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CLINICAL COMMENTARY, "ON THE SIDELINES"

MEDICAL SPORTS INJURIES IN THE YOUTH ATHLETE: EMERGENCY MANAGEMENT

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ABSTRACT

As the number of youth sports participants continues to rise over the past decade, so too have sports related injuries and emergency department visits. With low levels of oversight and regulation observed in youth sports, the responsibility for safety education of coaches, parents, law makers, organizations and institutions falls largely on the sports medicine practitioner. The highly publicized catastrophic events of concussion, sudden cardiac death, and heat related illness have moved these topics to the forefront of sports medicine discussions. Updated guidelines for concussion in youth athletes call for a more conservative approach to management in both the acute and return to sport phases. Athletes younger than eighteen suspected of having a concussion are no longer allowed to return to play on the same day. Reducing the risk of sudden cardiac death in the young athlete is a multi-factorial process encompassing pre-participation screenings, proper use of safety equipment, proper rules and regulations, and immediate access to Automated External Defibrillators (AED) as corner stones. Susceptibility to heat related illness for youth athletes is no longer viewed as rooted in physiologic variations from adults, but instead, as the result of various situations and conditions in which participation takes place. Hydration before, during and after strenuous exercise in a high heat stress environment is of significant importance. Knowledge of identification, management and risk reduction in emergency medical conditions of the young athlete positions the sports physical therapist as an effective provider, advocate and resource for safety in youth sports participation. This manuscript provides the basis for management of 3 major youth emergency sports medicine conditions.

Key words: youth sports injuries, sudden cardiac death, concussion, heat related illness, hydration

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INTRODUCTION

In the United States today, greater than 40 million children and adolescents participate in youth sports.[1,2] In 2001 there were 2.6 million emergency department visits by athletes from 5 to 24 years of age and 500,000 physician visits by high school athletes in the United States.[1] At that time, the estimated annual healthcare cost related to emergent care of the young athlete was two billion dollars.[1] As sports participation has risen, so too has the incidence of injuries across the spectrum of severity, from mild to catastrophic. In 2010, the National Athletic Trainers Association reported 50 fatal sports related injuries in children.[3] Currently across the United States there are multiple bills in legislation to prevent significant injuries to the youth athlete, however, as of 2010 only six percent have been enacted.[3] Three focus areas of concern are concussion, cardiac arrest, and heat illness.[3] With less than twenty percent of the 2 to 4 million youth athlete coaches in the United States receiving any formal training in coaching techniques, injury prevention, or first aid, the responsibility for emergency injury management as well as institutional, organizational, and community education is placed largely on the sports medicine practitioner.[2] This clinical commentary will assist physical therapists in the recognition and management of acute sports related medical injuries and conditions which require special attention in the youth athlete.

CONCUSSION

Concussion in sport (CIS) continues to be a highly publicized and discussed topic among the national media and sports medicine practitioners. Since 2001, there have been three international symposiums on CIS, however none with a pediatric focus.[4] Although the numbers of identified concussions occurring in the pediatric and adolescent population has continued to rise dramatically, appropriate management from acute injury to return to sport remains ill-defined and in its infancy. In 2010, the American Academy of Pediatrics (AAP) published a position statement on sports related concussions in children and adolescents thereby establishing basic management guidelines for the younger athlete.[4] The majority of these guidelines were adapted from the 2008 Zurich symposium.

The number of US emergency department visits for 14 to 19 year olds due to concussions has tripled from 1997 to 2007.[6,7] This group represented greater than forty percent of the concussions diagnosed in the emergency department during that timeframe and of those, between 30 and 58 percent were sports related.[6,7] It is important to recognize that due to under reporting of symptoms in this population and the challenges associated with identifying this syndrome, the number of youth concussions is likely far higher than statistics indicate. Additionally, the data on elementary and middle school athletes is lacking in completeness.

Management of the youth athlete with a concussion is a multi-step process. Identification, sideline assessment, referral, medical symptom resolution, and return to sport are all key components. An understanding of the syndrome assists in emergency care. A concussion is the result of a direct blow to the head, chin or face by a moving or stationary object. Indirect biomechanical forces as a result of acceleration/deceleration or rotational forces of the brain within the skull are also causative factors.[8] Recognition of a concussion is challenging as the seriousness of the syndrome is also not always consistent with the visualization of the injury and a young athlete's brain may be more susceptible to injury than the adult brain due to immature tissue development. Additionally, less than ten percent of those athletes with a concussion experience loss of consciousness (LOC).[4,8] Signs and symptoms of a concussion are listed in Table 1.

On field concussion assessment includes standard emergency care of airway, breathing and circulation assessment (ABC), as well as cervical and neurologic evaluation prior to moving the athlete to the sideline. (Figure 1) If the athlete is unconscious or reporting neck pain or neurologic symptoms, care for a cervical spine injury is necessary including facemask removal, appropriate spine boarding and transport to the emergency room.[9] Seizures which accompany the concussive event also mandate immediate transportation to the emergency department. Initial sideline assessment also includes a subjective history about symptoms and events prior, during, and after the injury to assess for both retrograde and ante grade amnesia, a neurologic exam, and balance testing. Continued monitoring, and reassessing for an exacerbation of signs and symptoms is recommended at 15 minute

Table 1. *Concussion Signs and Symptoms.*

Physical	Cognitive
• Headache • Nausea • Vomiting • Balance difficulty • Visual disturbance • Fatigue • Sensitivity to light and noise • Dazed • Stunned	• Foggy • Feeling Slow • Difficulty concentrating • Memory impairment • Confusion of current events • Slow processing • Repeated questions
Emotional	**Sleep**
• Irritability • Sadness • Labile Affect • Nervousness	• Drowsiness • Increased sleep • Decreased sleep • Difficulty falling asleep

Figure 1. *On field concussion assessment includes standard emergency care of airway, breathing and circulation assessment (ABC).*

intervals throughout the first hour, then intermittently through the next 24 to 48 hours with mandatory physician follow up care, preferably with a physician who specializes in concussion.[4,10] Various sideline assessment tools [Standardized Assessment of Concussion (SAC), Balance Error Scoring System (BESS), and Sport Concussion Assessment Tool 2 (SCAT2)] have been developed and implemented in adult athletes for concussion identification. The SAC test has shown good sensitivity and specificity outcomes, however, it has not been validated in the grade school athlete.[4] The SCAT 2 combines the BESS and SAC testing and is currently being studied with prospective outcomes currently unavailable. Neurologic testing includes the "three C's": cognition, coordination and cranial nerves.[10] Table 2 provides information regarding cranial nerve testing. The Glasglow coma scale may be utilized to identify a more serious head injury and a score less than 15 requires immediate referral to an emergency department. Addition-

Table 2. *Cranial Nerve Testing.*

CN II (Optic) – Visual acuity
CN III (Occulomotor) – Pupillary reaction
CN IV (Trochlear) – Eye movement
CN VII (Facial) – Smile/Grimace

ally, deterioration in health status which includes excessive vomiting, worsening headache, impaired balance and coordination or slurred speech also warrants an immediate referral to an emergency department. Following most concussion injuries it is typical for neurologic imaging to be unremarkable. Computed Tomography is indicated if the athlete presents with a cervical spine injury, skull fracture, decline in symptoms, seizures, suspicion of an intracranial bleed, or a LOC greater than 30 seconds. While LOC is a parameter for the determination of imaging, grading scales which use LOC as the predictors of severity are no longer utilized or recommended by the AAP.

In a young athlete, identification or suspicion of a concussion necessitates removal of the athlete from sports participation for the rest of the day and until further evaluated by a physician. Both cognitive and physical rest are paramount to the appropriate management of a youth athlete with a concussion. These measures insure maximal recovery of neural tissue. Most adult athletes with concussions become asymptomatic within a week of their initial injury; however the younger athlete often takes seven to ten days or longer to recover.[4] Additionally, because youth athletes are at elevated risk for a rare phenomenon known as second impact syndrome, a cautious return to sport is always recommended. Second impact syndrome appears to only occur in the pediatric and adolescent population and is the result of another concussive event to healing brain tissue prior to complete recovery of the initial injury.[5,8] While the second event can be seemingly minor, the compounded effects are frequently catastrophic with high morbidity and mortality rates.[5]

Once an athlete is asymptomatic at rest for twenty four hours, a symptom based approach is implemented for return to play with multiple tests used to identify whether symptoms have resolved. A clinical exam, neuropsychologic testing, balance and symptom reports at rest and with exertion are all used to identify concussion resolution and implementation of a return to athletics program. A five step sequence is used to progress the athlete safely back to sports participation. Progression to the next step occurs only if the athlete is symptom free for twenty four hours at the previous stage.[4] This process requires a minimum of five days. Refer to Table 3 for general guidelines of the progression.[4,8] In addition to physically challenging the athlete with a concussion, it is also important to challenge multiple

Table 3. *Concussion Return to Play Guidelines for the Youth Athlete.*

- Follows a sequential order
- Must be asymptomatic for 24 hours to progress to next level
- Symptom free with cognitive activity prior to start of physical activity

1. Light aerobic activity: light exertion, basic stretching and strengthening, simple balance exercises
2. Light to moderate exertion: increase aerobic endurance, low impact strengthening, movement and position changes
3. Moderate to aggressive exertion: impact activities, positional changes and head movement, unstable balance exercises, cognitive challenges, multiple system challenges
4. Functional Training: aggressive exertion, interval training, non contact sport specific exercises
5. Sport Specific Training: maximal exertion, high intensity, begin modified non contact practice
6. Gradual Return to play: practice prior to competition

The above table is adapted from the American Academy of Pediatrics guidelines and the University of Pittsburgh Medical Center concussion program.

Figure 2. *If predisposing cardiac factors of are identified in the youth athlete, further investigation via an echocardiogram is warranted.*

systems (cognition, balance, coordination) simultaneously. An example would be a reactionary agility drill which requires the athlete to sprint to different colored cones being called out by the therapist in random order with a pattern that mandates rapid, repeated directional changes. It is also important to tailor the rehabilitation program to the demands of the athlete's individual sport. For instance, a gymnast or figure skater needs to have the ability to spin or become inverted. A gradual asymptomatic progression into those activities would be required in that specific athlete's return to sport program.

SUDDEN CARDIAC DEATH

Sudden death in the youth athlete is rare, and when it occurs eighty five percent of the cases are attributed to cardiac emergencies.[11] Additional causes include heat illness, pulmonary disorders and drug induced system failure. About 50 combined high school and college cardiac deaths occur a year with a prevalence of 1:100,000 and 1:300,000 respectively.[11] The most common cause of cardiac death of athletes under the age of 30 is Hypertrophic Cardiac Myopathy (HCM).[11,12,13,14] In most cases, HCM is the muscular enlargement of the left ventricle and the septum with disorganization of the heart muscle fibers called myofiber disarray.[12,13,14] It is an inherited gene mutation that affects the heart muscle tissue and this dysfunction can lead to various cardiac complications which include: arrhythmias, blood flow obstruction, mitral valve problems, and sudden death. The symptomatology of HCM varies greatly among patients from uncomplicated health problems and daily lives to severe signs and symptoms of shortness of breath, chest pain or fainting.[12,13,14] Youth athletes who have HCM are at risk for cardiac arrhythmias during strenuous exercise mostly because they are asymptomatic and unaware they have a problem. When one family member is identified as having HCM, all close relatives are encouraged to undergo cardiac screening including an echocardiogram. For the youth athlete, ventricular hypertrophy is usually absent until early adolescence.[14] If predisposing factors are identified during a physician visit or a comprehensive pre-participation physical examination through family history, heart auscultation, and/or abnormal ECG findings, further investigation via an echocardiogram is warranted. (Figure 2) Any athlete suspected of having HCM is removed from participation until a complete cardiac evaluation is performed. An athlete with confirmed HCM is disqualified from most sports participation.[12,13,14]

Sudden death often occurs without symptoms or warning. The mechanism of cardiac arrest is due to heart arrhythmias of ventricular tachycardia and ventricular fibrillation.[12,13,14] Identification of athletes at risk, through pre-participation physicals,

access to quality medical care and observation of athletes who are showing signs of fainting, shortness of breath, or significant fatigue during sports participation is the key to prevention. When on the sidelines, the pre-established emergency response action plan for the event and the location of the nearest AED need to be known by all sports medicine personnel who are responsible for the care and safety of the athletes at that time. Immediate recognition and implementation of the EMS with initiation of CPR and AED is critical to survival.

Commotio Cordis is another cause of sudden cardiac death in the youth athlete. The instances are rare but catastrophic, with a survival rate of fifteen percent.[14] It is estimated that one in 200,000 high school athletes will die as a result.[15] Commotio Cordis is triggered by a direct blow to the chest wall over the heart with the exact timing of repolarization just prior to the "T" wave peak eliciting instantaneous cardiac arrhythmias. Blunt force to the chest wall can be caused by a baseball, softball, hockey puck or another athlete. Young male athletes between the ages of 5 to 15 appear to be the most at risk. Unlike HCM, commotio cortis occurs in healthy athletes with no cardiac pathology.[15,16] The narrow, under developed and pliable chest wall of the youth athlete has been identified as a plausible contributor to the mechanism.[15,16] The amount and rate of chest wall compression are also factors.[15] The highest incidences of injury are associated with those athletes who compete in baseball followed by hockey, lacrosse, soccer, softball, and karate. Upon impact, at the specific time in the heart rhythm cycle, various arrhythmias can result such as ventricular fibrillation, ventricular tachycardia, brady arrhythmias, and idio ventricular rhythm. The athlete collapses immediately and prompt CPR and defibrillation is necessary for survival. According to the American Heart Association, each minute in delay of treatment decreases the chance of survival by ten percent.[15] Injury prevention strategies include age appropriate safety balls, chest protectors, playing with children of comparable size and skill level, and AED accessibility.[15,16] Although the above strategies are not without limitations, they should facilitate a dialogue amongst parents, coaches, lawmakers and sports medicine practitioners on better preventative techniques.

DEHYDRATION AND HEAT-RELATED ILLNESS

Exertional heat illness encompasses a broad spectrum of conditions from muscle cramps to heat exhaustion and heat stroke. For the young athlete, these clinical manifestations are the direct result of physical activity in hot and humid temperatures when the body has become dehydrated.[18,19] Heat stroke is the third highest exercise-related cause of death in high school students in the United States and thousands of emergency department visits a year are due to heat related illness.[20] High rates of morbidity and mortality occur in athletes with symptoms of heat stroke if appropriate emergency management is delayed. Signs and symptoms of the heat illness spectrum are listed in Table 4. Acute management of heat related illness varies according to the severity of presentation, although general principles are similar in the heat illness spectrum. Refer to Table 5 for general management guidelines. For heat cramps, active stretching and massage are recommended while the athlete is rehydrating. Cautious return to play is advised only if complete resolution of symptoms and hydration are achieved. If the athlete is participating in multiple exercise sessions throughout the day, repeated bouts of muscle cramping should exclude the athlete from returning to play. Heat exhaustion is a more serious condition which requires prompt removal from participation. Hydration and body cooling are necessary to prevent further rise in core temperature. If the athlete is too disoriented to safely ingest fluids, or becomes unconscious, immediate transportation to a medical facility is warranted. Heat stroke occurs when the core body temperature rises to 104°F (40°C) or greater as the body's thermoregulatory and central nervous systems collapse. It is a medical emergency and the Emergency Medical Services (EMS) is to be activated. Aggressive cooling of the body is necessary and cold water immersion is best. Alternative cooling methods are the use of a hose/sprinkling system and ice bags to the groin and under the armpits.[19,21,22]

The susceptibility of the young athlete to heat related illness was previously thought to be a result of deficiencies in thermoregulation, a large surface to mass ratio, an increase in metabolic heat production, and a decreased ability to perspire.[17,18,20] However, new research has demonstrated that when environmental

Table 4. *Spectrum of Heat Illness.*

Heat cramps and dehydration: Cautious return to play

- Muscle cramps
- Thirst
- Fatigue
- Light-headedness
- Sweating
- Flushed face

Heat Exhaustion: Remove from play

- Dizziness
- Rapid pulse
- Headaches
- Nausea
- Vomiting
- Loss of coordination
- Profuse sweating
- Core temperature less than 104°F (40°C)

Heat Stroke: Medical emergency, Call 911

- Core temperature of 104°F (40°C) or higher
- Hot dry skin
- Multiple system failure
- Delirium
- Convulsions
- Abnormal vital signs

Table 5. *Guidelines for the Treatment of Heat Related Illness.*

- Remove athlete from participation
- Hydrate with water or sports drink
- Cool the athlete
  - Move to shaded area
  - Remove gear
  - "Fan"/circulate air
  - Apply water to skin ("mist" with a spray bottle as an example)
  - Change clothing
- Monitor status

conditions, physical exertion and dehydration are kept constant, adults and children respond similarly to heat.[17,21] Rectal, skin temperatures, and cardiac performance have been shown in newer studies to be comparable in both populations.[19] Therefore, the premise that youth athletes are more susceptible to heat-related illness because of their immature physiologic systems is being proved inaccurate and is no longer recognized

Table 6. *Heat Illness Prevention Strategies*[19,21,23]

Athlete responsibility	Coaches, athletic directors responsibilities
• Begin participation euhydrated • Be healthy • Be well rested • Absent of fever or infection • Wear sunscreen • Wear lightweight, light color, breathable clothing	• Heat index • Emergency response plan • Provide rest/ hydration breaks every 20 to 30 min • Wear only necessary safety equipment • Helmet removal while on the sideline • Acclimatize athletes • Allow deconditioned athletes to exercise as tolerated • Provide shade, ice and water for cooling • Design tournaments with longer breaks • Change times, postpone or cancel competition if heat index dangerously high

as a reason for heat-related illness by the AAP.[17] Instead, the circumstances and conditions of youth athletes participating in high heat stress environments appear to be the predisposing factors for heat illness as compared to adults.[17,21] Retrospective studies demonstrate that athletes respond differently to heat stress at various temperatures. Individual factors that increase the risk for heat related illness include decreased physical fitness, non-optimal body weight, lack of acclimation, dehydration, medications, infection, fever, and other complicated medical problems.[17,21,22] Environmental and situational conditions which put the youth athlete at risk include high humidity and heat, high heat index or wet bulb-globe temperature, decreased air motion, decreased access to shade, a sudden heat wave which does not allow time for acclimation, too much clothing or athletic equipment, multiple practice sessions or games in the same day or back to back days, and inappropriate access to rest and rehydration. Although heat related illness can be serious, it can also be prevented with alterations in the above individual, environmental, and situational circumstances.[17,21,22] Special attention should be paid to the heat index, which is a measure of environmental temperature and humidity for helping to determine if it is safe to play. Refer to Table 6 for prevention strategies.

Hydration

Maintaining optimal hydration status (euhydration) before, during and after athletic participation is necessary for assisting in prevention of heat related illness, optimizing performance, and aiding in recovery. (Figure 3) Small amounts of weight loss in children (one and two percent) due to fluid loss can have a significant negative impact on physiologic function and performance.[17] Keeping the youth athlete hydrated is challenging. Often by the time a young athlete recognizes the sensation of thirst, the body can be dehydrated by one to two percent.[21] Signs and symptoms of dehydration include thirst, dry mouth, fatigue, headache, dizziness, irritability, and muscle cramps. Youth athletes should be encouraged to drink even when they are not thirsty. Providing fluids that the athlete enjoys optimizes hydration. It has been demonstrated that adding flavoring to water increases consumption by forty five percent.[18] A six to eight percent carbohydrate solution made with glucose appears to be ideal in many settings.[17,21] In general, for activities lasting less than an hour, water is best, and activities that last longer than an hour or occur through multiple sessions in a day, a carbohydrate drink with electrolytes is recommended. Diluting a pre-made sports drink with a one to one ratio of water to sports drink is often more palatable for younger children.[17,18,21] Fruit juice, soda and other carbonated beverages can have a negative impact on the GI system and should be avoided. Identifying the best combination of fluid intake for each individual athlete should be practiced prior to competition to maximize hydration and avoid unexpected complications such

Figure 3. *Maintaining optimal hydration status (euhydration) before, during and after athletic participation is necessary for assisting in prevention of heat related illness.*

as gastrointestinal upset. General fluid intake guidelines for children and adolescents are listed in Table 7. Caffeine, found in carbonized beverages and energy drinks should be considered an erogogenic aid and therefore should be used with caution in this population as it can also negatively impact performance. Physiologic effects of excessive intake are increased heart rate and blood pressure, heart palpations, tremors and altered sleep patterns.

CONCLUSION

Sports injuries in youth athletes are a leading reason for sports participation attrition, along with pressures from coaches, parents and peers.[2,23] It is estimated that between 70 and 80 percent of youth athletes stop playing sports before high school. Statistics illustrate that only one in four younger star athletes become elite players in high school and only 1 in 16,000 high school athletes advance to professional status.[2] Given this information it is likely that the focus in youth athletics should be to emphasize fun and long term involvement in exercise and sports. For a young athlete who has the potential for many years of sports participation in the future, the risks of returning him/her to competition or practice on the same day of a medical incident far outweigh the short term perceived benefits. Therefore, a knowledgeable and conservative approach to the care and prevention of youth athlete emergent sports medical injuries and conditions optimizes successful acute management and promotes the likelihood of long term sports participation.

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Table 7. *Hydration Guidelines for Adolescents and Children*[17,21]

- Preparation: 20 min before
  - Adolescent: 8 to 10 oz
  - Children: 4 to 8 oz
- During participation
  - Adolescent: 6 to 12 oz every 20 min
  - Children: 4 oz every 20 min
- After: Rehydrate
  - Adolescent: for every pound loss replace with 20 to 24 oz
  - Children: for every pound lost, replace with 16 to 20 oz

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