Youth Football: Heat Stress and Injury Risk

EXPERT PANEL

Michael F. Bergeron, Ph.D., FACSM (Co-Chair)
Douglas B. McKeag, M.D., FACSM (Co-Chair)
Douglas J. Casa, Ph.D., ATC, FACSM
Priscilla M. Clarkson, Ph.D., FACSM
Randall W. Dick, FACSM
E. Randy Eichner, M.D., FACSM
Craig A. Horswill, Ph.D., FACSM
Anthony C. Luke, M.D., MPH
Frederick Mueller, Ph.D., FACSM
Thayne A. Munce, Ph.D.
William O. Roberts, M.D., FACSM
Thomas W. Rowland, M.D., FACSM

INTRODUCTION

From 1995 to 2001, 21 young football players reportedly died from heat stroke in the United States (68). Since that time, the media has highlighted a number of similar incidents, as well as other heat-related problems with young players on the football field, such as exertional collapse. Despite the recognized benefits of sufficient fluid intake and precautionary measures to optimize performance and reduce the risk of heat illness, heat- and dehydration-related problems persist on the football field—particularly in preseason practice.

This roundtable highlighted football-specific empirical data and practices that directly relate to heat stress effects and heat injury risk in youth football. The presentations underscored the operational issues and factors related to heat injury risk and prevention in this age group, with a specific emphasis on preseason practice. Discussions related to general physiological, clinical, and behavioral aspects of hydration, temperature regulation, and heat strain and the clinical management of heat injury were intentionally limited so the informational outcomes of this roundtable could be readily integrated into practical and effective guidelines and strategies to reduce the risk of heat injury for youth football athletes.

Recent published and unpublished on-field observations and survey-based information give new insight to fluid balance and core temperature responses during preseason practice, as well as how selected youth programs are managing environmental challenges and attempting to prevent on-field heat-related injuries. These new data, along with previous on-field observations and other published football-specific studies and reports, provided the bases for discussions during the roundtable.

FLUID LOSSES AND HYDRATION STATUS

As with adult athletes, maintaining fluid balance can be difficult for young football players, especially in hot and humid conditions. Intensity and duration of practice, scheduling of fluid breaks, uniform configurations, and number of sessions per day are also key factors in tempering or exacerbating this challenge. Unfortunately, specific data and insight regarding fluid loss and intake patterns in young football players during practice or games are very limited.

Stover et al. (89) observed moderate rates of sweating (<1 L·h^{-1}) and small body weight deficits (about 1%) in high school players during preseason practice. These measures were slightly lower than losses described in collegiate players training in similar moderate (wet bulb globe temperature [WBGT] 25°C) environmental conditions (87). In another recent on-field examination of high school players during two successive days of preseason football training in much hotter and more humid conditions (33°C, 56% relative humidity), Bergeron et al. (unpublished findings) noted similar pre- to postpractice body weight deficits of nearly 1%, despite each player consuming about 2 L of water during the daily 2-h practice sessions. Moreover, greater sweat fluid losses led to greater body weight deficits. This is not surprising, as athletes often do not match sweat loss with fluid intake during exercise in the heat (10,14). Bergeron et al. also noted that the 10 players presented with elevated urine specific gravities on day 1, suggesting that they were not well-hydrated at the start of practice. Notably, the same players had even higher urine specific gravities at the start of practice on day 2, suggesting that their recovery fluid intake to restore sweat fluid losses from the previous day

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was insufficient and that they were more dehydrated than on day 1. Stover et al. (89) also examined day-to-day changes in body weight and prepractice hydration status across 5 d of the two-a-day training sessions. The players' body weights remained steady, after an initial decrease (0.5 kg) after the first day, and urine specific gravities from prepractice samples remained high (yet unchanged), suggesting that these players were not well-hydrated as well before the start of each practice.

The above observations suggest that young football players tend to *begin* practice measurably dehydrated and this continues on successive days of practice, especially in the heat, even when the athletes have ample time and opportunity to rehydrate overnight. Large sweat losses, insufficient fluid intake, and consequent fluid deficits could likely impair performance and may increase the risk of hyperthermia and heat injury (47,87).

CORE BODY TEMPERATURE RESPONSES ON THE FIELD

Mandatory preseason football practices generally begin in the late summer for the fall youth and high school football seasons. With these physically demanding sessions being held during the hottest and most humid part of the year for many teams (33), it is no surprise that the high incidence of on-field heat-related problems is considered an expected "part of the game." Once acclimatized to the conditions, a football player's core body temperature is influenced by the intensity and duration of practice, uniform and protective equipment configuration, and the current environmental conditions (31,66), although hydration status and fitness may also have measurable contributing effects on the field. The consequences of a significant fluid deficit and lack of fitness are magnified in unacclimatized athletes, which put players at particularly high risk for incurring heat-related problems during the early days of preseason practice. Unfortunately, the data describing on-field core body temperature profiles in youth league and high school football players are either not available or are very limited (e.g., the only such data in high school players are not yet published). This makes it difficult to appreciate which players are at risk during practice sessions and which factors contributing to on-field body temperature elevation could be modified to protect the athletes.

The recent use of ingestible temperature sensor telemetry systems (e.g., CoreTemp®, HQ Inc., Palmetto, FL) in young football players has made on-field core body temperature measurement possible and allowed investigation into the profiles of young football players during practice. Bergeron et al. (unpublished findings) observed similar peak core body temperatures (38.4°C and 38.6°C, respectively) in 10 high school players on the field during two successive days of preseason practice in hot and humid conditions (33°C, 56% relative humidity). Notably, none of the hydration status determinants (prepractice urine specific gravity, fluid intake, sweat loss, and percent change in body weight) were statistically associated with any measure of core body temperature (average temperature, peak temperature, or rate of temperature increase). However, several asymptomatic players had peak core body temperature measurements slightly above 39°C on one or both days. Moreover, these particular players were seemingly not well-hydrated at the start of practice, as indicated by their urine specific gravity. Similarly, several other players, who had relatively high prepractice urine specific gravities, reached peak (observed) core body temperatures that were slightly less than 38.9°C. Had all the athletes been pushed to maintain higher practice intensity and a more constant workload, the relationships between indicators of hydration status and core temperature may have been stronger (34,40). Fowkes Godek et al. (31) found very similar results to those of Bergeron et al., in an on-field examination of 10 collegiate (Division II) football players during preseason training.

UNIFORM AND PROTECTIVE EQUIPMENT EFFECTS

Wearing a football uniform leads to an increase in metabolic heat production while concomitantly decreasing the effectiveness of heat loss mechanisms (15,32,59). The increased metabolic heat production is a consequence of a greater workload associated with the weight of the uniform; whereas inhibition of heat exchange, which varies with different uniform configurations, decreases the effectiveness of heat loss mechanisms (15,31,55,62).

The thermal stress of a uniform is significant, leading to a greater physiological strain for a given environmental condition (15,31,32,55,59). Guidelines for safe participation that account for the added thermal stress of football uniforms are necessary to improve the safety profile of football players during practice, but the thermal stress of uniforms imposed on youth football players has not been studied. Using a physiologic approach, critical environmental limits for uncompensable heat stress while wearing different football ensembles have been described for lean college-aged men exercising at an intensity thought to approximate that of active football players (22,55). A retrospective analysis of documented fatalities from heatstroke among football players indicated that these deaths occurred at or above these critical environmental limits. Still, estimates of metabolic heat production during football practices/games need to be validated, and if necessary, environmental guidelines using these parameters should be developed and verified for different player populations.

DIETARY SUPPLEMENT USE

Several studies (58,63,90) have examined dietary supplement use specifically in high school football players. From 170 questionnaires, Swirzinski et al. (90) showed that 31% of players reportedly used dietary supplements with the intent of building muscle and 90% of these players indicated creatine as their primary sport nutrition supplement. McGuine et al. (63) surveyed 1349 football players and reported that 30% used creatine. This study also found that the perceived risks with creatine use were dehydration (44.5%) and muscle cramps (38.8%), whereas 30.1% of football players reported no perceived risk. Friends were cited as the greatest source of encouragement for use of supplements, whereas parents and coaches were more likely to discourage the use. In contrast to the above findings on dietary supplement intake, Mason et al. (58) reported much lower use (e.g., 6% for creatine) in a study of the same age group athletes.

There are no studies on creatine safety in youth athletes, but two studies examined related safety issues in Division IA (NCAA) college football players (37,54). During the 1999 season, there was no greater incidence of cramping, excessive heat strain/dehydration, muscle pulls/strains, or total injuries/missed practice between creatine users and nonusers (37). In the other study (54), there was no difference in blood and urine screens (e.g., liver, kidney function) among the three examined groups: 5 players who had used creatine 7–12 months, 17 who had used creatine for 12–21 months, and 44 nonusers.

Whether certain dietary supplements make some players more susceptible to heat stress is not known, but the issue warrants ongoing vigilance by clinicians, scientists, and governing bodies for adverse effects of dietary supplement use in youth athletes and continued research into the effects of supplements used by youth football players.

EXERTIONAL RHABDOMYOLYSIS AND SICKLE CELL TRAIT

Exertional rhabdomyolysis. Exertional rhabdomyolysis refers to muscle fiber damage that occurs in response to strenuous and/or unaccustomed physical activity (20,38,51,53,56). Although a certain degree of rhabdomyolysis after exercise is common, fatal rhabdomyolysis is rare. Rhabdomyolysis can be immediately life threatening due to hyperkalemia, and a fatal event over time due to renal failure induced by the precipitation of myoglobin in the kidney. Factors that can exacerbate exercise-induced muscle damage and increase the risk of renal failure are dehydration, genetic conditions such as sickle cell trait and malignant hyperthermia (23,82,94), metabolic defects in the muscle (17,77), existing bacterial or viral infections (49,57), heat stress and exertional heatstroke (52), and nutritional supplement and drug use (13,81,83). Notably, there are relatively few case reports of exertional rhabdomyolysis in young athletes (9,45,65,75,78), but some are related to football practice (9,65,78). Two of these cases resulted in death—one player was determined to have sickle cell trait (78) and the other heat stroke (9). Another young football player experienced rhabdomyolysis-induced renal failure and survived (65).

Sickle cell trait. Sickle cell trait is generally benign, causes no anemia, and does not preclude top athleticism (91), but it poses a small risk of gross hematuria and splenic infarction at altitude. More alarming is the growing evidence that sudden, maximal exertion—especially in hot weather or when new to altitude—can evoke a grave syndrome of red blood cell sickling, fulminant rhabdomyolysis, lactic acidosis, and hyperkalemia, resulting in collapse and acute renal failure (27,48). Exertional compartment syndromes associated with sickling events can result in muscle necrosis and loss of limbs. Even a relatively moderate level of exercise in the heat can induce a low level of progressive sickling and inflammation (11). Since 1970, a number of cases, some fatal, have been described mostly in military recruits in basic training and football players running wind sprints (16,28,39).

The first case in football reported in 1974 involved a college player who collapsed on the first day of practice at altitude; in the following year, he collapsed again during practice and died (36). Sickle cell trait does not preclude top level football participation, as a survey of 579 NFL players showed 6.7% had sickle trait, which is similar to the prevalence of 8% among all African-Americans (69). Yet, sickle cell trait has caused the death of up to 10 college football players—many having sprinted only 800–1200 yards on the first or second day of practice, like the case described in an informative clinical report in 1992 (82). Sickling deaths have also occurred in high school and junior-high football players, though sometimes these are misreported as exertional heatstroke, as in the case of a 12-yr-old football player who had a rectal temperature of only 100.6° F when he arrived at the hospital (78), which would be an unlikely fatal body temperature. However, not all sickling collapses in football are fatal (16). Two recent cases in collegiate football were hospitalized but survived; one had a mild clinical course, but the other spent 2 wk on dialysis and was hospitalized for 2 months recovering from the systemic insult.

Sickling during football usually occurs during heavy exertion like wind sprints, timed miles, ramp running, mat drills, and weight training. Occasionally, sickling will happen during a football game—for example, when a running back participates in a series of running plays with little recovery time. Players who sickle severely during exercise collapse from muscle pain and malfunction, not ventricular fibrillation; so they can still talk after they fall to the ground. They complain of severe "cramping" pain in legs and low back. They also hyperventilate, to compensate for lactic acidosis from taxing ischemic muscles. Vital signs can deteriorate quickly, with the acidosis impairing the pumping power of the heart or hyperkalemia from fulminant rhabdomyolysis, causing fatal ventricular arrhythmias. Death can occur in the arena from cardiac arrhythmias or during the hospital admission from rhabdomyolysis and the secondary acute renal failure (28). Milder cases of sickling can be confused with heat cramping in football players; but sickling is characterized by earlier onset of pain, ischemic quality of cramping pain, higher elevations of serum creatine kinase, and slower return to play (several days).

RECOMMENDATIONS AND GUIDELINES

These recommendations and guidelines for youth football practice modification are a combination of evidence-based data and expert opinion that allow athletes to safely and

TABLE 1. Descriptions of evidence categories designators used to support the recommendations and guidelines.

Evidence Category	Level of Evidence	Definition
A	Randomized controlled trials (rich body of data)	Substantial number of well-designed studies; substantial number of subjects; consistent pattern of findings
B	Randomized controlled trials (limited body of data)	Limited number of studies; includes *post hoc*, field studies, subgroup, or meta-analyses; pertains when number of randomized controlled trials is small, results are inconsistent, or subject populations differed from the target population
C	Nonrandomized trials/observational studies	Evidence is from outcomes of uncontrolled or nonrandomized trials or from clinical observations or case studies
D	Panel consensus judgment	Used when guidance is needed, but literature is lacking; this is an expert judgment based on a synthesis of published evidence, panel consensus, clinical experience, and laboratory observations

Adapted from *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults* (http://nhlbi.nih.gov/guidelines/obesity/ob_exsum.pdf).

sufficiently acclimatize in the early season to improve the safety profile for each player (72,74,92). Graduated and repeated exposure to the heat stress, training intensity and volume, and insulating properties of the football uniform, combined with appropriate alterations of practice intensity and duration, equipment cover, and between practice recovery time, should allow physiological adaptation to occur safely and effectively (19). Most high school and college heat-related fatalities occur in the first 4 d of preseason practice (with days 1 and 2 having the highest risk) and are seemingly related to lack of acclimatization, associated with too much activity in hot, humid conditions. Although exertional heat stroke during football practice may not be totally preventable, the incidence can be dramatically reduced with more deliberate attention to progressive training and acclimatization, utilizing appropriate practice modification that reflects the environmental and physiological challenges facing football players. Death from heat stroke can be averted with prompt onsite recognition and appropriate cooling treatment.

The proposed acclimatization plan and practice modification guidelines, modified to recognize the unique aspects of youth athletes and programs, are based on models recently developed for college football players (24,25) and guidelines supported by the National Federation of State High School Associations (NFHS). The goal of these recommendations is to improve the football players' safety profile while practicing and conditioning in the heat. Appropriate fluid replacement during and after practice also contributes to heat illness reduction, and whereas improved hydration alone will not prevent exertional heat stroke or ensure heat protection, it is integral to football safety. Therefore, regular fluid breaks, designed to replace the majority of practice sweat losses, are an essential part of every practice plan. Water is an appropriate and adequate fluid replacement during preseason practice, although sports drinks can be advantageous in encouraging greater fluid intake and providing energy (carbohydrates) and electrolytes, which help to avert fatigue and maintain fluid balance (5,10,18,21,35,50,61,64,71,84,87,93).

A preparticipation exam should be integrated into the athlete's routine periodic health screening and specifically address medication and supplement use, cardiac disease, sickle cell trait, and previous heat injury. Any one of these factors (alone or in combination) may increase the risk of heat-related illness during football practices and games. Moreover, a review of fatal heat stroke cases indicates that athletes with recent or current illness, vomiting, diarrhea, or fever are at greater risk for exertional heat stroke. Therefore, athletes at any age should not practice or compete until these conditions are resolved. Although all athletes should be monitored for heat problems during practices and games, exam information that might affect an athlete's heat safety should be reviewed with the coaches and team medical staff and should be utilized to appropriately modify individual and team preseason practice sessions.

The current college age preseason acclimatization plan (24,25) and proposed NFHS guidelines, utilized as the basis for these recommendations, have been modified for the younger age groups for several reasons. It may take longer for prepubertal boys to acclimate to hot conditions compared to postpubertal males and college athletes (30,92), so the recommended acclimatization period is longer than the current college model. Moreover, youth athletes (including the high school age group) often have less physical preparation and opportunity (time) for acclimatization to football preseason practice sessions than college players, which may contribute to earlier fatigue and greater risk of injury compared with their college peers. Football players require a wide range of preparation and activity considerations during practice for safe training in the heat. However, coaches must accept that environmental conditions can, at times, be altogether too extreme for safe and effective football activity.

The remainder of this document summarizes the final consensus recommendations of the roundtable faculty, based on the presentations and subsequent discussions. Each of these recommendations is presented, using a format that reflects the evidence-based approach used during the 2-d meeting, bearing a designation of A, B, C, or D. These designators reflect the respective strength-of-evidence determinations, as noted below. The recommendations presented here all have level of evidence designators of C or D. This underscores the need for more football-specific, on-field data to address the myriad factors and challenges related to heat injury risk in young football players).

The primary goals of these recommendations are that each youth football participant begin each practice session:

- well hydrated, well rested, and well nourished, and
- with a normal resting body temperature.

ACCLIMATIZATION DURING THE FOOTBALL PRESEASON

When planning the preseason practices and schedules, coaches and league organizers should consider that many athletes in these age groups will report with minimal, if any, conditioning and without sufficient acclimatization to the heat stress challenges of on-field football practice. Therefore, to minimize heat strain and allow a safe transition to full-intensity practice in full gear, gradual and increasing exposure to practice intensity and duration, and gradual introduction of the different uniform configurations that considers the insulating properties of the equipment are critical (19,72,74,92). Most of the early-season football heat stroke deaths have occurred in the first 4 d of practice (with days 1 and 2 having the highest risk). These acclimatization recommendations are intended to reduce the incidence of exertional heat stroke, as well as the incidence of general injury, during the highest-risk days of the preseason.

High School

Two-a-day conditioning and training sessions should not be introduced in the first week of preseason practice, and the duration of conditioning-specific activities to optimize acclimatization and fitness should not exceed 60–90 $min{\cdot}d^{-1}$. Teaching the sport will require more daily time, but the total duration of practice in the first week should not exceed 3 h (including warm-up, conditioning, instruction, breaks, and cool-down) per day. Moreover, players should not be allowed to practice more than six consecutive days.

During the first week of practice, protective equipment should be introduced in stages, starting with the helmet and progressing to the shoulder pads and helmet, and finally to the full uniform. Athletes should spend at least one practice session in full gear, before full live contact is allowed. A second 60-min walk-through may be scheduled each of the first 5 d as a teaching opportunity for instruction in team formations and plays—however, there should be no running, conditioning, weight-room work, protective equipment (e.g., helmets, shoulder pads), or equipment related to football (e.g., footballs, blocking dummies, blocking sleds) utilized during these additional walk-through sessions.

If two-a-day sessions are introduced in the second week of practice, two-a-day sessions should not be scheduled on consecutive days. It is critical to provide both ample time between same-day sessions and specific instruction to the players for safe and sufficient recovery from the greater heat and fluid challenges of the multiple-session practices. A minimum of 3 h should be given for the athletes to cool-down, rest, eat, and sufficiently restore fluids between same-day sessions.

A suggested practice schedule emphasizing acclimatization during the first 14 d of a high school preseason is as follows:

- Initial 6-d acclimatization period:
  - *Days 1 and 2*—Single practice session with helmets only, no live contact, and not to exceed 3 h of warm-up, conditioning, instruction, and cool-down, with an emphasis on initiating acclimatization.
  - *Days 3, 4, and 5*—Single practice session with helmets and shoulder pads only, no live contact, and not to exceed 3 h of warm-up, conditioning, instruction, breaks, and cool-down, while emphasizing progressive acclimatization. Limited contact may be initiated with blocking sleds and tackling dummies on days 4 and 5.
  - *Day 6*—Single practice session with full pads allowed and not to exceed 3 h of warm-up, conditioning, instruction, breaks, and cool-down, with no live contact drills permitted (sleds and tackling dummies only) and an emphasis on acclimatization to the full uniform.
- *Day 7*—Off.
- *Days 8–13*—Allow multiple practice sessions on a two-a-day, one-a-day alternating rotation, with the option of full pads based on the practice modification parameters (see below), and not to exceed 3 h in one practice session (including warm-up, conditioning, instruction, breaks, and cool-down) and 5 h a day combined practice duration (including all within-session breaks), with at least three continuous hours of recovery time between same-day sessions.
- Intrasquad scrimmages should not be scheduled before day 12 of the 14-d period.
- *Day 14*—Off.
- Important reminders:
  - Multiple on-field conditioning and training sessions (e.g., two-a-day) should not be conducted on consecutive days.
  - The length of each practice session should not exceed 3 h (including warm-up, conditioning, instruction, breaks, and cool-down) and should be modified appropriately, in accordance with the environmental conditions (heat, humidity, and solar radiation).
  - There should be no more than six consecutive days of practice.

Level of evidence: C

References: (19,24,25,33,55,60,62,70,86)

Youth League

Youth football organizations with younger participants should develop a preseason acclimatization plan that has a greater emphasis on allowing prepubertal and pubertal athletes to safely learn the game and adjust to the demands of the sport. The preseason program should reflect that, for example, 10- to 11-yr-old boys may take 5 d to make the same heat adaptations that postpubertal players can accomplish in 2–3 d. As with high school teams, youth league players should not be allowed to practice more than six consecutive days.

A suggested model for younger players (below high school age) in youth football leagues is outlined by the following program parameters for preseason practices:

- 8–10 acclimatization episodes with 30–45 min of conditioning are recommended, at a rate of one per day or one every other day.
- No one practice session should last more than 2 h (including warm-up, conditioning, instruction, breaks, and cool-down).
- Preseason practices are limited to one session per day and 10 h total in a week (including within-session breaks).
- *First week (up to 10 h total)*—Shorts, shirts, and helmet only, with an emphasis on heat acclimatization and basic skills.
- *Second week (up to 10 h total)*—First 6 h in helmet and shoulder pads, and the remaining 4 h in full pads, without live contact (limited contact with blocking dummies and sleds permitted after total of 14 h of practice—weeks 1 and 2 combined).
- *Third week (up to 10 h total)*—Full pads with live contact permitted.
- No more than six consecutive days of practice.
- *Regular season practices*—Up to 6 h a week, with no practice session lasting longer than 2 h (including warm-up, conditioning, instruction, breaks, and cool-down).

Level of evidence: C

References: (19,25,33,44,46,55,60,62,70,86)

PRACTICE MODIFICATIONS TO REDUCE HEAT EXHAUSTION OR EXERTIONAL HEAT STROKE RISK

With increasing levels of heat and humidity, a player's capacity to dissipate body heat, minimize the accumulating heat strain, and tolerate the conditions is diminished. Consequently, the risk for heat exhaustion or exertional heat stroke can increase dramatically, especially if practice intensity is high. The addition of insulating football protective equipment compounds a young player's reduced capacity to dissipate heat. Therefore, appropriate activity modification decision processes should incorporate ambient temperature, relative humidity, and solar radiant heat load, in deriving a rational set of parameters to shorten exposures and reduce insulating gear. More frequent fluid and rest breaks should also be incorporated during practice, as environmental conditions become more challenging.

The operationally safe environmental thresholds for determining appropriate modifications in practice intensity, duration, number of breaks, and uniform configuration would theoretically decrease practice workload and remove insulating equipment, well before players experience uncompensable heat stress for the respective environment. But until more on-field data related to heat strain are collected from young players during actual preseason practices and correlated to heat injury risk, it is impossible to propose evidence-based environment-specific charts that coaches can use to modify practices. Therefore, coaches need to appreciate and anticipate as best they can (erring on the side of caution) the physiological challenges facing a player and implement appropriate changes to effectively reduce the associated clinical risks and improve the overall safety profile for young football athletes. Therefore:

- Practices should be modified for the safety of the athletes, in relation to the degree of environmental heat stress on the practice field. Consider this information when making practice modification decisions:

  —Midday (12:00–4:00 p.m.) is often the hottest part of the day, especially if it is a bright, sunny day. However, late afternoon or early evening (4:00–7:00 p.m.) can be just as hot or hotter in certain regions during the summer months.
  —When conditions are too extreme* (e.g., unusual high heat and humidity), practice should be canceled altogether, moved into air-conditioned spaces, or held outside as walk-through sessions with no protective gear or conditioning activities, with regular breaks for fluid consumption and reduced sun exposure.
  —Adjusting the work-to-rest ratio, by lowering the activity duration and/or intensity and increasing the frequency and duration of breaks, is an effective way to lower metabolic heat production and the thermal challenge to players.
  —Many activities can be continued safely, by simply removing equipment and having players participate in shorts with helmets and shoulder pads only (not full equipment) or shorts only (with all protective equipment removed), as heat stress increases.

*Extreme conditions, based on a laboratory study (55) designed to determine zones of compensable and uncompensable heat stress for various uniform configurations and translated into WBGT limits (22), would be indicated when the on-field WBGT is in excess of 91.5°F (33.1°C).

Level of evidence: C

References: (1,2,12,22,44,46,55,60,62,79,88)

- Players should wear as little covering as is appropriate, and helmets should be taken off whenever possible (e.g., during instruction).

Level of evidence: C

References: (55,60,62)

- Players should wear light-colored clothing during practice.

Level of evidence: D

- Regular breaks should be included in each practice session schedule, to allow rest, cooling, and fluid replacement, *at least* every 30–45 min. Breaks should be *more frequent*, as heat and humidity rise and the risk of excessive heat strain increases.

Level of evidence: C

References: (6,60).

- Fluid replacement should be further promoted by providing chilled fluids, easy access, and adequate time for ingestion, to encourage sufficient fluid intake and lessen progressive dehydration on the field. Common barriers to adequate fluid intake include a limited number of water coolers and excessive distance to the fluid stations.

Level of evidence: D

- Athletic trainers or volunteer staff should be encouraged to bring fluid to players on the field between "official" breaks, if portable fluid delivery systems are available.

Level of evidence: D

- During breaks, players should use shade when it is available, to reduce the radiant heat load.

Level of evidence: D

- Practice parameters should be individualized for athletes known to be at greater risk for heat injury.

Level of evidence: C

References: (12,26,43,44,67,73,80,85)

- Players with acute gastrointestinal or febrile illness should not be allowed to participate.

Level of evidence: C

References: (1,12)

- Players should not use stimulants such as ephedrine, Ma Haung (Chinese ephedra), and high-dose caffeine that are often found in certain dietary supplements and "energy" drinks.

Level of evidence: C

References: (76)

MONITORING PLAYERS DURING PRACTICE

The team support staff (including athletic trainers) must closely monitor all players for signs and symptoms of developing heat-related injury during football practice or competition in stressful environments. Players who are not acclimated or aerobically fit, especially the large linemen with excessive body mass index (BMI) and body fat mass, warrant closer and constant scrutiny for heat illness (7,8,41,42,44).

- Prepractice daily body weight and urine specific gravity or urine color can be used as indirect indicators of hydration status.

Level of evidence: C

References: (4,14,18)

- Body weight measurements taken just before and after practice can help in determining the amount of fluid that should be replaced to assist in recovery before the next practice and to educate regarding better fluid replacement during practice.

Level of evidence: C

References: (14,18,47,70,89)

- There should be an adequate number of coaches, staff, and athletic trainers to effectively monitor all athletes on the field for signs of heat illness.

Level of evidence: D

- All players should be observed during practices for changes in performance or personality that might be early indications of developing heat injury.

Level of evidence: C

References: (1,12,73)

- Any changes in player performance, personality, or well being, including pale color, bright red flushing, dizziness, headache, excessive fatigue, fainting, vomiting, or complaints of feeling hot or cold during practice or conditioning drills, should be sufficient reason to *immediately* stop practice for all affected players.

Level of evidence: D

- Besides general precautions to sufficiently hydrate, acclimatize, condition, and rest when ill and avoid certain dietary supplements and drugs, prudent special precautions for sickle-trait football players should include no day 1 fitness runs and no timed miles or sustained sprints over 500 m. Any cramping should be treated as sickling until proved otherwise.

Level of evidence: C

References: (27,28)

- Teams should use the "buddy" system to monitor players (two players who play the same position assigned to "keep an eye on" each other).

Level of evidence: D

- If exertional heat stroke is suspected, players should be stripped of equipment and cooled in a tub of cold water or by using rapidly rotating ice water towels to the extremities, trunk, and head and ice packs in the armpits, groin, and neck areas, until emergency personnel can assume care and evacuate the athlete to the nearest emergency facility. Importantly, cooling should continue en route.

Level of evidence: C

References: (3,29)

- If players experience severe muscle pain and weakness after practice, they should monitor urine color. If urine becomes tan or brown in the first hour up to several days after practice, they should immediately seek medical attention, as this may indicate that the kidneys are not functioning properly.

Level of evidence: C

References: (20,38,51,53)

- Leagues should provide annual education for coaches and support staff that addresses heat-related illness reduction, identification, and first aid for football players.

Level of evidence: D

FUTURE RESEARCH

Young football players should not have to suffer heat injuries or die from heatstroke. Heat injury can be reduced if parents, coaches, and other adults involved with youth football programs have access to and utilize the right information. Unfortunately, guidelines employed by youth football coaches, medical staff, and governing bodies to prevent or reduce the risk for heat-related injuries are not specific to football or based on football-specific, on-field data. The information presented here and the recommendations of this roundtable are intended to launch new and expanded programs of research and education to improve the health and safety of young football players, particularly during the preseason training period. However, more data are needed to fully understand the challenges facing young football players on the field, so that more effective strategies to reduce the incidence of heat injury can be developed. Specific suggestions for research topics to meet this objective include:

- Develop a surveillance system for youth football heat injury (that would capture incidents that resulted in death and otherwise) that includes a comprehensive description of concomitant practice conditions (e.g., time of day, environmental temperature and humidity, length of practice and frequency of water and rest breaks, uniform and equipment worn, exact activity when the incident occurred, first aid administered, elapsed time before medical help arrived, medical diagnosis, and autopsy reports).
- Determine regional differences in heat injury based on latitude temperature bands.
- Monitor core body temperature in players during practice, utilizing ingestible temperature sensor telemetry system technology.
- Establish validated estimates of metabolic heat production during football practices and games.
- Compare heat strain effects (thermoregulatory and cardiovascular) of full gear versus limited gear for youth players.
- Test the effectiveness of protective equipment (e.g., air-cooled, football shoulder pad system) designed to reduce heat strain.
- Develop core body temperature profiles of players at different levels of play in different environmental conditions, to determine age-specific "heat safety grids" and practice guidelines, based on actual practice in varying uniform and protective equipment configurations.
- Evaluate the effectiveness of the "buddy" system.
- Survey for supplement and medication use that may adversely affect heat balance in young players.
- Develop easy-to-use computerized models of heat exchange between the body and environment (considering football uniforms) that can be used by athletic trainers and coaches to make informed practice modification decisions.
- Evaluate the effectiveness of coaching education in heat-related illness reduction, identification, and first aid for football players.

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