigmata (3)

Risk factors for sudden death:

- Vigorous exercise
- Aortic root dilatation

## Arrhythmias

Pathophysiology:

- Abnormalities in atrial or ventricular rhythm include the following:
  - Congenital causes such as Wolfe-Parkinson-White syndrome, long Q-T syndrome, Brugada's syndrome, exercise-induced VT, and catecholaminergic polymorphic VT
  - Acquired causes such as electrolyte disturbance, medications or drug use, myocarditis, and other cardiomyopathies.

Risk factors for sudden death:

- Vigorous exercise
- Chest wall trauma
- Unexplained palpitations
- Sudden change in environment (i.e., sudden immersion in cold water)
- Family history of juvenile sudden death or stress-induced syncope

Illness reduction and modification evaluation of HCM, arrhythmias, coronary artery anomalies, arrhythmogenic right ventricular cardiomyopathy, and ruptured aortic aneurysm (Marfan's syndrome):

- Family history of premature sudden death, especially first-degree relatives, and heart disease in surviving relatives
- Personal history of heart murmur, hypertension, excessive fatigue, syncope or near syncope with exertion,

exertional chest pain, and excessive exertional shortness of breath

- Physical examination of pulses, heart murmurs, blood pressure, heart rhythm, and stigmata of Marfan's syndrome

Illness prevention interventions of hypertrophic cardiomyopathy, arrhythmias, coronary artery anomalies, arrhythmogenic right ventricular cardiomyopathy, and ruptured aortic aneurysm (Marfan's syndrome):

- Screening essentials include personal history, family history, and physical exam (20)
- Additional testing and/or consultation
- Controversy exists for EKG screening in asymptomatic athletes. A growing number of organizations are including EKG screening. Specific EKG interpretation criteria have been developed.
  - Certain causes of SCD can be identified by EKG screening, including HCM, ARVD, long QT syndrome, Brugada's syndrome, and Wolf-Parkinson-White syndrome.
  - Screening asymptomatic athletes has consequences, including the cost of the screening, cost of additional testing and expertise, false positives (no significant cardiac disease identified), and false negatives.
- Modification or preclusion of activity in those with identified disease
- Emergency action plan for all practices and competition

It is essential the team physician understand the following:

- The major causes of and risk factors for SCD.
- The role of preparticipation examination in screening for cardiac conditions.
- The importance of an emergency action plan for all practices and competition (16).
- Exertional symptoms are particularly worrisome.
- Despite screening, SCD may be the initial presentation.

It is desirable the team physician

- Coordinate, evaluate, and review the preparticipation examination.
- Implement an emergency action plan that includes the on-site availability of an automated external defibrillator.
- Work with the athletic care network to educate athletes, parents, and coaches regarding the common causes of sudden cardiac death.

## Commotio Cordis

Pathophysiology:

- Blunt chest trauma over the cardiac silhouette during a vulnerable period of the cardiac cycle, producing arrhythmia in an otherwise normal heart.
- Dramatic increase in survival with early defibrillation (within 3 minutes).



- In animal studies, the hardness of the ball correlates to induction of ventricular fibrillation.
- Almost 30% of fatal events occur in organized competitive sports where athletes are already wearing chest protectors.

Risk factors for sudden death:

- Age (majority younger than 16 years)
- Competitive sport
- Recreational sport

Illness Reduction and Modification Evaluation:

- No known tests

Illness Reduction and Modification Intervention:

- Emergency action plan in place
- Age-specific safety balls
- Educate coaches and athletes that athletes should avoid taking a direct blow to the chest (e.g., stepping in front of the shot)
- Educate coaches and health-care providers to recognize commotio cordis
- Chest protectors have not been shown to prevent commotio cordis.

It is essential the team physician understand the following:

- The clinical presentation of commotio cordis.
- The importance of having an emergency action plan.
- The importance of age-specific safety balls for sports at risk for commotio cordis.
- Chest protectors do not prevent commotio cordis.

It is desirable the team physician

- Implement an emergency action plan that includes the on-site availability of an automated external defibrillator.
- Educate athletes, parents, and coaches about commotio cordis.

## HEAD AND NECK

### Concussion

See the “Concussion (Mild Traumatic Brain Injury) and the Team Physician: A Consensus Statement” (14). Since its publication, some studies have shown that in addition to functional changes, there are microscopic structural changes on advanced imaging. The greatest challenge remains in primary concussion prevention. There are some injury reduction and modification strategies for limiting primary and subsequent concussions.

Injury Reduction and Modification Interventions:

- Enforcement of existing rules and consideration of rule changes
- Promotion of fair play (2,25,29–31)
- Technique modification (e.g., tackling, checking)

- Practice and play modifications (e.g., limiting contact exposure in practice)
- Programs to improve neck strength and preparation for impact (28)
- Concussion policies and laws
- Athletes with signs and/or symptoms of concussion should not continue participation.
- Rigid helmets are designed to prevent skull fracture and major head trauma; they have not been proven to prevent concussion.
- Head gear, helmet modifications, and mouth guards have also not been proven to prevent concussion.
- Educate athletes, parents, and coaches on the importance of reporting symptoms of concussion.

It is essential the team physician understand the following:

- The recognition and management principles of concussion.
- Treatment should be individualized to limit the risk of subsequent concussions.
  - Manage young athletes more conservatively than adults.
- There is no equipment proven to prevent concussion.
- Concussion policies and laws

It is desirable the team physician

- Coordinate the implementation of concussion awareness and education programs for medical staff, athletes, parents, coaches, administrators, and officials, with emphasis on the importance of reporting concussion.
- Work with coaches and administrators to implement a concussion reduction and modification program and policy.
- Discuss and advocate for rule enforcement and changes, fair play, practice and play modifications, and legislative action.
- Provide postinjury instructions to athletes and others.

### Cervical Spine Injury

Few intervention programs for the alteration and prevention of cervical spine (c-spine) injuries have been shown to be effective.

Pathophysiology, including risk factors:

- Axial loading of the slightly flexed c-spine is the mechanism that most often causes permanent or transient spinal cord injury in sport.
- Transient quadriplegia is a c-spine injury associated with sensory and/or motor changes in all four extremities. Some cases present only with bilateral upper extremity sensory and/or motor changes. Risk factors include the following:
  - Previous episode of transient quadriplegia
  - C-spine instability, stenosis, and spinal cord changes
  - Improper technique (e.g., spearing/axial load)
- “Stingers” are compression or distraction injuries of the cervical nerve root or brachial plexus that produce

transient unilateral radiating pain, burning, paresthesias, and occasionally weakness in the upper extremity.

- They usually involve either the C5 and/or C6 nerve roots, or the upper trunk of the brachial plexus.
- Previous episode of a stinger is a risk factor (6,7)
- Congenital and surgical spinal fusion, depending on level and number of levels fused, may alter participation in collision/contact sports

#### Injury Reduction and Modification Evaluation

- Athletes should have an evaluation including the following:
  - History of c-spine injury or abnormality
  - C-spine and neurological examination
  - Consideration of additional testing and/or consultation

#### Injury Reduction and Modification Interventions

- Sport-specific techniques to prevent c-spine injury (e.g., Heads Up Tackling technique in football)
- Enforcement of existing rules (e.g., spearing in football, checking from behind in ice hockey, stunting in cheerleading)
- Management of the downed athlete
  - Initiate the emergency action plan (16)
  - Immobilization of suspected c-spine injured athletes.
  - Be aware of modified EMS guidelines and protocols in the local jurisdiction.
- Comprehensive rehabilitation may limit risk of subsequent stingers (17)
- The role of shoulder pad modification and neck rolls in football in preventing cervical stingers is unclear
- Education of coaches, parents, and athletes regarding the importance of rules and techniques

It is essential the team physician understand the following:

- Mechanisms and risk factors for c-spine injury
- The importance of having an emergency action plan
- Local EMS guidelines and protocols

It is desirable the team physician

- Coordinate emergency action plan.
- Incorporate local EMS providers in at least one annual practice of emergency action plan.
- Work with the athletic care network to educate athletes, parents, and coaches on prevention principles and practices for sports where c-spine injury is possible.

## HEAT ILLNESS

Physiology/Pathophysiology:

- Heat illness occurs on a spectrum, with the most severe form being heat stroke, which may be life threatening.
  - May occur anytime, but most likely to occur in hot, humid weather.
  - Results from an inability to dissipate heat.

- Heat production during exercise is 15–20 times greater than at rest.
- Mechanisms to dissipate heat include primarily evaporation, as well as conduction, convection, and radiation. Evaporation is more efficient in acclimatized individuals.
- Risk factors:
  - Extrinsic
    - Environment
    - Excessive physical exertion and multiple same-day sessions
    - Inadequate rest and access to hydration
    - Equipment (e.g., helmets, pads)
    - Tight-fitting, dark, and nonbreathable clothing
    - Medications (e.g., antidepressants, diuretics, anti-hypertensives, and antihistamines, attention deficit hyperactivity disorder drugs)
    - Supplements and energy drinks (stimulants such as caffeine)
    - Alcohol
  - Intrinsic
    - Previous history of heat illness
    - Increased BMI
    - Dehydration
    - Medical conditions (e.g., illness and fever)
    - Lack of acclimatization
    - Low fitness
    - Sickle cell trait
    - Spinal cord-injured athlete
- Recent data demonstrates young athletes do not have a higher risk for heat illness when adequate hydration is maintained.

#### Injury Reduction and Modification Evaluation:

- Athletes should have a thorough preseason evaluation, including the following:
  - History of risk factors
  - Evaluation of fluid intake
  - Evaluation of present and anticipated volume/intensity of training and participation
  - Evaluation of athlete's state of acclimatization
  - Screening for sickle cell trait
- Monitor prepractice and postpractice weight of athletes
- Emergency action planning to include access to on-site cooling
- Address clothing and equipment
- Monitor on-site wet bulb globe temperature and/or heat stress index (12).

#### Injury Prevention Interventions:

- Review practice parameters (i.e., time of day, intensity, duration, and frequency).
- Optimize acclimatization and hydration strategies for practice and competition (4,12).

- Allow sufficient recovery between repeated exercise bouts or closely scheduled same-day training sessions or rounds of sports competition.
- Modify and/or cancel sport-specific activities based on environmental conditions.
- Review medication/supplement use.
- Implement sport/activity conditioning program with periodization (10).
- Optimize clothing (loose-fitting, light colors, breathable fabrics for exercise in the heat) and equipment (minimizing equipment on days with excessive heat).

It is essential the team physician

- Recognize the spectrum of heat illness and at-risk individuals.
- Establish a reliable method to assess ambient temperature and humidity.
- Understand the need for rapid, on-site cooling with cold water immersion (1).
- Understand the importance of modifying work/rest ratios.
- Recognize the early warning signs of heat illness.

It is desirable the team physician

- Establish an emergency action plan to manage acute heat illness (16).
- Screen athletes at the time of preseason evaluation for risk factors for heat illness.
- Oversee acclimatization recovery and hydration practices.
- Assist in scheduling practices and events around times of increased potential for heat illness.
- Implement mechanism for rapid, on-site cooling. Cool first, transport second.
- Work with coaches in modifying work/rest ratios during activity
- Educate athletes, parents, and coaches regarding the early warning signs of heat illness.

## EQUIPMENT AND INJURY REDUCTION AND MODIFICATION

Equipment selections and modifications have been shown to reduce and/or modify injury.

- Rigid helmets are designed to prevent skull fracture and major head trauma; they have not been proven to prevent concussion.
- Head gear, helmet modifications, and mouth guards have also not been proven to prevent concussion.
- Mouth guards decrease the risk of dental and facial injury.
- Faceshields provide protection from facial injuries and lacerations.
- Protective eye wear in women's lacrosse is associated with decreased incidence of eye injuries.
- Chest protectors have not been shown to prevent commotio cordis.

- Based on laboratory data, age-specific safety balls are recommended for prevention of commotio cordis.
- Wrist guards have been shown to reduce wrist injuries in snowboarding and skating sports (26).
- Prophylactic knee bracing has not been shown to prevent ACL injury. Its efficacy is unclear in preventing medial collateral ligament injury.
- Shin guards decrease the incidence of tibia fractures in soccer.
- Taping or bracing is useful for primary and secondary prevention of inversion ankle sprains.
- Breakaway bases decrease the incidence of ankle injuries/fractures in softball and baseball.

## Skin Infections

Pathophysiology:

- Increasing frequency of antimicrobial resistance among infectious organisms is of great concern.
- The recent emergence of MRSA is of particular concern. It is increasingly reported in wrestling, fencing, and football.
- Although the overall incidence of skin infections is small, prevention is possible.
- Infections are spread by direct physical contact or transfer of infection from one part of body to another, fomites (equipment, mats), and compromised skin barrier.

Risk factors:

- Previous history of infection
- Compromised host immune status
- Sports with close contact
- Poor personal hygiene
- Body shaving
- Overuse of antibiotics
- Sharing towels, razors, and equipment
- Facility cleanliness

Illness Reduction and Modification Evaluation

Athletes should have an evaluation before participation including the following:

- History of previous communicable skin lesions and treatment
- Comprehensive assessment for skin breaks and wounds
  - Identification of type and location of current communicable skin lesions and treatment
- Hygiene practices should be assessed both in the athlete and in facilities.

Illness Reduction and Modification Interventions

- Routine surveillance is recommended in all sports, especially high-risk sports (e.g., wrestling, football, and rugby).
- To decrease transmission, withhold athletes with bacterial, viral, and fungal infections from practice/competition until adequately treated (23).

- Promote good hygiene with regular bathing and nail trimming, emphasizing showering as soon as possible.
- Immediate laundering of uniforms, towels, and equipment.
- Instruct athletes to dry area of lesion last before discarding towel.
- Wash hands regularly with soap and water or use alcohol-based hand gel.
- Avoid sharing equipment, uniforms, towels, clothing, bedding, bar soap, razors, and toothbrushes.
- Coverage alone is never appropriate as a primary treatment or prevention of spread of disease.
  - Coverage of skin lesions only after they are non-infectious to prevent secondary infection.
- Prophylactic medications should be considered for those with frequent outbreaks.
- Cleaning of equipment and other environmental surfaces with which multiple athletes have bare skin contact.
- Encourage student athletes to report skin wounds and lesions.
- Education of coaches, officials, and health-care practitioners regarding common skin infections.

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It is essential the team physician

- Understand management principles and risk factors for common skin infections.
- Recognize common skin infections that may be contagious or become secondarily infected.

Is it desirable the team physician

- Understand return-to-play guidelines for common infections and infestations.
- Maintain accurate and complete records of type, location, and treatment for each lesion.
- Coordinate hygiene practice guidelines for practice and competition, travel, and the training room.
- Understand the role and use of drug prophylaxis for in-season athletes with recurrent infections.
- Understand the efficacy of treating potential MRSA carriers to prevent spread of infection is inconclusive (5).
- Work with the athletic care network or to educate athletes, coaches, officials, parents, and other health-care practitioners on recognizing and reporting, identifying, treating, and documenting skin lesions in athletes.

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