CSCCa and NSCA Joint Consensus Guidelines for Transition Periods: Safe Return to Training Following Inactivity

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ABSTRACT

THE INCIDENCE OF INJURIES AND DEATHS RELATED TO EXERTIONAL HEAT ILLNESS (EHI), EXERTIONAL RHABDOMYOLYSIS (ER), AND CARDIORESPIRATORY FAILURE HAS INCREASED SIGNIFICANTLY IN COLLEGE ATHLETES IN RECENT YEARS. DATA INDICATE THAT THESE INJURIES AND DEATHS ARE MORE LIKELY TO OCCUR DURING PERIODS WHEN ATHLETES ARE TRANSITIONING FROM RELATIVE INACTIVITY TO REGULAR TRAINING. TO ADDRESS THIS PROBLEM, THE CSCCA AND NSCA HAVE CREATED CONSENSUS GUIDELINES WHICH RECOMMEND UPPER LIMITS ON THE VOLUME, INTENSITY, AND WORK:REST RATIO DURING TRANSITION PERIODS WHERE ATHLETES ARE MOST VULNERABLE. THE CONSENSUS GUIDELINES PROVIDE STRENGTH AND CONDITIONING COACHES WITH A CLEAR FRAMEWORK FOR SAFE AND EFFECTIVE PROGRAM DESIGN IN THE FIRST 2–4 WEEKS FOLLOWING PERIODS OF INACTIVITY OR RETURN FROM EHI OR ER. ADHERING TO THE CONSENSUS GUIDELINES, CONDUCTING PREPARTICIPATION MEDICAL EVALUATIONS, AND ESTABLISHING EMERGENCY ACTION PLANS WILL REDUCE THE INCIDENCE OF INJURIES AND DEATHS IN COLLEGE ATHLETES.

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INTRODUCTION

OVERVIEW

Since 1982, the National Collegiate Athletic Association (NCAA) and the National Athletic Trainers' Association (NATA) have collaborated to maintain the largest ongoing collegiate sports injury database in the world (36). Data from the NCAA Injury Surveillance Program (https://www.ncaa.org/sport-science-institute/ncaa-injury-surveillance-program) indicate that, among all 25 NCAA sports programs, football consistently has the highest injury rates for both games (35.9 injuries per 1,000 athlete-exposures) and practices (9.6 injuries per 1,000 athlete-exposures) (69,75,76). More striking is the fact that college football has the highest rate of sudden death, "catastrophic" and "severe" injuries resulting from player contact, and debilitating injuries requiring hospitalization that occurred during noncontact practices or supervised strength training or conditioning sessions (23,25,74). In 2012, representatives from the NCAA, NATA, and medical organizations and the strength and conditioning community

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(including the National Strength and Conditioning Association [NSCA] and Collegiate Strength and Conditioning Coaches Association [CSCCa]) met to discuss and address the incidence of sudden death and debilitating injuries in collegiate conditioning sessions. This meeting resulted in the development, publication, promotion, and endorsement of best practice recommendations for strength and conditioning in collegiate sports (21). Although indirectly related, the increasing incidence of contact-related injuries, specifically spinal cord injuries, concussions, and chronic traumatic encephalopathy (15,38,54,56,57), prompted the National Football League (NFL) and the NCAA to implement stricter rules governing gameday competition and increase the penalties for infractions in an effort to provide greater oversight and better safeguard athletes. In 2017, the NCAA released their "Year-Round Football Practice Contact Recommendations" (www.ncaa.org/sport-science-institute/year-round-football-practice-contact-recommendations), which placed additional restrictions on practice sessions, especially in the preseason, with the intent of reducing contact-related injuries. 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 (20,23,25,33). For example, in an effort to reduce the number of athletes suffering exertional heat illnesses (EHIs), the NCAA joined forces with the NATA, the NSCA, the CSCCa, and several other athletic and medical organizations to develop guidelines for heat acclimatization that limit the number and intensity of summer practice sessions and the equipment that can be worn during those sessions (20,25).

The causes for concern and needs for intervention are clearly justified. In the past 20 years (1998–2018), 2 college football players died from direct contact catastrophic neck injuries suffered during games–one in 2001 and one in 2017. During the same time frame, 35 football players died during practice or as a result of participating in preseason conditioning workouts. Autopsy studies showed that most of the deaths were caused by exertional heat stroke (EHS) or underlying heart conditions (https://en.wikipedia.org/wiki/List_of_American_football_players_who_died_during_their_careers).

In addition to the cases of sudden death, there has been an alarming increase in the number of athletes who have suffered debilitating injuries (e.g., cardiorespiratory failure, EHIs and exertional rhabdomyolysis [ER]) during supervised strength and conditioning sessions. The EHI-related death of a college football player in June of 2018 is a reminder of the importance of keeping appropriate medical care of student-athletes at the forefront of sports and athletic competition. In the past, the thought that a highly conditioned athlete might have a potentially fatal heart condition or be susceptible to sudden death or hospitalization from a non–contact-related incident might have been unimaginable. But even one preventable death is unacceptable, and 35 such events have occurred in the past 2 decades. Although 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 has increased significantly. Attempts to understand the underlying causes of these tragic events have rightfully placed the profession under scrutiny, triggered considerable public outrage, and resulted in efforts to publish and implement preparticipation screening strategies, preparticipation medical evaluations (PMEs), injury prevention guidelines for practice sessions and formal competition, and guidelines for establishing emergency action plans (EAPs).

Fatalities and catastrophic events in collegiate sports continue to occur despite rule changes to enhance student-athlete safety and the availability of best practice recommendations for strength and conditioning. It is important to note that conditioning activities often occur during sport-specific practice, and such sessions may not be programmed, implemented, and/or supervised by a strength and conditioning coach. This occurs despite previously published and supported recommendations that all strength and conditioning sessions should be developed, implemented, and under the control of appropriately trained and certified strength and conditioning staff (21,70). It has also been expressed that, in some circumstances, even if the strength and conditioning coach is directing the conditioning aspects of a sports-specific practice, he or she may be subservient to the sports coach and as such not have the authority to determine how the conditioning session or activity was planned and/or implemented (70). Although a discussion on the roles and responsibilities of the strength and conditioning and sports coaches is warranted, it is beyond the scope of this article, but should be part of the discussion on improving the safety of student-athletes.

Strength and conditioning sessions must be appropriately designed and implemented to reflect the individual athletes' current levels of fitness and fatigue, so as to not induce excessive exertion. An athlete's current levels of fitness and fatigue are dynamic in nature due to the acute and chronic effects of sport training, strength and conditioning, nutrition, hydration, sleep, and various other factors (e.g., medications and supplements).

The incidence of non–contact-related injuries has increased significantly in the past decade, particularly in student-athletes who have recently returned to training after a period of inactivity (i.e., after a vacation between or during academic terms; January-February and July-August) when their level of conditioning has likely decreased. According to the National Center for Catastrophic Sport Injury Research (NCCSIR) (https://nccsir.unc.edu/files/2013/10/NCCSIR-34th-Annual-All-Sport-Report-1982_2016_FINAL.pdf), the risk of non-contact injury is significantly greater after periods of inactivity if training workloads and/or recovery strategies are not adjusted to reflect athletes' reduced level of fitness. The NCCSIR data indicate that almost 60% of noncontact injuries occur during these periods in which the athlete is transitioning back into training following a period of inactivity. This increase in noncontact injuries suggests that athletes are being exposed to excessive workloads in the period immediately after their return to campus, and/or their training workload is being increased at a faster rate than is appropriate. The risk for serious injury and death after a period of inactivity is well documented and was addressed in the 2012 Inter-Association Task Force's best practice recommendations (21): "conditioning periods should be phased in gradually and progressively to encourage proper exercise acclimatization and to minimize the risk of adverse effects on health." The CSCCa and NSCA continue to support these best practice recommendations for strength and conditioning sessions during transition periods for collegiate student-athletes.

Freshmen student-athletes are a special population of athletes that are at an even higher risk for injury because they transition from the training workload demands of high school to collegiate sports. Although strength and conditioning professionals account for this in their training workload prescription for freshmen athletes, it is worth reiterating as a reminder, so all staff associated with the training, health, and well-being of student-athletes have an integrated approach to this population. Transfer and walk-on student-athletes may also be at increased risk because they often approach training with a mentality of "more is better" in an effort to make the starting roster over established and/or scholarship athletes.

The fact that tragic events continue to occur reflects a need for all sports coaches, strength and conditioning staff, medical personnel, and administrators to be educated about the risks and potential risks associated with strength and conditioning training, particularly during transition periods. The NCAA and the NATA have published and posted a series of journal and lay articles providing best practice recommendations for the prevention and screening, recognition, and treatment of the most common conditions resulting in sudden death in athletes (23), guidelines for preseason heat acclimatization (20), guidelines for preventing EHIs (25), and best practices for sports medicine management at the college level (33). Recognizing the increasing incidence of debilitating noncontact injuries, it is surprising that there are presently no published guidelines for college coaches and their strength and conditioning staffs for training loads to be used for progressive conditioning following inactive periods (e.g., reporting for conditioning after a winter or summer break, returning to play after injury). The purpose of this joint CSCCa/NSCA article is to focus attention on non–contact-related injuries and provide guidance pertaining to the retraining of college athletes during transition periods. The recommendations and best practice guidelines presented are in alignment with those published previously by NATA, the NCAA Committee on Competitive Safeguards and Medical Aspects of Sports, the NCAA Division I Football Oversight Committee, and several other scientific, medical, and football organizations and are based on the emerging scientific consensus.

KEY TERMS

For the purposes of these guidelines, a "severe" injury is defined as resulting in loss of more than 21 days of participation. A "catastrophic" injury is defined as a permanent disability injury, serious injury (fractured neck or serious head injury) although the athlete has a full recovery, transient paralysis (athlete has no movement for a short time but has a complete recovery), heat stroke due to exercise, sudden cardiac arrest (SCA)/severe disruption, or fatality. Injuries are classified as traumatic or direct/contact-related and exertional/systemic or indirect/non–contact-related. Traumatic injuries are those which result directly from participation in the fundamental skills of the sport. Exertional/systemic injuries are caused by system failure (usually cardiac or thermoregulatory) as a result of exertion while participating in an activity, or by a complication which was secondary to a nonfatal injury. These definitions are supported by previously published literature (74).

DISCLAIMER

This document is intended to provide relevant practice parameters for strength and conditioning professionals to use when performing their responsibilities in providing services to athletes or other participants. The guidelines presented here are based on published scientific studies, pertinent statements from other associations, analysis of claims and litigation, and a consensus of expert views. However, this information is not a substitute for individualized judgment or independent professional advice.

Neither the NSCA, CSCCa, nor the contributors to this project assume any duty owed to third parties by those reading, interpreting, or implementing this information. When rendering services to third parties, these guidelines cannot be adopted for use with all participants without exercising independent judgment and decision-making based on the strength and conditioning coaches' individual training, education, and experience. Furthermore, strength and conditioning practitioners must stay abreast of new developments in the profession, so that these guidelines may evolve to meet particular service needs.

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IMPORTANCE OF PREPARTICIPATION MEDICAL EVALUATIONS AND ESTABLISHING EMERGENCY ACTION PLANS

Most student-athlete deaths are preventable, and student-athlete health and safety remains the profession's top priority. The *National Athletic Trainers' Association Position Statement: Preventing Sudden Death in Sports* (23) provides detailed guidelines and recommendations for the prevention, screening, recognition, and treatment of the most common conditions resulting in sudden death in organized sports. All college-level coaches, strength and conditioning staff members, athletic trainers (ATs), and athletic directors are expected to know the guidelines and assist in implementing the policies and procedures outlined in this document. Thoroughly screening athletes during the PMEs, creating and implementing EAPs, and following the guidelines and recommendations outlined by the NCAA and NATA will lower the likelihood that a debilitating or fatal incident will occur and improve the probability of survival should an event occur. The importance of adhering to and implementing these safety practices cannot be overstated.

The NATA position statement emphasizes the importance of establishing and practicing EAPs to appropriately respond to potentially fatal incidents (23). EAPs need to be specific to each athletic facility and venue (e.g., weight room, locker room, gym, and individual practice fields). At a minimum, each EAP should include the following: the scheduling and training of likely first responders in first aid, cardiopulmonary resuscitation (CPR), and automated external defibrillator (AED) use; the nearest location of necessary emergency equipment and supplies (e.g., AEDs, ice chests), and 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). The EAP should identify by name the person or people 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. Of greatest importance, EAPs need to be reviewed, discussed, and practiced on a regular basis (103).

To provide appropriate care and determine when emergency treatment is required, strength and conditioning professionals need to recognize the signs and symptoms associated with a variety of potentially fatal conditions. The 3 most relevant and potentially fatal conditions are sudden cardiac death (SCD), exertional heat stroke (EHS), and ER, and these will be described in detail in the following sections of these guidelines. Immediate emergency care for the athlete is critical for each of these 3 conditions since waiting on an ambulance to arrive may result in death or permanent disability. Consistent with NATA and NCAA recommendations, we urgently advocate training all college coaches and strength and conditioning staff members in first aid, CPR, and AED use, so that they can assist the certified ATs onsite in providing treatment until licensed medical professionals arrive. Although such care may be inadequate for some of the conditions described in these guidelines (e.g., SCD), and saving an athlete's life is not the responsibility of (nor is liability ascribed to) coaches or strength and conditioning staff members, these professionals must make every reasonable effort to ensure the health and safety of student-athletes.

SUDDEN CARDIAC DEATH

Pathophysiology. College athletes are considered to be one of the healthiest segments of our society, which is why the diagnosis of SCA or SCD is always shocking and has a profound impact on all of us. Tragically, SCD is the leading medical cause of death in NCAA athletes, and a majority (60–80%) of those deaths occur during or as a result of participating in noncontact conditioning sessions (64). The 2 most common causes are hypertrophic cardiomyopathy and congenital coronary anomalies, although there have been a wide range of postmortem diagnoses to include Marfan syndrome, myocarditis, valvular heart disease, aortic dissection, idiopathic left ventricular hypertrophy, long QT syndrome, Kawasaki disease, atherosclerotic coronary artery disease, and others (6,62–64,91). Fewer than 20% of SCD cases occur as a result of direct contact between athletes during practice sessions (92). The most common postmortem diagnosis in these latter cases has been commotio cordis ("agitation of the heart"), which results when a traumatic blow to the heart region induces a fatal ventricular arrhythmia and cardiac arrest. Unfortunately, autopsy reports do not always accurately depict the underlying pathological condition, and standardized protocols for cardiovascular autopsies are needed.

Incidence. Although the incidence of sudden death due to an underlying cardiovascular condition is relatively low at approximately 1:43,000 student-athletes per year, the rate of SCD is relatively high (4–6 deaths per year) (60,64,91). When researchers have analyzed the database of all NCAA deaths, their findings consistently indicate that males, black athletes, and basketball players are at a substantially higher risk, and that SCD is 3–5 times more likely to occur in black athletes (59,64,87,91). More research is needed to determine whether there is a higher incidence of potentially lethal cardiovascular disease in basketball players or whether the demands of the sport place a substantially higher risk on those with underlying disease. In any event, coaches, ATs, and other medical personnel need to make every effort to identify those athletes at increased risk and improve strategies to prevent these tragedies.

Symptoms and treatment. In any athlete who has collapsed in the absence of contact or trauma, suspicion for SCA should be high until normal airway, breathing, and circulation are confirmed. Agonal respiration or gasping for breath should be recognized as a sign of SCA as should seizure-like activity or jerking shortly after collapse. If normal breathing and pulse are absent, EMS should be alerted immediately and CPR should be performed in the order of chest compressions, airway, breathing while waiting for arrival of the AED, and stopped only for rhythm analysis and defibrillation. This should continue until EMS or other medically certified providers take over or the (previously unconscious) athlete starts to move. Early detection, prompt CPR, rapid activation of EMS, and early defibrillation are vital to the athlete's survival. For any athlete who has collapsed and is unresponsive, an AED should be applied as soon as possible for rhythm analysis and defibrillation, if indicated. The greatest factor affecting survival after SCA is the time from arrest to defibrillation, with survival rates ranging from 41 to 74% if bystander CPR is initiated and defibrillation occurs within 3–5 minutes of collapse (39,40,116).

Guidelines for prevention. The PME and traditional physical examinations are essential but have significant limitations (88). Improved screening strategies to include electrocardiogram (ECG) and echocardiogram (ECHO) need to be considered for athletes in the highest risk group (e.g., black athletes with a pre-existing cardiac condition or family history of cardiovascular disease). But even these types of tests are not definitive, and reports indicate that a substantial number (up to 80%) of the athletes who suffered from SCD would likely not have been reliably diagnosed with a 12-lead ECG administered during their preparticipation screening (87,91). Detection of asymptomatic cardiac conditions can be improved when standardized medical history forms are used to identify and attract attention to an athlete's personal or family history of previous episodes of exertional syncope (temporary loss of consciousness caused by a fall in blood pressure) or exercise intolerance, chest pain or discomfort, cardiac arrest, or sudden death of a family member. Continuing education and gaining a broader knowledge base about the anatomy and physiology of the cardiovascular and pulmonary systems and complications associated with cardiovascular disease and cardiac dysfunction are essential for coaches and conditioning staff members as well as ATs and health care professionals. At minimum, relevant staff should be aware of the 12-point preparticipation cardiovascular screening guidelines developed by the American Heart Association in 2007 for competitive athletes based on their medical history and physical examination (See Appendix, Supplemental Digital Content, http://links.lww.com/SCJ/A259) (89).

EXERTIONAL HEAT ILLNESSES

Pathophysiology. EHIs encompass a broad spectrum of disorders to include minor conditions such as muscle cramps (heat cramps), heat syncope, heat exhaustion, and exertional heat injury, as well as the more severe clinical condition of EHS. Coaches and ATs need to be able to distinguish between the various EHIs to prevent and treat them appropriately. The risks of EHIs are ever-present during exercise in the heat but can also result from exercising in normal environmental conditions. They usually occur during the first 5–6 days of unaccustomed heat exposure (e.g., during preseason conditioning), before athletes become acclimatized, blood volume expands, and cardiovascular adaptations are complete. In 2015, the NATA and NCAA released consensus guidelines regarding heat acclimatization protocols for football athletes at the high school and college levels (25) (Table 1). The NATA guidelines emphasize the importance of the initial conditioning period without use of protective equipment, followed by a gradual addition of further equipment. It is extremely important for all of us to understand the common causes and predisposing factors of EHIs. For example, athletes who have the sickle cell trait or who have a previous history of EHIs may be more vulnerable to EHIs, and especially EHS. Implementing strategies to address the common causes and mitigate their harmful effects is the best approach to help athletes avoid EHIs or reduce the risk of subsequent EHIs. The pathophysiology of EHS is multifactorial and includes the body's ability to thermoregulate efficiently and acclimatize to conditioning in a hot and humid environment. An athlete's physical condition, body mass, state of hydration and electrolyte balance, and health status are contributing factors as are certain types of medications and whether or not the athlete carries the sickle cell trait or has been a previous "heat casualty" (30,84,104).

EHS is the most severe form of EHI and is characterized by central nervous system (CNS) impairment and a core body temperature greater than 105°F (or 40.5°C) (5,18,47). EHS occur when the body's thermoregulatory system becomes overwhelmed due to excessive heat production (i.e., metabolic heat produced from exercising muscles) and/or a decrease in the body's ability to dissipate heat effectively. Thermoregulation is a complex interaction of the CNS, the cardiovascular system, and the skin to maintain a core temperature of approximately 98.6°F (37°C) (120). The body's temperature-regulation center is located in the hypothalamus and determines the setpoint for core temperature. The body's thermoregulatory system works through a negative feedback loop similar to a home heating system with the hypothalamus serving as the thermostat. The hypothalamus receives information regarding core and surface/skin temperatures from thermoreceptors and circulating blood. The hypothalamus then directs thermoregulatory mechanisms to adjust accordingly to initiate the appropriate heat-transfer responses. If core temperature falls below the normal setpoint (i.e., 98.6°F), peripheral vasoconstriction and shivering responses increase core temperature. If core temperature rises above the normal setpoint, cutaneous

Table 1
Recommendations for the prevention of exertional heat illnesses (EHI)

1. Athletes should be screened by physicians to identify those with risk factors for EHI or a history of EHI.
2. Athletes with a history of EHI or susceptible to EHI must be closely monitored.
3. Athletes should monitor their hydration status and replace fluids before, during, and after exercise.
4. Athletes should sleep at least 7 hours per night in a cool environment and eat a balanced diet.
5. Athletes should be discouraged from using dietary supplements or other substances that have a dehydrating effect.
6. Athletes should be acclimatized to the heat gradually over a 7- to 14-day period. Recognizing that the first 2–3 weeks of preseason practice present the greatest risk, all possible preventive measures should be used during this period.
7. Rest breaks should be planned, and the work-to-rest ratio modified to match environmental conditions and the intensity of the practice session.
8. A heat acclimatization policy should be developed with guidelines formulated for hot, humid weather conditions based on the type of activity and wet bulb globe temperature. In stressful environmental conditions, practice sessions should be delayed, shortened, or rescheduled.
9. The sports medicine staff are required to educate coaches and athletes on preventing and recognizing the signs and symptoms of EHI. The coaching and support staff must also review and rehearse their emergency action plan (EAP) specific to each training and practice site and game venue.
10. A cold-water or ice tub and ice towels should always be available to immerse or soak an athlete with suspected EHI. Immediate whole-body cooling is essential for treating EHI, especially heat stroke.
11. The assessment of rectal temperature is the clinical gold standard for obtaining core body temperature of athletes with EHI. No other methods of obtaining core body temperature (e.g., oral, tympanic, and temporal) are valid.
12. Certified athletic trainers are the primary providers of medical care for athletes who display signs or symptoms of EHI and have the authority to restrict an athlete from participating if EHI is suspected.
Reference: National Athletic Trainers' Association Position Statement: Exertional Heat Illnesses (https://www.nata.org/sites/default/files/ExternalHeatIllnesses.pdf) (25).

vasodilation and increased sweating occur to dissipate heat (120). Core temperature is determined by metabolic heat production and the transfer of body heat to and from the surrounding environment. Metabolic heat produced by intense exercise may approach 1,000 kcal/h, with more than 90% of the heat being generated from the exercise-induced increase in muscle metabolic activity. If the excess heat load is not efficiently dissipated away from the body, core temperature climbs rapidly. The most efficient mechanism to dissipate heat is the vaporization of sweat (i.e., evaporation), but this ability rapidly diminishes when the environmental humidity level is high or if the athlete is wearing heavy clothing or equipment. Although EHS is most likely to occur in hot and humid weather, it can manifest with intense exercise in any environmental condition.

Heat acclimatization is an essential part of the conditioning process and involves a series of adaptive physiological responses to repeated heat exposure over the course of 1–2 weeks. These adaptations include increases in plasma/blood volume, stroke volume, and sweat rate, and decreases in heart rate, core temperature, skin temperature, and sweat loss (4,108). Athletes should be allowed to acclimatize to the heat before practicing in pads or participating in multiple practice sessions per day (20,24). An athlete's ability to acclimatize largely depends on his or her initial level of fitness, as more highly conditioned athletes acclimatize more quickly. Trained athletes are much less susceptible to EHS due to the training-induced physiological adaptations described above. 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 (25,27). Finally, the athlete's ability to acclimatize depends largely on the intensity and frequency of practice or conditioning sessions. High-intensity exercise, regardless of whether it is performed on the practice field or in the weight room, can elevate the core temperature of an at-risk athlete (i.e., one who is unfit, overweight, or unacclimatized) to dangerous levels in less than 30 minutes. In fact, 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 risk for the athlete becoming a heat casualty (25).

The athlete's hydration status and corresponding electrolyte balance also play significant roles in EHI risk. Inadequate fluid intake, excess sweat loss, vomiting, diarrhea, medications, or supplements that have a dehydrating effect (e.g., diuretics, antihistamines, CNS stimulants, and antidepressants), and alcohol can all lead to a measurable fluid deficit. Dehydration of as little as 2% of body weight can negatively affect an athlete's performance and ability to thermoregulate effectively (26). Caution should be taken to ensure that athletes arrive at practice euhydrated (i.e., having re-established their weight since the last practice) and have the opportunity to regularly replace body water lost during practice. Measuring body weight change before and after practice sessions and across successive days is the preferred method for monitoring hydration status (120). Water loss that is not replaced by the next practice session increases the risk for EHIs (19,120). During intense exercise in the heat, sweat rates can be as high as 2 liters per hour (9). Hence, the rehydration rate may need to be increased during conditioning sessions conducted in the heat to minimize fluid deficits. Electrolyte imbalances, especially sodium and chloride, also result from high sweat rates, and athletes who are not heat acclimatized can lose significant amounts of these electrolytes during conditioning sessions. It is important to make sure that athletes are aware that the loss of electrolytes is equally important as the loss of water, and that replacing both reduces their risk of having EHIs or exertional hyponatremia (from consuming too much water) during conditioning sessions.

Finally, athletes who have the sickle cell trait are at increased risk for EHS, collapse, and sudden death. The sickle cell gene is common among people whose ancestry traces back to areas of the world where malaria has been common (e.g., Africa and India) and is believed to be a genetic adaptation acquired over generations to protect against malaria (43). One in 12 African Americans carries this gene compared with 1 in 10,000 Caucasian Americans. The inherited trait is not considered a disease (i.e., sickle cell disease) unless it is inherited from both parents. However, the sickle cell trait can result in an abnormality in the oxygen-carrying protein hemoglobin found inside red blood cells. This genetic abnormality leads to the normal biconcave disk-shaped red blood cells taking on a rigid, quarter moon or "sickle" shape under certain circumstances. Heat, dehydration, asthma, exercising at altitude, and inadequate acclimatization all increase the risk for medical complications in athletes with sickle cell trait. Although having the trait is not a barrier to participating in competitive sports, athletes with the trait experience higher rates of physical distress, including collapse and death during intense exercise.

Incidence. EHS is the third leading cause of sport-related death among college athletes, and football has the highest incidence rate among all intercollegiate sports programs (11). The number of sports-related EHS deaths has doubled since 1975 with more deaths having been reported between 2005 and 2009 than during any 5-year period of the preceding 30 years (90,99). The National Center for Catastrophic Sports Injury Research database also identified EHIs as the third most common cause of sports-related fatalities in high school and college football players between 1990 and 2010, accounting for 15.6% (n = 38) of reported deaths. Although the incidence of EHS-related death is relatively low among college athletes, the rate of occurrence of other forms of EHI remains disturbingly high. In a more recent study, researchers analyzed data from 4 NCAA football seasons (2004–2007) and divided the 60 participating universities and colleges into 5 geographic regions (31). Players were identified by position, equipment worn, and the specific type of EHI they suffered, and the researchers calculated the number of EHIs reported by ATs or that caused players to miss practices between August 1 and September 30 each year. Of the 553 cases of EHI reported, approximately 74% were related to exertional heat cramps, and approximately 26% were a combination of exertional heat syncope and heat exhaustion. Fortunately, there were no cases of EHS reported (31). The incidence of EHIs was more common in the Southeast region, where they accounted for 446 of the 553 cases. It was confirmed that the incidence of EHIs increases significantly in regions with relatively higher heat indexes, and especially when wet bulb globe temperature exceeds 82.0°F (27.8°C). In terms of timing, heat illness was most common in the first 3 days of practice, and when two-a-day practices began on day 6 (of the preseason), there was an increase in heat illness on days 7 and 8. Collectively, the studies reporting on the incidence rates of EHIs indicate that the most dangerous time for football players is during the first 14 days of preseason practice.

Symptoms and treatment. The 2 main diagnostic criteria for EHS are CNS dysfunction and a core temperature greater than 105°F (or 40.5°C) (5,19). In addition to the fatally high core body temperature, the key signs and symptoms of EHS include physical collapse, seizure, inability to walk, hypotension, tachycardia, dizziness, and vomiting. EHS-related death is preventable through immediate recognition of symptoms, core (rectal) temperature assessment, and rapid treatment through cold-water immersion (CWI) (5,23,25). Athletes who have EHS should be aggressively cooled, onsite if possible, within the "golden half hour" after collapse/onset of symptoms. The goal is to lower the athlete's body temperature to 102°F (38.9°C) or less within 30 minutes of collapse. Morbidity and mortality are more strongly linked to duration of hyperthermia, as opposed to the degree of hyperthermia, hence, the "cool first, transport second" principle (22). Immersing the athlete in cold water is the fastest method for whole-body cooling and is associated with the lowest rates of morbidity and mortality. If CWI is not available, other modalities such as wet ice towels placed over the entire body or cold-water dousing with or without fanning may be used but are not as effective. Policies and procedures for cooling athletes before transport to the hospital must be outlined and explicitly clear in the athletic department's EAP and shared with EMS responders, so that treatment by all coaches, trainers, and medical professionals involved is well-coordinated. If the athlete's body temperature is reduced to 102°F (38.9°C) or less within 30 minutes of symptom onset, mortality approaches or is actually zero, and most recover without serious consequences.

Guidelines for prevention. The most tragic fact surrounding EHS deaths in athletes is that the condition is entirely preventable. At the same time, the preventable nature of EHS means there is ample opportunity to prepare for these events and decrease the likelihood of their occurrence. The NATA, working in conjunction with the NCAA and several other athletic and medical organizations, published a position statement in 2015 with specific guidelines addressing the prevention, recognition, and treatment for EHIs (25). Their recommendations are designed to help strength and conditioning professionals and ATs maximize the health and safety of athletes as well as their performance. However, individual responses to physiologic stimuli and environmental conditions vary widely for the reasons described above (e.g., training status, BMI, and hydration status). Therefore, the recommendations in the NATA position statement do not guarantee full protection from EHIs but are designed to mitigate the associated risks. Nonetheless, their recommendations and prevention strategies should be carefully considered and implemented by coaches and ATs as part of an overall strategy for the prevention and treatment of EHIs.

A recent death during football conditioning drills in 2018 was both tragic and preventable. Based on the findings reported (https://www.usmd.edu/newsroom/Walters-Report-to-USM-Board-of-Regents.pdf), it was determined that there was a systematic failure at every level of oversight (coaches, ATs, and university administrators). The conditioning test that was conducted (and that resulted in the student-athlete's death) was on the initial day back from a 4-week break, and there had been no acclimatization period before the intense conditioning session; there was no reported record of individual fitness assessment by the strength and conditioning staff before the conditioning session. When the incident occurred, the coaching and athletic training staff failed to recognize the severity of the incident and were reportedly not familiar with the university's EAP; although visibly in distress, the student-athlete was "walked around the field for 34 minutes after becoming symptomatic" for EHI; the student-athlete's rectal temperature was not established nor monitored; the student-athlete's vital signs were not established nor monitored; immediate and aggressive cooling of the student-athlete did not occur, although ice packs and ice towels were eventually used; cold-water immersion tubs were available but were not set-up before the practice session activity nor were they used during the incident; the trauma bag used for football conditioning had to be retrieved from the training room for treatment; there was a breakdown in communication and confusion as to where staff personnel should meet EMS upon their arrival; staff personnel were not sent or directed to meet EMS at the predetermined location as was indicated on the university EAP. In summary, although the university's EAP may have met the intent of established guidelines, the university's coaching and athletic training staff and administrators failed to plan, practice, and implement best practice guidelines.

EXERTIONAL RHABDOMYOLYSIS

Pathophysiology. Rhabdomyolysis is a relatively uncommon but potentially fatal condition characterized by the large-scale breakdown of skeletal muscle resulting in the release of intracellular contents into the circulatory system. These cellular contents include myoglobin and potassium as well as the enzymes creatine kinase (CK), lactate dehydrogenase, serum glutamic oxalacetic transaminase, and aldolase (77,111). Release of these intracellular components causes electrolyte disturbances such as hyperkalemia, which can lead to nausea, vomiting, mental confusion, coma, and cardiac arrhythmias. Rhabdomyolysis precipitates acute kidney injury in 13–67% of affected individuals and accounts for 5–10% of all cases of acute renal failure in the United States. Urine may be dark, often described as tea-colored, due to the presence of the myoglobin. Damage to the kidneys may result in oliguria or absent urine production, usually 12–24 hours after the initial muscle damage. These signs and symptoms are nonspecific and may not always be present. An elevated plasma CK level is the most sensitive laboratory marker, indicating muscle injury, hyperkalemia, compartment syndrome, and acute renal failure. These are the major life-threatening complications (85,94).

When conditioning exercises or extreme physical exertion leads to rhabdomyolysis, it is clinically referred to as ER. Although ER is the most common diagnosis, rhabdomyolysis is also associated with a number of other conditions to include crush injuries, hypothermia and hyperthermia, sickle cell trait (and other ischemic conditions), snake bites, infections, medications, and inherited conditions (e.g., metabolic myopathies) (80). Regardless of the cause, the pathophysiology of muscle cell destruction follows a common pathway. Damaged muscle cells are affected by direct cell membrane destruction or by energy depletion (i.e., adenosine triphosphate [ATP]). When Na^+/K^+-ATPase and

Ca^{2+}-ATPase pumps in the cell's membrane become dysfunctional, excess calcium begins to accumulate inside the cell. Excessive intracellular calcium, in turn, activates proteases and apoptosis pathways. Simultaneously, the cell's inability to remove reactive oxidative species leads to mitochondrial dysfunction (53). Collectively, these conditions lead to muscle cell death and the release of the dead cell's contents into the circulatory system as described above. These guidelines will focus on the prevention, recognition, and treatment of ER.

Incidence. The syndrome of rhabdomyolysis was first described in detail during World War II after the Blitz of London at which time it was associated with crush injuries (14). A similar condition was also reported in concentration camp survivors (34). The first case of ER was reported in 1960 when 31 US marines were hospitalized after performing an excessive number of squat jumps (50). More recent military studies indicate that ER occurs in up to 40% of individuals undergoing basic training, usually within the first 6 days. The military considers the primary risk factors for ER to be the trainees' low levels of fitness and the introduction of repetitive exercises (e.g., low-crawling push-ups, sit-ups, and squats). The military studies conducted to date report that there is resolution of myoglobinuria (excess myoglobin in the blood) within 2 to 3 days, with clinical improvement of most symptoms within 1 week. Also worth noting is that 25% of all cases of heat stroke in the military between 1980 and 2000 were associated with ER, and that acute renal failure developed in 33% of those individuals (https://health.mil/News/Gallery/Infographics/2017/04/04/Update-Exertional-Rhabdomyolysis-Active-Component-US-Armed-Forces-2012-2016) (1,7).

Other than military recruits, college athletes returning from a period of inactivity are the group most susceptible to developing ER (1,3,7,44,46,82,98,102). It has also been reported in bodybuilders, marathon runners, and recreational weight trainers who engage in high-volume training programs or hybrid workouts that incorporate resistance training circuits with sprints (12,16,28,48,49,110,113). Workouts that emphasize eccentric muscle contractions also seem to place athletes at a higher level of risk for ER (29,79,121).

One of the most publicized cases to date of ER occurred in January 2011 (45,128). Two days after a 3-week winter break, the football team started an intense strength training program that included barbell snatches, pull-ups, dumbbell rows, and weighted sled drills. The most challenging task in the workout was the assignment for athletes to perform 100 back squats with 50% of their 1 repetition maximum (1RM) as measured at their last assessment. Although the times for completing the squat workout were not posted, the athletes were timed and may have viewed it as a competition. Within 1 week, 13 football players were hospitalized with ER (their CK levels ranged from 96,987 to 331,044 IU/L, whereas normal levels are between 22-198 IU/L). Although some of the athletes developed transient renal dysfunction, none developed compartment syndrome, and all were discharged within a few days as their symptoms subsided. This one event led to the inclusion of an obligatory acclimatization period during the initial days of preseason training (www.iowaregents.edu/media/cms/finalreportonrhabdoincident-pdf1A6655AB.pdf).

In the following year (2012), 5 football players were hospitalized after a similar squat workout, with one athlete suffering compartment syndrome in both quadriceps (109). In 2017, a strength and conditioning coach was suspended, and the university issued an apology on behalf of its athletic department after 3 football players were hospitalized after enduring a series of grueling strength and conditioning workouts. Numerous athletes in NCAA programs other than football have been hospitalized for ER. In 2007, for example, the new swim coach had his athletes perform as many push-ups as possible in a minute followed by as many free-standing squats in a minute, repeating the cycle for 10 minutes. The conditioning session was followed by a strenuous swim workout, and the entire regimen was repeated the next 2 days. Not surprisingly, 7 of the swimmers (males and females) were hospitalized for ER. In 2011, it was 3 members of a university women's soccer team; in 2012, it was 6 women's lacrosse players; and in 2016, it was 8 volleyball players. College ROTC cadets have also been affected. In the most prominent case involving ROTC cadets, 11 of 44 (25%) were hospitalized for ER after participating in a timed "extreme conditioning program" that consisted of a mile run, 100 pull-ups, 200 push-ups, 300 free-standing squats, and the completion of another mile run (113).

Collectively, the military studies and those involving college athletes indicate that specific factors increase the risk of ER to include hyperthermia, hydration status, whether the athlete carries the sickle cell trait, and the types of supplements the athlete may be ingesting (www.health.mil/News/Gallery/Infographics/2017/04/04/Update-Exertional-Rhabdomyolysis-Active-Component-US-Armed-Forces-2012-2016) (3,44,102). 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 toward the surface of the skin to dissipate heat as the body attempts to thermoregulate (16). 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 (43). Consequently, athletes who carry the sickle cell trait and experience exertional sickling may be at a higher risk of death from ER than those without the trait (3,44,61,65,125).

Symptoms and treatment. Although mild cases may not cause symptoms, most athletes with ER experience a common set of complaints (115,136). Most symptoms appear within hours to days after the condition develops. Common symptoms include muscle pain that is often aching and throbbing, muscle weakness, muscle swelling or inflammation, dark- or cola- or tea-colored urine, general exhaustion or fatigue, irregular heartbeat, dizziness, light-headed, or feeling faint, confusion or disorientation, nausea or vomiting. A secondary condition called compartment syndrome may occur after intravenous (IV) fluid is administered. This secondary condition causes the compression of nerves, blood vessels, and muscle, and can result in additional tissue damage and problems with blood flow. Medical attention should be sought any time an athlete presents with symptoms associated with ER. Untreated cases can become serious and may cause life-threatening complications such as kidney failure or liver problems. Blood tests for CK, a product of muscle breakdown, and urine tests for myoglobin can help diagnose rhabdomyolysis (although in half of the athletes with ER, the myoglobin is negative). Additional tests may be administered to rule out other problems or be used to check for complications.

Treatment depends on the severity of the case, symptoms, and presence of additional health complications that may increase the risk of kidney damage. In severe cases, kidney damage can be irreversible without early treatment. Hence, early diagnosis and treatment are critical for a successful recovery. 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. Management of electrolyte abnormalities (e.g., potassium, calcium, and phosphorus) helps protect the heart and other vital organs. In the event that compartment syndrome threatens muscle death or nerve damage, a surgical procedure (fasciotomy) can be used to relieve tension or pressure and loss of circulation.

Guidelines for prevention. All the studies on ER referenced above share a common set of core characteristics. All involve athletes or military trainees/cadets performing a high volume of submaximal resistance exercises or body weight exercises (push-ups, pull-ups, etc.) to fatigue and/or in a limited time frame. Most cases of ER cited above occur when an individual is exposed to a novel workout regimen or following a period of detraining (i.e., returning from winter or summer break). Many occur in hot environmental conditions or in training facilities that have poor climate control. Athletes who are dehydrated and/or carry the sickle cell trait are at increased risk. Finally, most cases involving college athletes were caused by a new or an overzealous coach using exercise as punishment or trying to build "mental toughness" (46,109). More often than not, it is a combination of these factors that results in athletes being hospitalized for rhabdomyolysis. To maximize prevention strategies, every strength and conditioning coach and his or her staff members, and all ATs should be educated about ER, the causes and symptoms, and engage in best practices for preventing it.

RETURN TO TRAINING DURING TRANSITION PERIODS

In February 2018, the NCAA Chief Medical Officer, Brian Hainline, issued a set of guidelines recognizing that periods where athletes have undergone significant detraining increase the likelihood of injury resulting from training. The guidelines recommend that during this time as athletes transition back into training, workouts should have lower work-to-rest ratios and progress gradually up to full intensity. In addition, workouts should be documented and made available for administrative staff.

Certainly, one of the challenges during the training of athletes is the design and application of the appropriate exercise, volume, intensity, and rest that will maximize performance enhancement while minimizing the likelihood of exercise-induced injuries. This includes the identification of symptoms specific to ER, EHIs, and cardiac issues due to pre-existing health conditions and genetic factors, as mentioned earlier in this article. It also requires clear, standardized training guidelines for new, returning, and post-ER/EHI athletes (122,133). Although no preventive intervention will eliminate all risk, following a standardized plan can minimize the risk inherent during transition periods. The mission of this CSCCa/NSCA Joint Committee is to provide evidence-based guidelines for training to decrease the risk of ER, EHIs, and cardiovascular-related incidents following inactive periods. These guidelines should also apply to 'optional' practices and workouts.

There are 3 scenarios that need to be considered following a period of inactivity. The first scenario is for returning athletes who have experienced a 2-week break or longer or for student-athletes who are beginning under a new head sport coach. It should be noted that these programming guidelines should be applied to student-athletes in all sports. The second scenario is for new athletes such as freshman or transfer student-athletes that are coming off a period of inactivity, or all student-athletes who are beginning under a new head strength and conditioning coach. The third scenario is for student-athletes returning to training after an incident of ER or EHI. This final scenario will involve a 6- to 8-week rehabilitation program (117) to provide the reintroduction and progression of physical stress to the student-athlete.

The Joint Committee recommends that prescription of conditioning drills after the period of inactivity follows a schedule of reduced volume or workload adhering to the 50/30/20/10 rules

Table 2
Overview of recommended guidelines for training after transition periods

Status	Conditioning activities	Testing	Weight training	Plyometrics
Midseason athletes	Conditioning program on file with appropriate sport administrator			
Returning athletes or new sport coach	50/30% weekly reduction from max conditioning volume on file over 2 weeks. Even distribution per week.	20/10% weekly reduction in workload (volume, intensity, or rest time) for any tests over 2 weeks.	FIT rule to guide volume, intensity, and W:R ratio over 2 weeks. IRV between 11 and 30 (Tables 7 and 8).	<70 foot contacts per session first week, 1:4 W:R. <100 foot contacts/session, 1:3 W:R second week. Intensity as appropriate.
New athletes or new head strength coach	50/30/20/10% weekly reduction from max conditioning volume on file over 4 weeks. Even distribution per week.	50% reduction in testing volume, completed on first day. 30/20/10% weekly reduction in test volume if repeated in following 3 weeks.	FIT rule to guide volume, intensity, and W:R ratio over 2 weeks. IRV between 11 and 30 (Tables 7 and 8).	<70 foot contacts per session first week, 1:4 W:R. <100 foot contacts/session, 1:3 W:R second week. Intensity as appropriate.
Return from ER, EHI, or long inactivity	50/30/20/10% weekly reduction from max conditioning volume on file over 4 weeks. Even distribution per week.	50% reduction in testing volume, completed on first day. 30/20/10% weekly reduction in test volume if repeated in following weeks.	Gradual increase over 5 weeks (Table 9), followed by FIT rule limitations for 1 week.	<80 foot contacts per session at low intensity, 1–2 sessions per week, gradual increase in foot contacts and intensity over 5 weeks (Table 10)

EHI = exertional heat illness; ER = exertional rhabdomyolysis; IRV = intensity relative volume.

for a 2-week period (for returning athletes/new head sport coach), or a 4-week period (for new athletes/new head strength and conditioning coach). These are summarized in Table 2. 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. This conditioning program should be submitted to an appropriate sport administrator before the return to training. 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) in the first week, and a 1:3 W:R or greater in the second week (21). For these new athletes, a conditioning test must be completed on the first day of training and should be performed 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 2 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 standard loads thereafter. Any testing would be performed at a 20% reduction in the workload (through reductions in volume, intensity, or rest time) if completed in the first week and a 10% reduction if completed in the second week. Furthermore, the FIT rule (frequency, intensity volume, and time of rest interval) outlines the recommendations for resistance training during these transition periods. The following paragraphs and associated tables describe the application of these concepts. Note that each coach may decide to reduce the volume and/or intensity by a greater amount based on environmental conditions and/or individual athletes' needs.

The 50/30/20/10 rules and the FIT rule will ensure that strength and conditioning coaches are evaluating their programs to be certain that student-athletes return to training in a safe, effective manner. These guidelines are meant to protect student-athletes in all sports, but also strength and conditioning coaches and universities without stifling the expertise, autonomy, and creativity of the strength and conditioning coach. These rules, used during the first 2–4 weeks of mandatory training after a period of inactivity, give every strength and conditioning coach a standardized roadmap, much like ATs have with the concussion protocol. The recommendations are based on research on detraining showing that reduced activity can lead to decreases in muscle strength (2,32,59,131), aerobic capacity (73,127,130,131), anaerobic capacity (73,93,137), and induce skeletal muscle atrophy (32,59,78,100,101,132). These decrements are seen in a wide range of ages (2,67,78,105,135), potentially inducing injury or illness. Although some studies

Table 3
Reductions in workload for team-based field sport repeat sprint ability (RSA) test

Week (reduction %)	Volume	Intensity (s)	Rest time (s)
Week 1 volume (20%)	230 yds	6–8	45
Week 2 volume (10%)	260 yds	6–8	45
Week 3 volume (normal)	285 yds	6–8	45

indicate that previously trained athletes undergoing short periods of detraining (1–4 weeks) do not exhibit a large detraining effect (51,59,72,78,106,124), the preponderance of evidence supports at least a brief period of lower workload to offset detraining effects that might appear, especially with longer periods of inactivity.

RETURN TO TRAINING 50/30/20/10 CONDITIONING AND TESTING RULE FOR RETURNING ATHLETES OR PROGRAMS WITH A NEW HEAD SPORT COACH

Retraining following short detraining periods can induce restorative improvements in aerobic and anaerobic performances (73,100,127), as well as muscular strength and hypertrophy (67,105,106,132,134). Retraining is especially effective for developing muscle strength and hypertrophy as there is evidence that the myonuclei obtained during hypertrophy are maintained even during extreme atrophy (13,55). Myonuclei serve as required machinery for muscle growth, thus a greater number of myonuclei facilitate the restoration of skeletal muscle mass lost during inactive periods. Furthermore, studies involving humans (8,41,52) and rats (10) have shown initial training and/or retraining enhances myocardial morphology and function. Therefore, a 2-week transition period of decreased workload should be sufficient to allow athletes to fully recover any loss in strength or metabolic capabilities following inactivity. However, extra caution should be exercised when assigning volume loads for returning athletes. Therefore, the Joint Committee recommends that weekly conditioning volume be reduced by 50% from the uppermost volume on file in week 1 with a 1:4 or greater W:R and 30% in week 2 with a 1:3 or greater W:R. For example, if the total conditioning volume for football athletes is 4,000 yards per week, this should be reduced to no more than 2,000 yards in the first week and a maximum of 2,800 yards in the second week during the transition period. The daily volume must be reasonably distributed over 2 or more days per week to avoid injury.

If conditioning testing is completed, then the workload (whether through intensity, volume, rest time, or a combination) should be reduced by 20% in the first week and 10% in the second week. Because of the reduction in workload, there is no mandate to change the W:R for these testing sessions. Tables 3–6 outline examples of application of the rules for testing of returning athletes. For example, the application of a standard repeat sprint ability (RSA) test with duration of 6–8 seconds should consist of 45-second rests between bouts, and in the case of team-based field sports, should not exceed a weekly sprint volume of 285 yards in the first 2 weeks of conditioning (66). The 20% and 10% reductions would result in a sprint volume of approximately 230 and 260 yards, respectively, before reaching the 285 yards (Table 3). Exercise-induced muscle damage in the form of delayed-onset muscle soreness has been shown to result in decreased performance in RSA (37), and this is taken into account with the reduced workload in the first 2 weeks under these guidelines. Additional examples of options for reductions in testing workload can be seen in Tables 4–6. The standards for these tests may vary from program to program but should fall in line with established standards by sport and skill level (e.g., Division I athlete). Standardized tests and norms for different athletes can be found in the NSCA's Guide to Tests and Assessments (97). Coaches should apply these changes in intensity, volume, or both to the standards they have set for their given program as maximal capacity expected of the athlete for each conditioning drill.

RETURN TO TRAINING 50/30/20/10 CONDITIONING RULE FOR NEW ATHLETES, OR PROGRAMS WITH A NEW HEAD STRENGTH AND CONDITIONING COACH

On entry into a program, new athletes (freshmen or transfers) may not be physiologically prepared for the demands of testing or training after a period of detraining. Two to 4 weeks of detraining can result in decreases in aerobic and anaerobic performance (73) with associated decreases in capillary density and blood volume (100). Likewise, brief detraining periods result in only small decreases to strength (71). However, longer periods of inactivity (including a lack of in-season training) result in much larger strength losses (58,83,123), and thus, the retraining process must be undertaken with more caution. Understanding timelines associated with the degree of detraining and retraining provide a justification for reduced volume and/or intensity of training when embarking on a new program or resuming training during transition periods.

Because the detraining period and physiological conditioning will vary from athlete to athlete and will be especially unknown for athletes with no previous history or test results in the program, the Joint Committee mandates a safety precaution consisting of a minimum 50% reduction in volume from the uppermost conditioning volume on file in week 1, and 30, 20, and 10% reduction in the following 3 weeks, respectively. A 1:4 or greater W:R should be used for week 1, and a 1:3 or greater W:R for week 2. For these new athletes, conditioning

Table 4
Options for reductions in workload for 110-yard sprint test for American football (101)

Week	Options for reduction (%)	Repetitions	Intensity (s)	Rest time (s)
Week 1	Volume (20%)	13	15	45
	Intensity (20%)	16	18	45
	Rest time (20%)	16	15	54
	Intensity (10%) and rest time (10%)	16	17	50
Week 2	Volume (10%)	14	15	45
	Intensity (10%)	16	17	45
	Rest time (10%)	16	15	50
	Intensity (5%) and rest time (5%)	16	16	47
Week 3	Normal	16	15	45

Example provided is for skill positions. Baseline intensity for linemen is 18 seconds.

testing must be completed on the first day of return to training and should be performed at 50% of the standard volume of the test on file with the administrator, using 1:4 or greater W:R. 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 CONDITIONING RULE FOR RETURN TO TRAINING AFTER LONG INACTIVITY, EXERTIONAL HEAT ILLNESS, OR EXERTIONAL RHABDOMYOLYSIS

The return to training recommendations that have been previously outlined apply to student-athletes who are free of a recent ER or EHI incident that prevented them from training, but 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. Schleich et al. (122) outlined a 4-phase approach with phase I being 2 weeks of activities of daily living only, while a 1-week phase II begins the use of aquatic exercises and warm-up exercises. Phase III adds resistance exercises performed with body weight only, core training, stretching, and addition of stationary cycling on the fourth day. Finally, phase IV introduces resistance training with 20–25% of estimated 1RM, agility exercises and running (122). These 4 phases follow the progression of physical function after injury as outlined by Cartwright and Pitney (17) that includes an 8-step plan of (a) mobility, (b) flexibility, (c) proprioception, (d) muscular strength, (e) muscular endurance, (f) muscular power, (g) cardiovascular endurance, and (h) sport-specific function. Once the student-athlete completes the 4 phases and has been released to the strength and conditioning coach, 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 for effective physical adaptations (118). The strength and conditioning coach 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 (117). The progression of conditioning and weight training must take into account managing of training load, recovery, and fatigue to reduce the chance of reinjury (129), more specifically a reoccurrence of ER and EHI.

FIT RULE FOR WEIGHT TRAINING ACTIVITY

Return to weight training during a transition period following a period of active rest or minimal training requires attention to the physical stress applied to incoming and returning athletes. In the first 2 weeks, the strength and conditioning coach should be cognizant of the type of training stimulus, volume, intensity, frequency, and the potential risk for each student-athlete. The FIT rule is designed to ensure that frequency, intensity relative volume (IRV), and time of rest interval are appropriately administered to minimize the chance of severe muscle damage.

Frequency is defined as the number of training sessions completed per week for a specific muscle group or movement type (95). For example, the student-athlete might train a total of 5 days in the week, but only train lower body for 3 days, so the frequency for lower-body movements would be 3. The strength and conditioning coach must use discretion on how to distribute training exercises to meet the frequency parameter for each muscle group or movement type. It is recommended that frequency not exceed 3 days in the first week following a period of inactivity and no more than 4 days in the second week. IRV is a derivation of volume load that includes the %1RM (95,107,138) and is calculated with the following equation:

$$\text{Sets} \times \text{Reps} \times \%1\text{RM as a decimal} = \text{IRV units.}$$

The strength and conditioning coach has a wide range of set and

Table 5
Options for reductions in workload for 60-yard shuttle test for collegiate basketball: 18 total reps divided among 3–4 sets, 12 seconds to complete, 45 seconds rest between reps, and 90 seconds between sets

Week	Options for reduction (%)	Repetitions	Intensity (s)	Rest time (s)
Week 1	Volume (20%)	14	12	45
	Intensity (20%)	18	14	45
	Rest time (20%)	18	12	54
	Intensity (10%) and rest time (10%)	18	13	50
Week 2	Volume (10%)	16	12	45
	Intensity (10%)	18	13	45
	Rest time (10%)	18	12	50
	Intensity (5%) and rest time (5%)	18	13	47
Week 3	Normal	18	12	45

rep combinations or manipulations that can be used in his or her student-athlete's training program. A systematic review by McMaster et al. (95) indicates that IRVs between 11 and 20 provide the greatest strength increases, whereas IRVs between 21 and 30 produce strength increases that are somewhat lower. An IRV below 11 may not be adequate to improve strength. Therefore, the Joint Committee recommends an IRV between 11 and 30 for a specific muscle group or movement type. IRVs of greater than 30 are contraindicated in the 2 weeks following period of inactivity. Table 7 provides practical examples of how to apply IRV to a weight training program. Each strength and conditioning coach will use his or her own judgment regarding limitations on the return to training program. The options presented are meant to illustrate the freedom for various styles of programming within the FIT rule.

Time of rest interval, also known as work-to-rest ratio (W:R), is a vital component that must be considered in reducing the risk of ER in student-athletes. As described earlier, ER is often related to high volume training programs or hybrid workouts that incorporate resistance training circuits with sprints. 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. Additional rest time, however, is necessary as it allows the cardiorespiratory and circulatory system to deliver oxygen to muscles and reduce the potential for muscle cell damage. Consequently, based on the W:R guidelines provided in the *Inter-Association Task Force for Preventing Sudden Death in Collegiate Conditioning Sessions*, the Joint Committee recommends that all weight training activity use a 1:4 or greater W:R during week 1 and a 1:3 or greater W:R during week 2 (21). The rest provided during more traditional strength training will be much greater, but this minimum standard will provide protection for student-athletes engaging in high-volume/high-intensity training sessions. The Joint Committee recommends that strength and conditioning coaches follow the parameters outlined by the FIT rule in Table 8 to further protect student-athletes against the increased risk of ER during their return to regular training during transition periods. After reviewing the information in Table 8, coaches should begin to evaluate the periodized lifts in their current programs, which they may find already fall within the designated guidelines.

TRIPLE EXTENSION EXERCISES

Triple extension exercises (e.g., cleans, snatches, etc.) are unique in their demands on the body. Although there has been no known research on volume limits for triple extension exercises, and although no cases of ER have been reported due to a high volume of loaded triple extension exercises, precautions should still be taken to avoid unnecessary risk. Strength and conditioning coaches who do use triple extension exercises in their student-athletes' programs should subscribe to best practice protocols in terms of volume, intensity, and W:R ratio. Based on best practices, the Joint Committee recommends that for all triple extension exercises, IRV should not exceed 25 units in the first 2 weeks during transition periods. In addition, daily total volume as defined by sets × repetitions in these exercises should not exceed 50 repetitions while weekly total volume should not exceed 125 repetitions in week 1 and 150 repetitions in week 2.

PLYOMETRIC EXERCISES

Although loaded triple extension exercises are traditionally used for developing power, many programs use plyometric exercise as the primary method of training to improve power in student-athletes. These exercises should also be monitored and documented by the strength and conditioning coach in the first 2 weeks following periods of inactivity. Applying the FIT rule to plyometric exercise may be more challenging because of 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

Table 6 Options for reductions in workload for half gasser test for collegiate softball: 20 reps, 106 yards per rep (sprint distance is 53 yards one direction), 19 seconds to complete 1-repetition, 1-minute rest				
Week	**Options for reduction (%)**	**Repetitions (yards)**	**Intensity (s)**	**Rest time**
Week 1	Volume (20%)	16 (1,696)	19	1 min
	Intensity (20%)	20 (2,120)	23	1 min
	Rest time (20%)	20 (2,120)	19	1 min 12 s
	Intensity (10%) and rest time (10%)	20 (2,120)	21	1 min 6 s
Week 2	Volume (10%)	18 (1,908)	19	1 min
	Intensity (10%)	20 (2,120)	21	1 min
	Rest time (10%)	20 (2,120)	19	1 min 6 s
	Intensity (5%) and rest time (5%)	20 (2,120)	20	1 min 3 s
Week 3	Normal	20 (2,120)	19	1 min

athletes (112), plyometric workouts in the first 2 weeks should not exceed 70-foot contacts in week 1 and 100 in week 2 for the average-sized athlete, using exercises of an intensity determined by the strength and conditioning coach. This should be modified for athletes with higher body mass or athletes with lower than average strength levels, at the strength and conditioning coach's discretion. Returning athletes can engage in normal volumes in weeks 3 and 4 while new athletes should follow a 20/10% reduction during that time. The time of rest interval for plyometric exercises should have a 1:4 or greater W:R in week 1 and a 1:3 or greater W:R in week 2.

ADDITIONAL CONSIDERATIONS FOR WEIGHT TRAINING RETURN FROM EXERTIONAL RHABDOMYOLYSIS AND EXERTIONAL HEAT ILLNESSES

Testing the student-athlete's muscular strength and power levels after ER and EHIs requires attention to the eccentric muscle contractions as they are precursors to ER in particular (42). Before unrestricted weight and power training, student-athletes need to first return to baseline muscular strength or power levels. This can be based on test results for the athlete before the injury. Strength and power levels vary per sport, athlete position, training age, and previous injury history, thus requiring the strength and conditioning coach to individualize testing for these student-athletes. Therefore, the initial tests in the weight training program should assess all muscle groups that will be tested on unrestricted return to training. The tests for strength and power would count as a training session in the first week because the loading will be stressful on the recovering muscles. After a hiatus from strength and conditioning as result of ER/EHI, the inclusion of weight training that emphasizes or incorporates an eccentric muscular contraction must be gradually reintroduced because eccentric training has been accepted as a mechanism that increases the chance of muscular damage that may result in temporary decreases in physical performance (37,81,96,119). The appropriate and consistent application of eccentric training, however, can increase physical performance (96,139) and should be included as soon as tolerated by the athlete. These student-athletes returning to training after ER or EHIs should be treated as beginning athletes that have no experience with any weight training activities and should follow previously described guidelines (126). After the testing sessions, frequency should begin with only 2 weight training sessions in the first and possibly second week, progressing to 3 times a week (126). If muscle soreness dissipates

Table 7 Intensity relative volume (IRV) practical examples in the first 2 weeks after a transitional period					
Example	**Sets**	**Repetitions**	**% 1RM**	**IRV units**	**Range level**
1	3	12	0.65	23.4	Acceptable
2	5	10	0.60	30.0	Acceptable
3	5	8	0.70	28	Acceptable
4	8	5	0.75	30.0	Acceptable
5	10	10	0.50	50	Much too high

Includes warm-up sets.

RM = repetition maximum.

Table 8
The FIT rule

Category	Week 1 parameter	Week 2 parameter	Citation
Frequency	3 sessions/wk maximum	4 sessions/wk maximum	McMaster et al., (95)
IRV	11–30 units	11–30 units	McMaster et al., (95)
Time rest interval	1:4 W:R minimum	*1:3 W:R minimum	Casa et al., (25)

*W:R ratio after 2 weeks should be a minimum of 1:2 for the remainder of the preseason (21).

IRV = intensity relative volume.

within 48 hours after the end of the weight training session, then higher training frequency may be included. Rest periods between sets in these first 2 weeks of training after ER should be at minimum 5 minutes for strength and power development (126). Table 9 provides a possible progression for student-athletes returning from ER.

The decision to include plyometrics, speed, and agility exercises should meet the criteria previously established for the beginner level inclusion for these activities (e.g., back squatting 1.5 times body weight (35,112)). For student-athletes returning from ER/EHIs, plyometric exercise volume should be no more than 70-foot contacts in the first week and gradually increased to 100-foot contacts dependent on muscle soreness (Table 10) (112). The intensity classifications as described by Potach and Chu (112) will allow strength and conditioning coaches to appropriately adjust intensity, as higher intensity exercises usually involve significant eccentric activity. Before the addition of any plyometric exercises, student-athletes should be free from muscle soreness after linear sprint sessions. The strength and conditioning coach's decision to include plyometric and agility exercises, and the rate progression of such, should be carefully considered for each student-athlete and may not coincide with their weight training regimen. Once linear sprints can be performed without increased muscle soreness and the student-athlete is able to perform them at their previous training volumes, then agility and change of direction drills can be added. The FIT rule will be applied to these student-athletes only after they have achieved baseline levels for all strength and power tests.

The progression of a strength and conditioning program for a student-athlete recovering from ER does not follow the same guidelines as those of student-athletes returning from active rest period. After 14 days or more of detraining (with no activity as could be the case for an athlete returning from ER), athletes may demonstrate decrements in strength performance, whereas active rest periods of adequate training volume or intensity may prevent a decrement (68,71). For those recovering from ER, physical performance increases should follow the guidelines outlined by Schleich et al. (122) and described earlier in this document, or an equivalent protocol deemed safe by the sports medicine staff. Once this protocol is completed and the athlete is released by the sports medicine staff, the 50/30/20/10 rule and FIT rule should be followed. Student-athletes returning from ER or EHIs will need continued monitoring for injury reoccurrence and may require a greater amount of time to develop a level of physical fitness that

Table 9
Suggested weight training progression for return to training after exertional rhabdomyolysis

Week	Sets	Set volume (repetitions)	Intensity (% of 1RM)	Rest time (min)	Frequency (d)
1	1–2	5–6	Light (<75%)	5	1–2
2	2–3	5–8	Light (<75%)	3–5	1–2
3	2–3	3–6	Moderate (75–85%)	3–5	2–3
4	2–5	2–6	Moderate (75–85%)	2–5	2–3
5	2–5	1–6	Mod. heavy (85–90%)	2–5	2–5
6	FIT rule applied				

RM = repetition maximum.

Table 10
Plyometric training progression for return to training after exertional rhabdomyolysis

Week	Session volume (foot contacts)	Intensity	Rest time (min)	Frequency (d)
1	70	Low	5	1–2
2	80–100	Low	3–5	1–2
3	80	Moderate	3–5	2–3
4	80–100	Moderate	2–5	2–3
5	80	High	2–5	2–5
6	FIT rule applied			

Intensity is classified as low, moderate, or high based on vertical displacement, leg support, velocity of movement, etc., as described by Potach and Chu (112).

can accommodate higher training volumes and intensities (86,100,114).

TESTING FOR RETURN TO TRAINING

It is paramount that strength and conditioning coaches establish new baseline testing values and compare them with established norms or previous baseline values. Szczepanik et al. (133) address the need of identifying these student-athletes that are high risk for ER and would require screening by medical staff during initial entry into a collegiate sports program. It is recommended that the strength and conditioning coach register a standard conditioning test for athletes of a given sport with the appropriate administrator. As dictated by the 50/30/20/10 rule for athletes returning from ER, EHI, or long-term inactivity, testing should be performed at 50% of the registered test volume. If these student-athletes are returning after a bout of ER, this new test will provide information on the amount of change (if any) that needs to be addressed in training. For example, if a coach normally uses a repeated 300-yard shuttle test with a 2-minute rest to assess the percentage of change between the first and second test, he or she would instead use a single 300-yard test. A poor performance on this test compared with data on file or normative data would require the strength and conditioning coach to assign longer recovery (3–5 minutes) or lower volume (e.g., distances completed) for those athletes. Furthermore, Satkunskiene et al. (119) suggest that running technique may be slightly altered after acute muscle damage, and that consequently, coaches should note and monitor any changes in running technique. Anaerobic baseline tests should be specific to each sport and appropriate for the student-athlete returning to training. It is of paramount importance that the strength and conditioning coaching staff closely monitor the athletes during these tests for signs of distress, curtailing the test if appropriate. The nature of ER requires that the conditioning be individualized as the recovery period will vary with each student-athlete and his or her speed of adaptation (30,42).

CONCLUSION

The implementation of the new CSCCa and NSCA guidelines to include the documentation of testing and training programs is essential for the prevention of EHIs, ER, and injuries related to preexisting cardiorespiratory conditions or genetic factors. Substantial evidence indicates that student-athletes are at a significantly greater risk when they return to training following a period of inactivity, during the active recovery phase following an injury, or when there is a change in coaching staff. The strength and conditioning staff should carefully plan, implement, and evaluate testing protocols and training programs and provide documentation to the designated athletic administrator or university compliance officer. The documentation and submission of these assessments and training programs is the minimum requirement, and more precise monitoring and documentation of athletes' fitness level, health status, hydration level, and use of medications and dietary supplements is strongly recommended. Strength and conditioning coaches may elect to be more conservative in their exercise prescription based on individual athletes' needs or environmental conditions. If there is an incident of ER, EHI, or a cardiovascular-related event, the NCAA can begin the investigation by consulting the documentation provided to the compliance officer and by interviewing the student-athletes involved. As a profession, strength and conditioning coaches stand at a crossroads and need to be proactive in effecting change in the training of all student-athletes. Strength and conditioning coaches must continue to develop professionally with the intent of decreasing negative outcomes of student-athlete training. The intent of these guidelines is to provide clear parameters to decrease the risk of issues such as ER, EHIs, and cardiovascular-related incidents through guidelines for coaches in the first 2–4 weeks of mandatory strength and conditioning training following periods of inactivity. The 50/30/20/10 rules for conditioning activities and the FIT rule for weight training will help strength and conditioning coaches evaluate their programs and administer them in a safe and effective manner.

SUMMARY

Based on the information presented in these consensus guidelines, the Joint Committee representing the CSCCa and the NSCA provides the following collective recommendations:

- It is critical for the strength and conditioning coach to have access to preparticipation medical evaluations (PME). Look for "red flags" on pre-existing conditions (i.e., sickle cell trait), that would put specific athletes at risk. It is also important for the strength and conditioning coach to be aware of acute illnesses, medications (both prescriptions and over the counter drugs), and nutritional supplements athletes may be taking, (including preworkout drinks), and side effects of those supplements during exercise.

- It is critical for the head strength and conditioning coach to have a written emergency action plan (EAP). Every member of his or her staff should be aware of the plan and know his or her role in performing the plan in an emergency situation. It is recommended that an in-service practice run of the procedure be performed annually, at minimum.
- All strength and conditioning coaches should have proper education, experience, and an NSCA-/CSCCa-approved certification. It is also recommended to partner and communicate with recognized professional organizations to review and implement best practices to ensure the safety of all student-athletes. This includes working closely with sport coaches, sports medicine personnel, and administrative staffs.
- All strength and conditioning coaches must know the early signs and symptoms of exertional injuries outlined in this article. This includes exertional heat illness (EHI), exertional rhabdomyolysis (ER), and other cardiac-related issues that can occur during training. All strength and conditioning coaches must monitor environmental conditions and adjust the training volume and intensity during extreme levels of heat and humidity.
- All strength and conditioning coaches should provide oversight regarding related areas that are normally handled by sports medicine personnel. This includes monitoring the hydration status of athletes by daily weigh-in/weigh-out routines and making sure ice bath and cold-water immersion tubs are always accessible. In addition, athletes should be allowed to acclimatize to extreme environmental conditions through progressive conditioning.
- The head strength and conditioning coach should record a written conditioning program that is considered the upper limit for conditioning volume. This will be used, depending on the status of the athlete, to determine the maximum allowable limits using the 50/30/20/10 rules in the first 2–4 weeks of training after periods of inactivity, as outlined in these guidelines. In addition to the 50/30/20/10 rules for returning and new athletes, programs should adhere to the FIT rule for resistance training.
- Student-athletes who are new to the training program (freshmen and transfers) or returning from injuries should be tested to determine their current level of fitness. The test will be determined by the head strength and conditioning coach, but the standard tests that are used in the program should be registered with the appropriate athletics administrator. It is recommended that the strength and conditioning coach use 50% of the volume of these standard tests for athletes who are new to the training program or returning from injury.
- Once an appropriate conditioning program is determined for new athletes, the volume should not be increased by more than the recommended amount per week. For athletes returning from EHI or ER, the progression should follow the recommendations outlined in this document. For resistance training, the FIT rule (sets × reps × %1RM as a decimal = IRV units) should be followed. It is recommended that this index stay between 11 and 30 IRV units, and a 1:4 or greater W:R be applied to all weight training activity (loaded, body weight, and plyometric) in week 1, followed in week 2 by a 1:3 or greater W:R. A majority of strength training activities will be afforded W:Rs that far exceed 1:4 or 1:3, but these are the minimum standards.
- Finally, it is strongly recommended that all workouts be preplanned, so that a written copy is logged for each day. Once planned, the strength and conditioning staff and/or sports coaches should not exceed this level of volume and intensity. Training should not be used as a punishment or to test the commitment and/or mental toughness of the athletes.

These recommendations are not exhaustive and do not address every type of injury that can occur in all sports. It is the responsibility of each coach to use good judgment in designing a safe and effective training program for his or her athletes. It is the hope of the Joint Committee that following these guidelines will significantly reduce the likelihood of preventable deaths and debilitating injuries from strength and conditioning activities.

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