Athlete at Risk Conditions CEU Summation Article

INTRODUCTION

As a strength and conditioning coach (SCC), your student-athletes' safety is predicated on communication with sports medicine personnel, athlete monitoring/observation, and knowledge of how to adjust programming. SCC's need to be aware of various classifications of risks to athletes such as: acute injuries (e.g., concussions), exertional (e.g., rhabdomyolysis), and pre-existing (e.g., sickle cell trait) -- all of which require awareness of signs and symptoms, at-risk training, and the steps necessary to improve safety. The review of any physical conditions that may be exacerbated or which may place an athlete at risk of hospitalization or death must be assessed by the sports medicine team and physician.

The NCAA and several other athletic and medical organizations have also worked diligently to provide university athletic programs and their coaching staffs with guidelines and best practice recommendations to reduce the incidence of non-contact-related injuries and sudden death. While the likelihood of a college athlete suffering a potentially fatal event has always been, and remains minimal, strength and conditioning professionals must be cognizant of the fact that the number of deaths and hospitalizations have increased significantly, with 35 such events in the past two decades (CSCCa/NSCA consensus document). The SCC must be made aware of the specific condition(s) an athlete may have, as well as the causation of symptoms. In addition the SCC must have the ability to recognize symptoms and follow emergency action plans should an athlete succumb to the conditions.

EMERGENCY ACTION PLANS (EAP)

Emergency action plans need to be specific to each athletic facility and venue (e.g., weight room, locker room, gym, individual practice fields). At a <u>minimum</u>, each EAP is required to be reviewed and practiced annually and include the following:

- the scheduling and training of likely first responders in first aid, cardiopulmonary resuscitation (CPR),and automated external defibrillator (AED) use (this includes all primary health providers such as athletic trainers and team physicians, the athletic director and director of medical services, and all strength and conditioning coaches).
- the nearest location of necessary emergency equipment and supplies (e.g., AEDs, ice chests)
- the nearest location of telephones and the communication plan to be used to contact local emergency medical services (EMS) and pertinent university personnel (e.g., athletic director).

- Identification by name of the person(s) responsible for the documentation of all personnel training, equipment maintenance, policies and procedures, actions to be taken during an emergency, and evaluation of any response.

The EAP should be coordinated with the university's campus police and emergency services, the local EMS agency, and the local hospital and should undergo consistent review and practice (CSCCa/NSCA Consensus document).

The NCAA interassociation consensus statement on cardiovascular care of student athletes also describes the following important components of the EAP to help reduce of the risk of death by cardiac arrest:

- It is important the EAP establish an effective emergency communication system and that this system be in place before the beginning of the academic year (Hainline et al., 2016).
- There should be easy access to an AED in the immediate vicinity (within a 3-minute walk) with the AED checked for readiness to use prior to each practice or competition (Hainline et al., 2016).
- Signage is clearly visible and strategically placed to indicate the location of each AED.
- AED's are never behind locked doors and are checked at least monthly (with appropriate sign-off maintenance record) for proper battery charge and functional electrode pads.
- Emergency medical service entry and exit are pre-determined and secured.

SPECIFIC CONDITIONS

While the three most relevant and potentially fatal conditions are sudden cardiac death (SCD), exertional heat stroke (EHS), and exertional rhabdomyolysis (ER) (CSCCa/NSCA Consensus document), this manuscript highlights the primary domains of six different physical conditions that place athletes at a higher risk of injury/death during strength and conditioning sessions. A brief summary of key principles from the CSCCa/NSCA Consensus document on transition periods and safe return to training is also presented.

CONCUSSIONS

Concussions are the result of a traumatic impact to the brain inside the skull that results in the loss of training and competition time, and potentially hospitalization. It can also impact other health conditions. The diagnosis and management of sport-related concussion is challenging for many reasons. The results of physical and cognitive examinations are often normal as are those of additional tests such as brain computerized tomography, brain MRI, electroencephalograms, and blood tests. The clinical effects of sport-related concussion are often subtle and difficult to detect with existing sport-related concussion assessment tools. “Signal detection” in clinical measures (e.g., cognitive and balance testing) often quickly diminish in the acute setting of early recovery. Although cognitive function and balance assessed within 24 hours with various sideline tests (Standardized Assessment of Concussion and Balance Error Scoring System, respectively) have been shown to be useful in diagnosing concussion, these tests often normalize within a few days and cannot be used to make a definitive diagnosis. Student-athletes may under-report symptoms and inflate their level of recovery in hopes of being rapidly cleared for return to competition. It is important to understand, however, that when a student-athlete does not report symptoms for treatment at the time of injury, return to play is delayed. A study by the NCAA showed that delayed reporting of concussion symptoms revealed about a five day longer return to play (NCAA concussion best practices).

Concussion risk is multi-faceted and is in large part brought about by repetitive contact/collision forces coupled with limited recovery time, which is one of the reasons that the majority of concussions in football occur during preseason. A brain that is primed from repetitive head impact may be more susceptible to developing a concussion than a brain that has not had repeated exposure. Interestingly, neck strength appears to be an important physical attribute that is correlated with a reduction in concussion occurrence (Collins et al., 2014), although no single physical attribute can prevent concussion.

Athletes that sustain a concussion can experience headaches, dizziness, impaired movement, susceptibility to fatigue, dysfunction in the autonomic nervous system, and reduced cognitive ability (Alsco et al., 2012; Costello et al., 2018; National Collegiate Athletic Association 2016). Athletes that have had previous concussions may be susceptible to other risks as stated by Alsoco et al, (2012), “Athletes with a history of concussion reported a greater number of symptoms associated with exertional heat illness (EHI) than those without such a history.” Once an athlete has entered collegiate athletics, he/she should be part of a management plan as outlined by the National Collegiate Athletic Association (2016) that includes education, pre-participation assessment, recognition and diagnosis of concussion, and post-concussion management.

CONCUSSION MANAGEMENT PLAN

The NCAA concussion best practices document suggests the following steps for a concussion management plan:

1. Education – concussion fact sheets and other applicable education material should be provided to student-athletes, coaches, team physicians, athletic trainers, and athletic directors *annually*.
2. Pre-participation assessment – should include a brain injury/concussion history, symptom evaluation, cognitive assessment, and a balance evaluation.

3. Recognition and Diagnosis of Concussion – All student-athletes who are experiencing signs, symptoms, or behaviors consistent with a sport related concussion, at rest or with exertion, must be removed from practice or competition and referred to an athletic trainer or team physician with experience in concussion management. A student-athlete diagnosed with sport-related concussion should not be allowed to return to play in the current game or practice and should be withheld from athletic activity for a day (24 hours) to allow for more definitive medical assessment.
4. Post-concussion management – Such management includes but is not limited to clinical evaluation at the time of injury. When a rapid assessment of concussion is necessary (such as during competition), the following should be performed: a symptoms assessment; a physical and neurological exam; and a balance exam. The Sport Concussion Assessment Tool 3 (SCAT3) should also be implemented and the results compared to the athlete's baseline evaluation. Transportation to the nearest hospital should occur if: the athlete exhibits a prolonged loss of consciousness (longer than 1 minute) or a focal neurological deficit; repeatedly vomits; his/her mental state or other neurological signs appear to worsen; or there is suspicion of a potential spine injury.

RETURN TO ACTIVITY AND RETURN TO PLAY FROM CONCUSSION

Unlike other injuries, the timeline for return to play from concussion is often difficult to project. The return to play decision is based on a protocol of step-wise increases in physical activity that includes both an incremental increase in physical demands and contact risk supervised by the physician or physician-designee. Initial management always includes both relative cognitive and physical rest. The return to play progression cannot be initiated until the student-athlete has returned to his/her baseline level of symptoms, cognitive function, and balance. The return to play progression should follow the suggested general outline listed below:

1. Light aerobic exercise (walking, swimming, or stationary bike). No resistance training. If asymptomatic with light aerobic exercise, then;
2. Sport-specific activity with no head impact. If asymptomatic, then;
3. Non-contact sport drills and resumption of progressive resistance training. If asymptomatic with non-contact drills and resistance training, then;
4. Unrestricted training. If asymptomatic with unrestricted training, then;
5. Return to competition. Medical clearance will be determined by the team physician or physician designee or the athletic trainer in consult with the team physician.

EXERTIONAL RHABDOMYOLYSIS (ER)

Athletes that are detrained, unaccustomed to training, or below their baseline fitness level are more susceptible to *exertional rhabdomyolysis* (ER), especially when the programming has high training volume, an over-emphasis on eccentric exercises, inadequate rest between exercise bouts, or training in an extreme heat environment (Asplund et al, 2016; Ebereman et al, 2011). SCC's should be observant if athletes are demonstrating: greater than usual signs of muscular stiffness; fatigue and/or pain; difficulty standing from a ½ kneeling position; the inability to urinate or the presence of coffee colored urine; and possibly loss of mobility, as these can be indicators of ER (Asplund et al, 2016; Ebereman et al, 2011; National Collegiate Athletic Association, 2014). Exertional rhabdomyolysis is the result of trauma and the breakdown of skeletal muscles that release muscular biochemicals (e.g., creatine kinase, myoglobin) into the blood stream, stressing the kidneys (Asplund et al, 2016; Ebereman et al, 2011; National Collegiate Athletic Association, 2014). Blood tests for creatine kinase, a product of muscle breakdown, are most commonly used to help diagnose ER. Urine tests for myoglobin can also help diagnose rhabdomyolysis (although in half of the athletes with ER, the myoglobin is negative) (CSCCa Consensus document). When occurring in association with heat stress, cardiac arrhythmias are also likely.

EFFECT OF EHI AND SICKLE CELL ON RHABDOMYOLYSIS RISK

It should not be surprising that ER is highly correlated with EHI as both conditions can result when blood flow is shunted away from exercising skeletal muscle and towards the surface of the skin to dissipate heat as the body attempts to thermoregulate (20). Athletes who have the sickle cell trait may also be at increased risk for ER as the odd-shaped sickle red blood cells have a tendency to block small vessels, leading to ischemic rhabdomyolysis (48). Interestingly, the military tied sickle cell trait to sudden death during recruit basic training. They reported that recruits with sickle cell trait were 30 times more likely to die during basic training. The main cause of death was rhabdomyolysis – and the risk of exertional rhabdomyolysis was about 200 times greater for those with sickle cell trait (NATA Consensus statement Sickle Cell Trait).

MANAGEMENT OF RHABDOMYOLYSIS

If the physical symptoms of ER are not treated, severe kidney damage and even death is possible. Athletes who develop the symptoms associated with ER need to be quickly admitted to the hospital. Treatment with IV fluids helps maintain urine production and prevent kidney failure. Large volumes of water are often administered to rehydrate the body and flush out any myoglobin. Dialysis may be necessary to help the kidneys filter waste products while they are recovering.

SCC's should be aware that athletes with sickle cell trait have a greater chance of suffering from ER with improper programming (Asplund et al, 2016). As programs are developed and implemented, they should be reviewed for appropriate work- to-rest ratios that allow for adequate muscular recovery and for progression to higher training intensities such as increased repetitions (Asplund et al., 2015; Casa et al., 2012). College athletes returning from a period of inactivity or detraining are the group most susceptible to developing ER (CSCCa/NSCA Consensus document). Athletes with a previous incident of ER should be classified as high risk by the sports medicine staff so the SCC can be more attentive to these athletes (Asplund et al., 2015; Casa et al., 2012). When training high-risk athletes, those returning from ER, or following a transition period (e.g., summer break), the SCC should avoid introducing non-planned exercises and should offer gradual increases in the return to training loads, being careful not to over-emphasize eccentric muscular actions. Use of extra drills or exercise to determine the "toughness" of an athlete should be avoided (Casa et al., 2012; National Collegiate Athletic Association, 2014). Furthermore, any use of activity as a method of punishment or discipline can increase the chance of ER, especially when those activities are performed at a greater volume or intensity than normal training (Casa et al., 2012).

Programs should be progressed based on an athletes' improvements from the training over a period of several weeks (also see the CSCCa recommendations for the 50/30/20/10 Rule), while expectations of achieving conditioning in several days should be avoided (National Collegiate Athletic Association, 2014). The practice of "pushing" an athlete after fatigue has diminished performance can increase the chance of ER and should be avoided by the SCC (National Collegiate Athletic Association, 2014). Athletes returning from prolonged inactivity should be provided an appropriate level of training volume and intensity during these transition periods. SCC's should be aware of the increased risk of developing ER for an athlete who has previously experienced an exertional heat illness (EHI).

EXERTIONAL HEAT ILLNESSES (EHI)

Exertional Heat Illness can come in one of two primary forms: *Heat Exhaustion* (HE) or *Exertional Heat Stroke* (EHS). Both HE and EHS are a result of developing hyperthermia – elevated body temperature. Exertional Hyperthermia is defined as a core body temperature above 40^0 C (104^0 F) (Armstrong et al., 2007). Hyperthermia is generally considered the pre-cursor for developing HE. *Exhaustion* is a physiologic response to work and is defined as the inability to continue exercise. Exhaustion can occur with heavy exertion in all temperature ranges, but occurs more quickly in hot and hot/humid environments. When physiologic exhaustion results in collapse, the clinical syndrome is often referred to as heat exhaustion (Armstrong et al., 2007). In controlled laboratory studies, pre-cooling the body will extend the time to exhaustion, and pre-heating will shorten the time to exhaustion, but in both circumstances athletes tend to terminate exercise due to fatigue at a rectal temperature of about 40^0 C.

Heat exhaustion should be a protection mechanism for athletes to reduce the risk of developing EHS. This is because once exercise is stopped, exercise-induced metabolic heat production decreases while heat dissipation to the environment increases.

EHS is defined in the field by rectal temperature >40^{0}C at collapse and by central nervous system disturbances, as well as multiple system organ failure. Almost all EHS patients exhibit sweat-soaked and pale skin at the time of collapse, as opposed to the dry, hot, and flushed skin that is described in the presentation of non-exertional (or classic) heatstroke. This level of heat exhaustion will also exhibit lower blood pressure as well as increased heart-rate and respiration.

MANAGEMENT OF EXERTIONAL HEAT STROKE

A SCC must recognize EHS as a life threatening medical emergency in which the first thing to be done is to begin immediate whole body cooling. Cooling should be initiated first and, if there are no other life-threatening complications, completed on-site prior to evacuation to the hospital emergency department. Athletes who rapidly become lucid during cooling usually have the best prognosis.

Cold water/ice water immersion provides the fastest whole body cooling rate and the lowest morbidity and mortality for EHS. When water immersion is unavailable, ice water towels/sheets on the head, trunk, and extremities with ice packs to the neck, groin, and axilla offer slower but reasonable cooling rates. Mist fans are not very useful and only help cool in dry climates. Immersion is the gold standard! The longer it takes to get the athlete cooled down, the more secondary organ and system failures occur.

EXERCISE PROGRAMMING AND ACCLIMATION TO PREVENT EHI

A program of prudent exercise in the heat along with acclimatization, improved cardiorespiratory physical fitness (aerobic base), and reasonable fluid replacement during exercise reduce the risk and incidence of both HE and EHS (Armstrong et al., 2007).

SCC’s should adjust their programming for the first 10 to 14 days of training in a new environment so athletes can acclimate (National Collegiate Athletic Association, 2014). Keep in mind that athletes with a high body mass index (BMI$\geq$30) also generally take longer to acclimatize and are at increased risk for EHS because they have a lower ratio of surface area to mass, and hence, their bodies are less efficient at dissipating heat (CSCCa Consensus document). Acclimation periods that implement gradual training progression and longer rest periods will help decrease the risk of both EHI and rhabdomyolysis (Armstrong et al., 2007, NATA white paper on EHI).

In American football, EHS usually occurs during the initial four days of preseason practice, which for most players is during the hottest and most humid time of the day and when the athlete is the least fit. During training sessions, the SCC should be observant of early signs of exertional heat illnesses (EHI) such as muscle cramping, confusion, dizziness, nausea, and vomiting. A decrease in normal performance may quickly precede the onset of exertional heat stroke (Armstrong et al., 2007; Asplund et al, 2016; National Collegiate Athletic Association, 2014).

To reduce the chance of an EHI during training, SCC's should program work-to-rest ratios that are adjusted based on the athletes' acclimation level (e.g., training period/status), environment, and past injury history (e.g., concussion). During a program's increases in training volume and intensity in high heat index climates, there should be adequate cooling modalities (e.g., misting fans) and frequent hydration breaks (Alosco et al., 2012; Armstrong et al., 2007; Casa et al., 2012;). The relative intensity of exercise, which is based in part on the athlete's fitness level, has the greatest influence on the rate of increase in core temperature and the risk of becoming a heat casualty (CSCCa/NSCA Consensus document).

TEMPERATURE AND HUMIDITY AND HYDRATION CONSIDERATIONS TO REDUCE EHI

The greatest risk for EHI exists, however, when the wet-bulb globe temperature (WBGT) exceeds 82^0 Fahrenheit during high intensity exercise and/or strenuous exercise that lasts greater than 1 hour, regardless of how well conditioned or heat acclimated the athlete may be (Armstrong et al., 2007, National Collegiate Athletic Association, 2014). NATA best practice recommendations for exercising in high heat stress environments suggest modifications such as a work:rest ratio of 10 minutes rest for every 40 minutes of exercise/practice and regular hydration breaks to reduce the risk of heat illness. For WBGT less than 82^0 F, a minimum of at least 3 separate rest breaks each hour with a minimum duration of 3 minutes each, is suggested. Length of activity and removal of unnecessary equipment or pads is also a suggested modification (NATA white paper on EHI). WBGT over 92^0 F is too dangerous, and no outdoor workouts should occur in this condition (NATA white paper on EHI).

The reduction of EHI risk begins with appropriate programming and acclimatization, partnered with good hydration habits, and the monitoring of signs and symptoms (Armstrong et al., 2007; National Collegiate Athletic Association, 2014). Dehydration of as little as 2% of body weight can negatively affect an athlete's performance and ability to effectively thermoregulate (CSCCa/NSCA Consensus document). When fluid deficits exceed 3-5% of body weight, sweat production and skin blood flow decline, reducing heat dissipation (Armstrong et al., 2007). Further dehydration significantly reduces exercise tolerance and increases fatigue by decreasing cardiac output and sweat production. This in turn hastens the rise of internal core temperature (Armstrong et al., 2007). Appropriate fluid ingestion before and during exercise minimizes dehydration and reduces the rate at which core body temperature rises. The risk of EHI, however, still continues even in hydrated athletes (Armstrong et al., 2007).

RETURN TO ACTIVITY/PLAY FOLLOWING HE OR EHS

Five recommendations have been proposed for the return to training and competition after an athlete has had an episode of EHI (Armstrong et al., 2007):

1. Refrain from exercise for at least 7 days following release from medical care.
2. Follow up in 1 week for physical exam and lab testing of affected organs related to the injury as indicated by the physician.
3. When cleared for activity, SCC's should start exercise in a cool environment and gradually introduce heat exposure as intensity also gradually progresses.
4. If return to activity is difficult, consider a laboratory exercise heat tolerance test at about 1 month post-incident.
5. Clear the athlete for full competition if heat tolerance exists after 2-4 weeks and the SCC observes no signs/symptoms of EHI during that time when training.

An athlete who has had an episode of heat exhaustion should not return to activity the same day even though symptoms from heat exhaustion have been resolved. HE symptoms tend to resolve on site for most athletes once the athlete is placed in the shade (or cool area) with the legs elevated, given oral fluids, and allowed to rest. It is suggested to wait at least 24-48 hours before returning to full activity following heat exhaustion.

RESPIRATORY DISEASES AND CONDITIONS

SCC's should be aware of athletes that have: existing respiratory problems such as expiratory flow limitations, chronic obstructive pulmonary disorder (COPD), or vocal chord disorders; or susceptibility to respiratory disorders such as exercise induced asthma (EIA) and/or exercise induced bronchospasm or constriction (EIB). It is important to know the exact diagnosis, signs and symptoms, specific training precautions, and if unique additions need to be included in the emergency action plan. Athletes with pulmonary disorders may experience intermittent inflammation and constriction of the bronchial airways during activity (Burnett et al., 2016; Bussotti et al., 2014; Stang et al., 2018). Athletes in sports such as cross-country running, marathons, Nordic cross-country skiing, and others that require high endurance training loads (e.g., large volumes of inspired air) are at an increased risk of developing EIB (Bussotti et al., 2014). Research identifying environmental factors that increase risk of pulmonary dysfunction and disorders describes 3 primary risk factors: dry air (hot or cold), cold temperatures, and air quality (presence of allergens or pollution). Ultimately, conditioning in moderate temperatures with moderate humidity is ideal, but not realistic based on region. However, training modifications (such as moving indoors, addition of humidifiers) can be made if air conditions appear to be exacerbating respiratory conditions.

BEING AWARE OF SIGNS OF RESPIRATORY DISTRESS

During training, the SCC should be observant if athletes are showing signs of chest tightness (e.g., grasping of chest or verbal recognition), wheezing, shallow rapid breathing, coughing, or shortness of breath. The most common occurrence of *exercise induced asthma* is recognized by shortness of breath, coughing, and wheezing during conditioning drills. Sports that are performed at high intensity (e.g., high intensity interval training, > 80% HR max) or classified as endurance intensity (e.g., 75% VO_{2max}) have been associated with increased risk of EIB or respiratory complications (Bussotti et al., 2014; Stang et al., 2018). This association is important for the SCC to understand as athletes with a diagnosed respiratory condition may need more time to acclimate or adapt to the training stimulus, and other training adjustments may need to occur if in an extreme environment (e.g., elevated pollution level, hot or cold temperatures in dry air).

The SCC should be in contact with the sports medicine staff regarding which athletes may need an inhaler or "epi-pen" on site in case respiratory distress occurs. Furthermore, acute respiratory illnesses can increase the risk to athletes and require adjustment to the strength and conditioning program (Spence et al., 2007). Swimming and other aquatic sports have a higher prevalence of athletes developing upper respiratory tract infections such as rhinitis due to the presence of warm, moist chloramine, allergens, and natural nitrogen compounds such as sweat and urine. Consequently, athletes require monitoring for signs and symptoms when conditioning programs take place in this type of environment (Bussotti et al., 2014). Conditioning drills performed in colder air temperatures increase the athlete's risk to exercise induced bronchoconstriction, and this is exacerbated if the air is dry. One method to reduce the risk of respiratory illnesses in the cold is having athletes' breathe through the nose while using masks to assist in both warming and moistening the air prior to entering the air passages (Bussotti et al., 2014). Heat and moisture exchanging mouthpieces are also available and may be more beneficial when the aerobic intensity of training is higher (greater than 35 L/min) since nasal breathing alone becomes insufficient (Bussotti et al., 2014). Athletes that are transferring, are in their first year, or who may be competing in elevations greater than 2000 m (6600 ft) have a greater chance of experiencing acute mountain sickness (AMS), with at least 25% overall being susceptible (Bussotti et al., 2014). The SCC should assist other team personnel in identifying athletes with AMS when competing in elevated environments. Symptoms to watch for include: headache, loss of appetite, nausea, dizziness and/or insomnia. SCC's can reduce the occurrence of respiratory illnesses by adjusting training programs based on progressive athletic conditioning, a knowledge of at-risk environments, and awareness of pre-existing physical conditions.

CARDIOVASCULAR DISEASES AND CONDITIONS

All athletes should undergo cardiovascular screening prior to the start of the academic and athletic seasons for: Marfan Syndrome; hypertrophic cardiomyopathy; and other cardiac dysfunctions that can be life threatening during strength and conditioning training sessions, practices, and competitions (Braverman et al., 2015; Hainline et al., 2016).

SUDDEN CARDIAC DEATH

Tragically, sudden cardiac death (SCD) is the leading medical cause of death in NCAA athletes, and a vast majority (60-80%) of those deaths occur during or as a result of participating in non-contact conditioning sessions. The two most common causes are hypertrophic cardiomyopathy and congenital coronary anomalies (CSCCa/NSCA Consensus document). Fewer than 20% of SCD cases occur as a result of direct contact during practice sessions. Post-mortem diagnosis in these cases suggests that the blow from direct contact induces a fatal ventricular arrhythmia and cardiac arrest.

Annually, the minimum cardiovascular screening for a student-athlete should include a standardized personal and family history assessment (Hainline et al., 2016). The most common cause of SCD in young athletes is hypertrophic cardiomyopathy and is the most common non-traumatic cause of death among collegiate student-athletes (Hainline et al., 2016). The SCC should treat any incident in which an athlete collapses and experiences a seizure during a conditioning session as sudden cardiac arrest unless a collision has taken place. (Casa et al., 2012). Rapid fluctuations of intensity in sports increase the chance of a cardiac event with men’s basketball having the highest risk of sudden cardiac death (Hainline et al., 2016). Athletes that experience a cardiovascular event during strength and conditioning sessions –collapsing, becoming unresponsive, or experiencing a seizure— need immediate activation of the emergency medical services system, CPR, and access to an AED. (Casa et al., 2012). The SCC should be able to access an AED in less than 3 minutes to maximize the athlete’s chances of recovering from the cardiac event. Emergency situations can be reduced in athletes with cardiovascular diseases through pre-participation screening, communication with sports medicine staff regarding medical conditions, and appropriate programming adjustments based on the specific disease (Hainline et al., 2016). Athletes that have demonstrated severe cardiovascular conditions, such as Marfan syndrome and abnormal aortic diameter size, may require restrictions in their programming or exclusion from specific sports participation (e.g., exclusion from collision sports) (Braverman et al., 2015). SCC’s will need to monitor heart rate and rate of perceived exertion as well as to watch for physical signs that the training load is greater than the athlete can tolerate. Furthermore, “two a day” sessions during the initial week (5 days) of summer sport training should be limited to every other day to reduce the chance of sudden cardiac death (Armstrong et al., 2007). The athletic trainer assigned to the sport team should serve as the primary supervisor for athlete health care with the collaboration of the SCC (Casa et al., 2012). Lastly, improving the cardiovascular health of athletes suggests a lowering risk of an EHI occurring (McClelland et al., 2018).

SICKLE CELL TRAIT

The health screening of athletes prior to the start of their collegiate athletic career or when transferring into a program should involve a medical determination regarding whether or not an athlete has the sickle cell trait (SCT). This precautionary step reduces the risk of an exertional collapse associated with SCT (Anderson 2017; Casa et al., 2012; O'Connor et al., 2012).

WHAT IS SICKLE CELL TRAIT?

The red blood cells in athletes with SCT take on a quarter-moon shape under certain conditions, which impairs their travel through blood vessels. Athletes with SCT have an increased risk of blood vessel blockage that could impair the delivery of needed nutrients and the removal of byproducts for muscular actions. Exercise related deaths have been shown to be 40 times greater in individuals with SCT than those without. For these athletes, programming adjustments should be made based on WBGT and should include reductions in training load, increased rest periods, and adequate hydration (Asplund et al, 2016; National Athletic Trainers Association, 2018; Ferster & Eichner, 2012).

MONITORING WARNING SIGNS

Athletes with SCT should be observed during any training program for signs of muscle weakness, unexpected collapse or kneeling during a session, slumping posture, or rapid breathing. These are all visual indications that an athlete is on the verge of exertional collapse (Asplund et al, 2016; O'Connor et al, 2012). Exertional collapse associated with SCT is often confused with heat cramps, heat exhaustion, or even heat stroke. But unlike heat stroke, sickle collapse occurs early in the workout and usually before there has been enough time for a significant rise in body temperature to occur (Asplund et al, 2016). Furthermore, SCC's should be alert to athletes with SCT who are complaining of increasing pain and weakness in the leg, buttocks, and low back muscles because these areas tend to be more susceptible to injury (Asplund et al, 2016).

ATHLETE SAFETY AND MODIFICATIONS

The SCC can help reduce the chance of an exertional collapse associated with SCT during the initial two weeks of conditioning by gradually increasing repeated high-intensity (e.g. > 90% VO2max) exercises and by gradually reducing the rest times between sets (O'Connor et al, 2012). Athletes performing repetitive sprints/interval training who have high levels of blood lactate accumulation should increase their recovery time between bouts if they have SCT (National Athletic Trainers Association, 2018). Athletes with SCT should be encouraged to participate in a year-round conditioning program, emphasizing the early season training to establish an aerobic base, acclimatize to heat/humidity, and arrive to the start of the pre-season camp conditioned and acclimated (Asplund et al, 2016). The physical exertions imposed on athletes at the beginning of pre-season requiring maximal efforts for longer than two minutes can be triggers for sickle cell collapse (National Athletic Trainers Association, 2018; Ferster & Eichner, 2012). In sickle cell trait, strenuous exercise invokes four conditions that together can trigger sickling: 1) severe hypoxemia; 2) metabolic acidosis; 3) hyperthermia in muscles; and 4) red-blood-cell dehydration. Hot and humid environments can contribute to more rapid rises of internal temperature. Consequently, decreasing intensity and volume in this setting, along with adequate hydration, is important to reduce the risk of sickling. Athlete physical preparation, appropriate progression, and recognition of the signs of exertional collapse related to SCT can reduce athlete risk and improve recovery (Asplund et al, 2016). Athlete safety and performance can be maximized with proper acclimatization, programming, and appropriate emergency training.

RETURN TO TRAINING 50/30/20/10 RULE AND THE F.I.T RULE (SUMMARIZED FROM THE CSCCA/NSCA JOINT CONSENSUS DOCUMENT)

In February 2018, the NCAA Chief Medical Officer (Brian Hainline, MD) issued a set of guidelines recognizing that periods during which athletes have undergone significant detraining increase the likelihood of injury resulting from a return to training. The guidelines recommend that as athlete's transition back into training, workouts should have greater work-to-rest ratios and progress gradually to full intensity. Additionally, workouts should be documented and made available for administrative staff.

Creating workouts for athletes with appropriate exercise volume, intensity, and rest to maximize performance enhancement while minimizing the likelihood of exercise-induced injuries, is a challenge for the SCC. Knowledge of symptoms specific to ER, EHIs, and cardiac issues is vital to minimize the risk inherent during transition periods. Consequently, a joint committee comprised of CSCCa and NSCA leadership was created to address these issues. The mission of this Committee was to provide evidence-based guidelines for training to decrease the risk of ER, EHIs, and cardiovascular-related incidents following periods of inactivity. In July 2019, the Return to Training Protocols—the 50/30/20/10 Rule and the F.I.T Rule-- were published.

There are three important scenarios to consider following a period of inactivity for all student-athletes in all sports.

1st: A returning athlete who has experienced a 2-week or longer break, or a student-athlete who is beginning under a new head sport coach.

2nd: A new athlete such as a freshman or transfer student-athlete coming off a period of inactivity, or all student-athletes beginning under a new head SCC.

3rd: A student-athlete returning to training following an incident of ER or EHI. This final scenario will involve a 6 to 8-week rehabilitation program prior to the athlete being released to begin transition training by the SCC.

THE 50/30/20/10 RULE FOR THE FIRST 2 SCENARIOS.

These recommendations have been created based on a thorough review of research showing that detraining and/or reduced activity leads to physiologic changes in muscle. Thus, the Committee recommends that prescription of conditioning drills after a period of inactivity follow a scheduled reduction in volume or workload adhering to the 50/30/20/10 Rule for a 2-week period (for returning athletes/new head sport coach), or a 4-week period (for new athletes/new head SCC). These rules provide a recommended percentage weekly reduction of volumes and/or workloads for conditioning and testing in the first 2-4 weeks of return to training, based on the uppermost volume of the conditioning program. For example, with a new athlete entering the program, the conditioning volume for the first week would be initially reduced by at least 50% of the uppermost conditioning volume on file, and by 30%, 20%, and 10% in the following 3 weeks, respectively, with a 1:4 or greater work:rest ratio (W:R) during the first week. For new athletes, a conditioning test must be completed on the first day of training and should be done at 50% of the test volume on file with the administrator with a 1:4 or greater W:R. In the case of an athlete returning from a period of inactivity of two weeks or more, the reduction in conditioning volume would be at least 50% in the first week, and then 30% in the second week, returning to normal training by the third week.

Because the detraining period and physiological conditioning will vary from athlete to athlete and will be especially unknown for athletes with no prior history or test results in the program, the Committee mandates a safety precaution consisting of gradual return to training using this Rule. A 1:4 or greater W:R should be used for week 1, and a 1:3 or greater W:R for week 2. Although not mandatory, testing may be repeated, but should follow the Rule for conditioning activities, with a 30/20/10% weekly reduction in volume at standard intensities and rest times.

THE 50/30/20/10 RULE FOR THE THIRD SCENARIO.

For student-athletes who have suffered serious injury, EHI, or ER, the recovery is more difficult. The time frame a student-athlete may be removed from training and practices may vary, but once he or she is released from hospitalized medical care, the return to training process can begin. This initial process should follow a 4-phase approach as outlined in the

Joint Consensus document and will commonly take 4-6 weeks before the athlete is released to the SCC and team training.

Once the student-athlete completes the four phases and has been released to the SCC, it is the coach's responsibility to continue the progression. The monitoring of the student-athlete's recovery and program effectiveness during the return to training is critical. The SCC will continue with the gradual increase in volume of conditioning drills and weight training following a minimum 50/30/20/10% reduction in volume over a 4-week period before a return to regular training. Overall, this return to training for a student-athlete after release from the medical staff may be a 6 to 8-week period to provide adequate time to build a strength and conditioning base. The progression of conditioning and weight training must take into account the managing of training load, recovery, and fatigue to reduce the chance of re-injury or a reoccurrence of ER and EHI.

F.I.T. RULE FOR WEIGHT TRAINING ACTIVITY

The F.I.T. Rule is designed to ensure that frequency, intensity relative volume, and time of rest interval are appropriately administered to minimize the chance of severe muscle damage during weight training activity.

FREQUENCY

Frequency is the number of training sessions completed per week for a specific muscle group or movement type. It is recommended that frequency not exceed 3 days in the first week following a period of inactivity and not exceed 4 days in the second week.

INTENSITY (RELATIVE VOLUME)

Intensity relative volume is a derivation of volume load that includes the %1RM and is calculated with the following equation:

Sets x Reps x %1RM as a decimal = IRV units

An IRV range of 11-20 provides the greatest strength increases, while an IRV range of 21-30 produces strength increases that are somewhat lower. An IRV below 11 may not be adequate to improve strength. Therefore, the Committee recommends an IRV range of 11-30 for a specific muscle group or movement type. IRVs of greater than 30 are contraindicated in the two weeks following a period of inactivity. *Tables are included in the consensus document for practical examples.*

TIME OF REST INTERVAL (WORK-TO-REST RATIO)

In most of the cases of ER in student-athletes referenced earlier, student athletes were subjected to a W:R of 1:1 or less. The Committee recommends that all weight training activity utilize a 1:4 or greater W:R during week 1 and a 1:3 or greater W:R during week 2. The Committee also recommends that SCC's follow the parameters outlined by the F.I.T. Rule in *Table 8* of the consensus document to reduce the risk of ER during their return to regular training during transition periods.

TRIPLE EXTENSION EXERCISES

The Committee recommends that for all triple extension exercises, IRV should not exceed 25 units in the first two weeks during transition periods. In addition, daily total volume (DTV) as defined by sets x repetitions in these exercises, should not exceed 50 repetitions, while weekly total volume (WTV) should not exceed 125 repetitions in Week 1 and 150 repetitions in Week 2

PLYOMETRIC EXERCISES

Applying the F.I.T. Rule to plyometric exercise may be more challenging due to differences in body mass and relative strength levels, but an estimate could be obtained using the 50/30/20/10 Rule. For example, based on previously accepted volume recommendations of 120-140 foot contacts for in-season athletes, plyometric workouts in the first two weeks should include around 70 foot contacts in week 1 and 100 in week 2 for the average-sized athlete. This should be modified for larger athletes and for those with lower strength levels.

The CSCCa/NSCA Joint Consensus document also covers additional considerations for return to resistance training for athletes who have experienced ER or EHI, including tables for progression and plyometrics (*Tables 9 and 10*). Please refer to this document to comply with proper return to training progression.

CONCLUSION

The development of an emergency action plan (EAP) should be established, discussed, and regularly practiced by the strength and conditioning staff at least annually or more often as new staff are hired. The location of the automated external defibrillator (AED) and other resuscitation items should be clearly marked and known by all coaches and athletes.

Appendix A of this document provides an outline of the different conditions, their physiology, programming, rest and recovery, signs and symptoms, as well as treatment and health related factors. The role of each SCC should be understood prior to the start of the training the year as well as what adjustments are necessary if the training location is changed due to inclement weather, sport practice alterations, or university functions. Athletes' prescreening by the sports medicine staff should be completed before the start of practices and information on at-risk athletes shared with the strength and conditioning staff about any restrictions or precautions that may need to be applied to programming. Departmental meetings prior to the start of pre-season training should include reviews of exertional illnesses and diseases that may pose a risk to athlete safety, along with educational discussions on how strength and conditioning programs will need to be adjusted.

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Appendix A. (Armstrong et al., 2007; Asplund and O'Connor, 2015; Braverman et al., 2015; Burnett et al., 2016; Bussotti et al., 2014; Casa et al., 2012; Casa & Armstrong, 2003; Collins et al., 2014; Costello et al., 2018; Hainline et al., 2016; NATA Consensus Statement Sickle Cell Trait; NCAA, 2014; NCAA Interassociation Consensus, 2016)

At-Risk Condition	Physiology of Conditions	Programming	Rest and recovery	Signs and symptoms	Treatment and Health
Concussions and chronic traumatic encephalopathy (CTE)	Concussion: mild traumatic brain injury; Swelling of fluid in cranial space; CTE: neurodegenerative disease	Increase neck strength in off-season; Aerobic exercise initially post; Light resistance training if asymptomatic; Strength training to reduce head displacement	Symptoms persistent for 3 months is post-concussion syndrome; Gradually reduce rest if asymptomatic; Hot/humid environments need > rest as EHI risk increases	Cognitive tests differ from baseline; Emotional distress, anxiety and academic stress or difficulty; CTE: symptoms similar of dementia; Mood swings, altered personality	Pre-season > occurrence of concussion; Coach and athlete targeted approach; Annual training for coaching staff; Balance error scoring system for assessment
Cardiovascular	Hypertrophic cardiomyopathy; Loeys-Dietz syndrome; Marfan syndrome; Genetic aortic diseases; High blood pressure	Monitor heart rate during strenuous exercise; Isometric exercises should be limited with condition; > Susceptibility to EHI; Gradual increase of interval training with heart rate spikes & drops	Greater rest periods with heart condition; Hot/humid environments need > rest; Recovery that allows gradual decrease in exercise heart rate; Greater rests with detrained athletes.	Irregular ECG; Seizures; Sudden athlete collapse or unresponsive; Severe tightness and pain in chest, between scapulae, and radiating down left arm; Difficulty breathing; Syncope	Men's basketball > chance of sudden cardiac death; 3 min to access AED; Athletes should have ECG or MRI prior to start of season and annually with preexisting condition
Exertional Rhabdomyolysis (ER)	Excessive, prolonged, or repetitive exercise; Training not part of a periodized/progressive program; Unfamiliar/novel training; Prolonged layoff (e.g. 3 months) of inactivity	Gradual progression of training load, addition of eccentric exercises and longer rest; 48 hours between "two a day" practices; Low training intensity returning from injury; No "extra" training	Programs need to be progressed over weeks not days (< 7 days); Fluid intake during breaks; Increase rest with diminished performance	Elevated serum creatine kinase, tissue edema, possible cardiac arrhythmias, muscular pain and dark "cola" colored urine; Rapid onset of muscle pain, weakness, or swelling	Athletes with previous ER need monitoring; Record reports of unusual muscle pain, weakness or stiffness; Prolonged inactivity increases risk of ER; Excessive stimulant use increases risk

Exertional Heat Illness (EHI)	Chance of heat stroke with Wet bulb globe temperature (WBGT) > 82°F; Exhaustion is inability to continue exercise; Exertional heat cramps from prolonged strenuous exercise in heat	Heat acclimatization ≈ 2 weeks; Gradual progression and longer rest; 48 hours between "two a day" practices; No exercise 7 days following medical release; Train during cooler hours of the day or in climate controlled	High heat 40 min maximum before 10 min rest; Full return following heat stroke 2-4 weeks; Daily body weight measurements; fluid intake every 15 min break in WBGT 75.0–78.6°F;	Heat exhaustion: low blood pressure, elevated pulse, respiratory rates sweaty, and pale/ashen; Heat stroke: body's heat dissipation ability is exceeded, cessation of sweating, and red/dry skin	Immediate cooling of body, hydration if conscious, move into shade, increase cool air circulation; Ice tubs or towels soaking in ice buckets; increased susceptibility to reoccurrence of EHI
Respiratory	Asthma; Exercise-induced bronchoconstriction Cystic fibrosis; Chronic obstructive pulmonary disorder; Upper respiratory tract infection	Use mask if training in cold environment (< 35° F); Sprint intervals and like training may induce asthmatic attacks; Breathing through the nose to reduce respiratory irritation; Develop aerobic base prior to preseason	Allow time for fast-acting bronchodilator to take effect; Gradually reduce rest times during intervals; Rest periods should be in ventilated and warm air environment; Fluid intake during rests	Shortness of breath, coughing and wheezing; Chest tightness; Inflammation and constriction bronchial airways; Chronic air obstruction/scarring	Fast-acting bronchodilator; Prescreening for bronchoconstriction; Respiratory care for positive diagnosed athletes;
Sickle Cell Trait (SCT)	Red blood cells are ¼ moon shaped, increased blood viscosity; Sickle cells block blood vessels creating ischemic situation; SCT increases chance of ER	Gradually increase anaerobic training; closely monitor SCT athletes during interval training; Develop aerobic fitness base; Program longer rest after extended inactivity/illness/injury	Increased rest between anaerobic sets; Adequate sleep prior to exercise; Increase rest and decrease total volume in hot/humid environment	Blood vessel blockage, muscular weakness, kneeling or slumping, severe muscle pain or cramping; ER symptoms; Collapse	Maximal effort training of 2-3 minutes may induce exertional sickling; Avoid timed runs; Include ≥ 48 hrs. between training and testing