Journal of Athletic Training 2021;56(4):352–361
doi: 10.4085/1062-6050-596-20
© by the National Athletic Trainers' Association, Inc
www.natajournals.org

Roundtable on Preseason Heat Safety in Secondary School Athletics: Heat Acclimatization

William M. Adams, PhD, ATC*; Yuri Hosokawa, PhD, ATC†; Douglas J. Casa, PhD, ATC‡; Julien D. Périard, PhD§; Sebastien Racinais, PhD||; Jonathan E. Wingo, PhD¶; Susan W. Yeargin, PhD, ATC#; Samantha E. Scarneo-Miller, PhD, ATC; Zachary Y. Kerr, PhD, MPH††; Luke N. Belval, PhD, ATC, CSCS‡‡; Denise Alosa, MS, ATC§§||||; David Csillan, MS, ATC¶¶; Cynthia LaBella, MD##; Lisa Walker, ATC*****

*Hydration, Environment, and Thermal Stress Lab, Department of Kinesiology, University of North Carolina at Greensboro; †Faculty of Sport Sciences, Waseda University, Tokorozawa, Saitama, Japan; ‡Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs; §Research Institute for Sport and Exercise, University of Canberra, Bruce, Australia; ||Research and Scientific Support Department, ASPETAR Orthopaedic and Sports Medicine Hospital, Doha, Qatar; ¶Department of Kinesiology, University of Alabama, Tuscaloosa; #Department of Exercise Science, University of South Carolina, Columbia; **Division of Athletic Training, School of Medicine, West Virginia University, Morgantown; ††Department of Exercise and Sport Science, University of North Carolina at Chapel Hill; ‡‡Institute for Exercise and Environmental Medicine, Texas Health Presbyterian Hospital Dallas and University of Texas Southwestern Medical Center, Dallas; §§Athletic Medicine, South Burlington School District, Burlington, VT; ||||College of Nursing and Health Science, University of Vermont, Burlington; ¶¶Department of Physical Therapy, Princeton Orthopedic Associates, NJ; ##Department of Pediatrics, Northwestern University Feinberg School of Medicine Institute for Sports Medicine, Ann & Robert H. Lurie Children's Hospital of Chicago, IL; ***Springville High School, UT

Objective: To provide best-practice recommendations for developing and implementing heat-acclimatization strategies in secondary school athletics.

Data Sources: An extensive literature review on topics related to heat acclimatization and heat acclimation was conducted by a group of content experts. Using the Delphi method, action-oriented recommendations were developed.

Conclusions: A period of heat acclimatization consisting of $\geq$14 consecutive days should be implemented at the start of fall preseason training or practices for all secondary school athletes to mitigate the risk of exertional heat illness. The heat-acclimatization guidelines should outline specific actions for secondary school athletics personnel to use, including the duration of training, the number of training sessions permitted per day, and adequate rest periods in a cool environment. Further, these guidelines should include sport-specific and athlete-specific recommendations, such as phasing in protective equipment and reintroducing heat acclimatization after periods of inactivity. Heat-acclimatization guidelines should be clearly detailed in the secondary school's policy and procedures manual and disseminated to all stakeholders. Heat-acclimatization guidelines, when used in conjunction with current best practices surrounding the prevention, management, and care of secondary school student-athletes with exertional heat stroke, will optimize their health and safety.

Key Words: acclimation, adaptations, exertional heat illness, exertional heat stroke

Exertional heat stroke (EHS) is consistently ranked among the top 3 causes of sudden death in sport and physical activity.[1,2] Previous position,[3–6] consensus,[7] and interassociation task force[8] statements have provided recommendations for *heat acclimatization*, the process whereby repeated exposure to heat stress elicits physiological adaptations to improve thermal tolerance, as a method of attenuating the EHS risk. Although the implementation of heat-acclimatization guidelines in secondary school athletics has been effective in reducing the EHS risk,[9,10] the current recommendations provide limited guidance regarding implementation across all sports.

ROUNDTABLE MEETING

A multidisciplinary group of content experts was formed and a roundtable meeting convened on May 28, 2019, in Orlando, Florida, to discuss preseason heat safety for secondary school student-athletes. The multidisciplinary group comprised 33 practitioner and scientist content

Downloaded from http://meridian.allenpress.com/jat/article-pdf/56/4/352/3019796/i1062-6050-56-4-352.pdf by guest on 01 March 2024

experts who met the following criteria: (1) expertise in the management and care of patients with exertional heat illness; (2) active involvement in providing clinical care to secondary school student-athletes; and (3) expertise in biometeorology, thermal physiology, or epidemiology. Specifically, the roundtable participants consisted of scientists with expertise in the management and care of EHS (n = 12), clinically practicing secondary school athletic trainers (n = 7), sports medicine physicians (n = 5), scientists with expertise in thermal physiology (n = 5), scientists with expertise in biometeorology (n = 2), an emergency department physician (n = 1), and a sports injury epidemiologist (n = 1).

From the roundtable attendees, a working group (n = 14) was formed to draft this document. Their primary purpose was to develop evidence-based recommendations and implementation strategies for heat acclimatization in secondary school athletics. The working group responsible for drafting this document comprised scientists with expertise in the management and care of exertional heat stroke (n = 6), clinically practicing secondary school athletic trainers (n = 3), scientists with expertise in thermal physiology (n = 3), a sports medicine physician (n = 1), and a sports injury epidemiologist (n = 1).

METHODS

The *Delphi method*, a framework for establishing consensus through the unbiased aggregation of expert opinion on a topic,[11] was used to develop consensus among the roundtable attendees. Aligning with current best practices for the use of the Delphi method, we followed a 2-stage process: an exploration phase and an evaluation phase. A full description of this process is available elsewhere[12,13]; however, we provide a brief overview in the sections that follow.

Exploration Phase

The working-group members conducted a review of the relevant literature, which served as the foundation for developing action-oriented recommendations. Specifically, the review focused on the induction and decay of heat acclimatization; physiological adaptations obtained from heat acclimatization; time course of heat acclimatization; sport-specific heat-acclimatization considerations; age, sex, and environmental heat-acclimatization considerations; and heat-acclimatization implementation strategies.

Evaluation Phase

After the exploration phase, the working group prepared action-oriented recommendations for use in secondary school athletics. Once the recommendations were finalized, the roundtable participants were emailed a link to an anonymous survey (Qualtrics) for scoring. Roundtable attendees assessed each recommendation for validity, feasibility, and clarity using a Likert-type scale (range = 1–9), in which a higher score indicated that a recommendation was more valid, feasible, or clear, respectively. If they wished, attendees could provide comments to support their score for each recommendation. For scoring purposes, *validity* was operationally defined as whether the recommendation was substantiated based on current data, theory, literature, or other scientific evidence. *Feasibility* was operationally defined as whether it was realistic to expect individuals or campuses to implement the recommendation, keeping in mind the widely varying resources and competing demands that individuals and campuses may face. *Clarity* was operationally defined as whether the recommendation was clear and easily understood.

We compiled the scores from each attendee and calculated the mean scores for each construct (ie, validity, feasibility, and clarity) and each recommendation. Any recommendation with a score <4 was discarded, and any recommendation with a score ≥ 7 was retained in the final version. All mean scores of 4 to 6 were revisited for further discussion; the working group revised these recommendations using input from the survey open comments. All roundtable attendees then performed a second round of scoring for the revised recommendations using the same methods as in the first round. Recommendations with mean scores ≥ 4 but <7 after the second round of scoring were assessed by 3 roundtable members (W.M.A, Y.H., D.J.C.) and modified by consensus.

NARRATIVE REVIEW

Physiological Adaptations to Heat Acclimatization

Heat acclimation or acclimatization involves repeated exposure to environmental conditions that elicit profuse sweating, increase skin blood flow, and elevate skin and core body temperature, leading to physiological adaptations that reduce the negative effects of heat stress on health and performance. *Heat acclimation* refers to the adaptations that occur after a period of heat exposure undertaken in artificial or laboratory settings, whereas *heat acclimatization* occurs in natural outdoor environments. Although the physiological adaptations elicited by artificial and natural environments are similar,[14,15] exercise heat acclimatization has been suggested to provide more specific adaptations due to the regular exposure to particular training environments (ie, ambient temperature, humidity, solar radiation).[16]

The adaptations that develop during heat acclimation or acclimatization include plasma volume expansion and better maintenance of fluid balance, lower exercising core temperature, enhanced sweating and skin blood-flow responses, improved cardiovascular stability, and less reliance on carbohydrate metabolism during exercise in the heat at a given workload.[16–18] A complete list of physiological adaptations afforded by heat acclimatization is available in the Figure. These adaptations allow for improved submaximal exercise performance and increased maximal aerobic uptake ($\dot{V}O_2max$),[19,20] attenuation of perceived fatigue within training sessions,[21] and enhanced thermal comfort in the heat.[22–24] However, support for enhanced thermal comfort is lacking in the contemporary literature. As we explain later, the magnitude and time frame of induction vary among individuals and depend on intensity, duration, frequency, and number of heat exposures, as well as the environmental conditions (eg, dry or humid heat).

Time Course of Heat Acclimatization and Decay

Generally speaking, 75% to 80% of heat-acclimation adaptations are achieved during the first 7 days of heat

Downloaded from http://meridian.allenpress.com/jat/article-pdf/56/4/352/3019796/1062-6050-56-4-352.pdf by guest on 01 March 2024

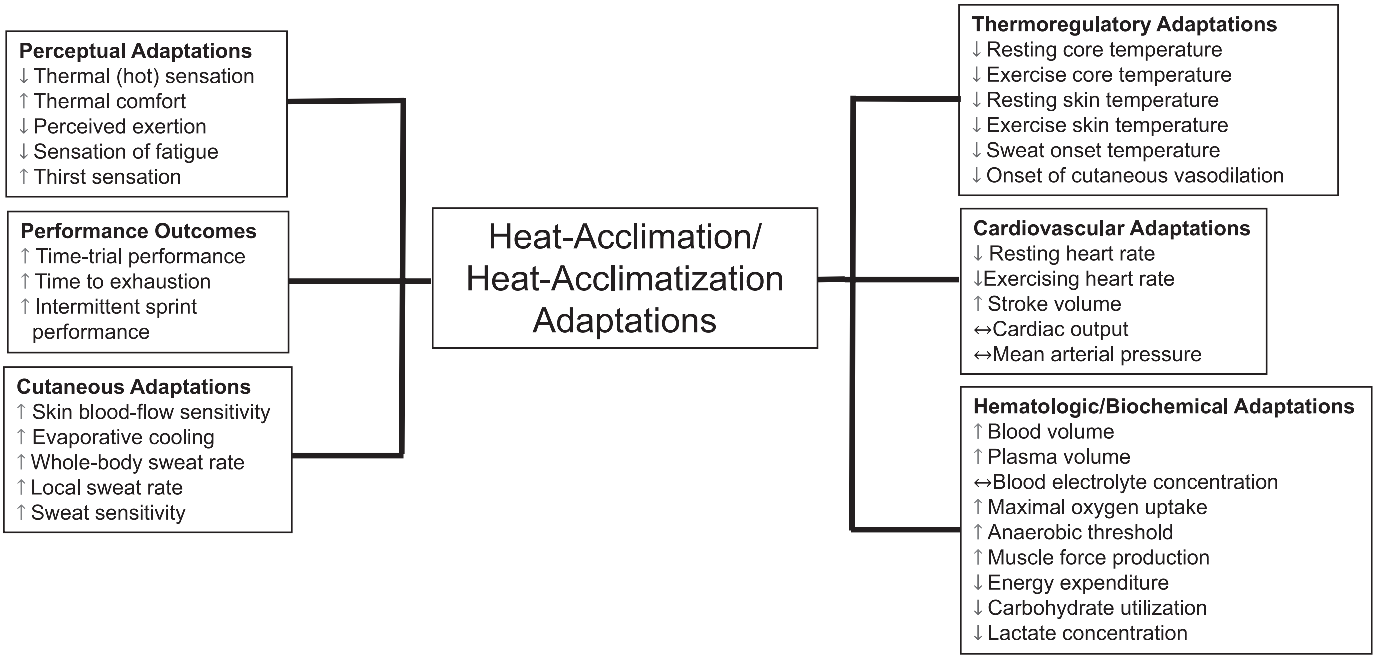

Figure. Physiological adaptations after heat acclimation or acclimatization.[46] ↑ = increased physiological response, ↓ = decreased physiological response, ↔ = equivocal physiological response.

exposure,[16,25] yet large interindividual variations exist.[26,27] Although a few days of heat exposure provide some level of heat acclimation or acclimatization, athletes generally require >10 days for full expression of cardiovascular and sudomotor (ie, sweating and skin blood-flow responses) adaptations[20,28,29] and at least 2 weeks to optimize their physical performance in hot ambient conditions.[30] Repetitive heat exposures within a day (ie, multiple practices in a single day) do not appear to expedite the process; thus, single daily exposures (ie, 1 practice per day) during 2 full weeks of heat exposure is the safest effective strategy.[31] Further, multiple heat exposures in a given day (eg, 2 practice sessions per day) may be detrimental to an athlete's safety based on evidence[32] of greater thermal strain during a second exercise session compared with the first in a given day.

Once acclimation occurs, adaptations decay in the absence of heat exposure. The authors[33] of a recent meta-analysis determined that approximately one-third of adaptations were lost in the 2 weeks after heat acclimation in the absence of heat exposure. The rate of decay in the adaptations of heart rate and body core temperature was approximately 2.5% per day without heat exposure. Importantly, training in cool conditions and regular heat exposure (even passive heat exposure) delay the loss of adaptation. Moreover, a second heat acclimation or acclimatization phase during the decay period (within 1 month) appears to provide a faster rate of adaptation than the first phase.[33] For example, 2 and 4 days of reacclimation after 12 and 26 days without heat exposures were sufficient to regain an acclimation level similar to that obtained during the initial 10 days of acclimation.[34] Therefore, for athletes in individual sports (and possibly those in team sports), coaches can plan for an initial comprehensive heat-acclimatization period of at least 2 weeks, followed by a tapering period and then reacclimation in the few days before competition.[35]

Induction of Heat Acclimatization

The induction of heat acclimation or acclimatization involves daily heat-exposure sessions of 60 to 90 minutes[16,36] and can be achieved through a variety of passive, active, or combination protocols.[33] Although passive heat acclimation (eg, posttraining saunas or hot baths) can be used after training in a cool environment,[37–40] the lack of appropriate monitoring and supervision in the secondary school setting renders this method inappropriate, so it should not be attempted. Self-paced exercise heat acclimatization (ie, the individual self-selection of exercise intensity) was developed by the military to ensure that recruits could adapt at their own pace.[41,42] This approach is still used by large athletic teams (eg, American football and soccer teams)[26,43,44] and endurance athletes.[28] Other approaches that are more laboratory based (ie, requiring greater control) include performing exercise at a constant work rate[20] or attaining and sustaining a given core body temperature (eg, 38.5°C).[45]

The logistical constraints associated with these approaches make them more difficult to implement, particularly with large groups of athletes. An alternative may be to maintain a predetermined heart rate when exercising in the heat, as it provides a good overall indicator of the cardiovascular strain elicited by exercise in a given environment.[16] This approach requires a heart-rate monitor and strict maintenance of a given heart rate, which may not be practical or feasible in many secondary school settings. A more practical approach uses a rating of perceived exertion to ensure that a particular exercise intensity is maintained. However, the use of perceived exertion as a tool for monitoring intensity may be fraught with concerns such as misreporting by the athletes. Regardless of how intensity is gauged, high-intensity efforts during the heat-acclimatization process should be completed at the start of a given practice or training session so as to reduce the risk of heat

Downloaded from http://meridian.allenpress.com/jat/article-pdf/56/4/352/3019796/i1062-6050-56-4-352.pdf by guest on 01 March 2024

illness and preserve performance. The choice of approach may therefore be determined by the athlete population (eg, individual versus team sport), availability of equipment for monitoring physiological responses (eg, core body temperature, heart rate), available facilities (eg, heat chamber, sauna), and prevailing ambient conditions.[46] Within the context of secondary school athletics (ie, large athletics teams with limited physiological monitoring capabilities), the most feasible approach is likely to be the self-paced method.

Sex-, Age-, Sport-, and Fitness-Specific Considerations for Heat Acclimatization

Sex-Specific Considerations for Heat Acclimatization. Before the 1960s, investigators questioned whether women had the physiological capacity to acclimate to heat.[47] However, this notion was discounted in later studies[48,49] that demonstrated women indeed acclimated to heat. Early work also led to the misconception that women thermoregulated less effectively than men before acclimatization but more effectively after acclimatization,[49–51] perhaps because of greater sweating efficiency in women.[52] More recent data[50,53,54] suggests that these past findings were confounded by sex differences in biophysical factors (body mass and body surface area) that explained most of the variability between sexes in thermoregulatory responses during heat stress. That said, women have reduced sweating sensitivity as a result of less sweat output per gland at high exercise intensities (500 W or 300 W/m^2),[55] which ultimately results in less evaporative heat loss compared with men of comparable body size.[56,57]

Regardless of sex differences in sweating, if matched for aerobic fitness and the ratio of surface area to mass, men and women have similar responses to heat acclimatization.[52,58] Furthermore, the process by which men and women acclimatize and the outcomes of acclimatization do not seem to differ.[59,60] The time course of heat acclimatization has also typically been considered similar in men and women[48,49,51]; historically, 7–10 days are necessary for near-full expression. Shorter regimens (eg, 4–5 days) have also been shown to be effective in both men and women.[59,61,62] However, cardiovascular and core body temperature responses in men appear to stabilize after 5 days, whereas women require $>$5 days to achieve same.[59,61,62] Therefore, allowing $>$10 days of heat acclimatization provides near-optimal benefits for both males and females.

Age-Specific Considerations for Heat Acclimatization. In younger populations and in the context of secondary school athletics, age itself does not affect thermoregulation. Nevertheless, pubertal status has some influence. The idea that prepubertal children are more vulnerable to heat stress was purported for many years, but this notion has been challenged by experts and perceptions have altered.[63–65] The larger ratio of body surface area to mass in children and adolescents affords the possibility of greater convective and radiative heat exchange than in adults, depending on the external environment. Thus, prepubertal children are more dependent on convective and radiative heat-loss mechanisms. In addition, even though sweat rates in prepubertal children are lower than those in adults, their sweat droplet dispersion results in equally efficient evaporation.[63,64,66] Significant differences in cardiovascular responses between prepubertal and postpubertal children exercising in the heat have not been found.[65] Based on these examinations of thermoregulatory and cardiovascular responses, prepubertal and postpubertal children appear to adapt similarly during heat acclimatization. In the United States, puberty has begun in the average female by age 13 and in the average male by age 14.[67] As a result, the majority of high school sport athletic teams will be composed of pubertal or postpubertal children. The same set of heat-acclimatization guidelines can be used for athletes at all competitive levels in the secondary school system (ie, freshman, junior varsity, and varsity). If a secondary school includes younger ages (ie, middle school athletes), differences in heat-loss mechanisms should be considered, particularly in terms of break frequency and length. For middle school–aged athletes, in whom reliance on convective and radiative heat loss is greater, modifying work-to-rest ratios and providing access to a shaded or cool environment during activity may help mitigate risk.

Sport-Specific Considerations for Heat Acclimatization. As long as the aforementioned principles are followed (ie, increasing sweating, skin blood flow, and core body and skin temperatures), no evidence indicates that different types of physical activity (eg, soccer versus American football) produce different or delayed adaptations.[33,68] Metabolic heat generation is the biggest driver of core body temperature. Regardless of the specific sport, appropriate work-to-rest ratios balance active periods of high metabolic heat production with rest periods of lower metabolic heat production that facilitate heat dissipation.[3,5] This balance is imperative in reducing the risk of exertional heat illness, particularly EHS.[69–71] Therefore, training in sports that involve continuous endurance activity with limited to no breaks (eg, cross-country) should be based on relative (rather than fixed) exercise intensity (eg, perceived exertion) and exercise length restricted during the heat-acclimatization time frame to ensure student-athlete safety.

Sport protective equipment can cover large portions of the body.[72–75] Depending on the padding material and its proximity to the body, heat transfer may be affected. With protective equipment, extra clothing, or both, evaporative heat loss will also be limited due to garment or equipment saturation with sweat. Further, convective heat loss is attenuated due to the microenvironment between the protective equipment or clothing, which will remain constant and approach skin temperature.[72–75] Gradually adding protective equipment over time during the heat-acclimatization period (eg, 1 new piece of equipment per day for the first few days) allows the body to adapt to the added stressor; however, when protective equipment, extra clothing, or both are worn, the rate of rise in core body temperature will be greater than in conditions without these added garments, regardless of heat-acclimatization status. Player positions of concern in secondary school sports because of equipment or clothing include all American football positions; all men's lacrosse positions; goalies in field hockey, soccer, and women's lacrosse; and catchers in baseball or softball.

Training-Status–Specific Considerations for Heat Acclimatization. Training status (ie, overall fitness) should also be considered when deciding how to develop heat-acclimatization guidelines. Evidence suggests that individ-

Downloaded from http://meridian.allenpress.com/jat/article-pdf/56/4/352/3019796/1062-6050-56-4-352.pdf by guest on 01 March 2024

uals who are more physically fit demonstrate partial heat acclimatization, as supported by their habitual training, which elevates exercising core body temperature and skin temperature and elicits an increased sweat rate, all of which improve thermoregulatory capacity.[46] Even though individuals with greater physical fitness may exhibit partial heat acclimatization, the magnitudes of physiological adaptations to heat acclimation are similar when individuals of various aerobic fitness levels are compared.[39] Thus, heat acclimatization in the context of secondary school athletics may not need to be altered based on overall athlete fitness levels. However, based on the evidence supporting fitness-mediated physiological adaptations for improving thermoregulatory capacity,[46] a period of training aimed at improving cardiovascular fitness before heat exposure may be of benefit in reducing the EHS risk.[76]

Implementing Heat Acclimatization in Sport and Training

Recently, Kerr et al[77] identified a lack of compliance with the guidelines provided in the 2009 National Athletic Trainers' Association consensus statement on heat acclimatization (https://meridian.allenpress.com/jat/article/44/3/332/110945/Preseason-Heat-Acclimatization-Guidelines-for). Specifically, 3.9% of athletic trainers working in high schools with football reported full compliance with the guidelines.[77] When state high school athletics associations or legislative bodies required local high schools to develop policies, the risk of exertional heat illness appeared to decrease by approximately 55%.[9] Despite this, implementation of heat-acclimatization guidelines in secondary school athletics at the state level was disparate.[78,79] Within the United States, only 8 of the 51 state and District of Columbia high school athletics associations required their member schools to meet all of the current best practices for heat acclimatization.[79] This is an important point to consider in the context of local adoption of such policies: prior researchers[77] found that secondary schools were more likely to adopt a comprehensive policy when it was required at the state level. Despite the influence of state-level policy on local adoption, barriers preventing the adoption and implementation of health and safety policies in secondary school athletics persist.

Perceived barriers related to the adoption and implementation of these guidelines in secondary school settings have been identified (Table 1).[80] Strategies to overcome such barriers are recommended to help facilitate proper implementation.[81] It is important to acknowledge that every secondary school has unique characteristics and that tailored approaches, which adapt but do not drastically alter the guidelines, will help to meet the needs of individual schools. Further, tailored approaches should consider stakeholder feedback to help foster "buy in." Proactive planning will aid in proper implementation as the sport season begins.

CONSENSUS RECOMMENDATIONS

From the narrative review, the working group developed an initial list of 27 recommendations for review. After the first round of review, 4 recommendations received scores $\geq$4 but $<$7 for validity, 5 recommendations received scores $\geq$4 but $<$7 for feasibility, and 4 recommendations received scores $\geq$4 but $<$7 for clarity. In total, consensus occurred on 20 recommendations (scores $\geq$7 in all 3 constructs), which were carried forward to the final document. The working group used the open-ended comments obtained during the initial round of scoring to address and revise the 7 recommendations that scored $\geq$4 but $<$7 on any 1 construct. Based on these comments, the working group removed 2 recommendations, and the 5 revised recommendations were disseminated to the meeting attendees for a second round of scoring.

After the second round of scoring, 2 recommendations received scores $\geq$4 but $<$7 for clarity, and 1 recommendation received a score of 6.77 for feasibility. After reviewing the relevant open-ended comments, the working group revised the recommendations and included them in the final list of 25 recommendations, which addressed (1) heat-acclimatization induction and time course, (2) practice-structure considerations, (3) sport-specific considerations, (4) athlete-specific considerations, and (5) implementation strategies.

Heat-Acclimatization Induction and Time Course

1. Exercise heat acclimatization can be achieved via repeated heat exposure, coupled with exercise, that elicits sweating, increases skin blood flow, and elevates internal body temperature.
2. At least 10 training sessions over 14 consecutive days of heat acclimatization are recommended.
3. A total of 60 to 90 minutes of training per day in the heat is advised to induce and optimize the physiological adaptations associated with heat acclimatization.
4. During the heat acclimatization period, training may take place when the environmental heat is less (eg, early morning or late afternoon or evening) to reduce the risk of heat-related illness but still initiate the adaptation process.

Practice-Structure Considerations

1. Regardless of the environmental conditions, the length of any single training session during days 1 through 7 of the heat-acclimatization period should last $\leq$120 minutes.
2. The length of any single training session during days 8 through 14 of sport activity should be $\leq$150 minutes.
3. For days 1 through 6 of the heat-acclimatization period, only 1 training session per day is permitted. An additional 60-minute walkthrough session is permitted on days 1 through 6 for instructional or strategy purposes only and should be separated from the training session by at least 3 hours of continuous rest in a cool (eg, indoor, air-conditioned) environment.
4. Two training sessions per day are not permitted before day 7 of the heat-acclimatization period; once initiated, double practices may not occur on consecutive days. The time between training sessions must be at least 3 hours, with student-athletes allowed to recover in a cool environment.
5. Break stations (ie, shaded areas where athletes can rest and have unlimited access to fluids) should be available at the training venue. If possible, cooling devices (eg, fans, cold towels) should be used during breaks.

Downloaded from http://meridian.allenpress.com/jat/article-pdf/56/4/352/3019796/1062-6050-56-4-352.pdf by guest on 01 March 2024

Table 1. Perceived Barriers to and Strategies for Facilitating Proper Heat-Acclimatization Implementation

Perceived Barrier	Strategy to Facilitate Proper Implementation
Financial	Create a written policy that outlines how to modify practices. Aside from staffing time, cost is negligible. Templates and model policies are available from organizations such as the Korey Stringer Institute (https://ksi.uconn.edu/prevention/sports-medicine-policies-procedures/#).
Consistency with other available guidelines (eg, National Athletic Trainers' Association position statements, American College of Sports Medicine guidelines, state requirements)	Generally, the many available heat-acclimatization guidelines all advocate for the gradual progression of exercise in the heat. When unsure of the appropriate reference, refer to and consult state guidelines first. If no state guidelines exist or if they are subpar (ie, do not contain the minimum requirements as described in this article), reach out to mentors, colleagues, and neighboring states to identify how the policy should look.
Stakeholder "buy in," administrator support, lack of time to train coaches, and role delineation	Host a stakeholder meeting at the beginning of each year to which all coaches, administrators, and other key stakeholders (eg, parents or guardians) are invited. The meeting will educate stakeholders on how the secondary school is putting life-saving protocols into place—the who, what, when, and why. Allow attendees to have a voice in the meeting, encourage them to discuss the advantages and challenges of certain protocols, and make changes to better fit the needs of the stakeholders (without jeopardizing safety or having less than best practices).
"It is not hot where I live"	Advocate that exertional heat illness events are relative to the environment in which athletes are participating—a hot day in the northern United States may not bring the same environmental heat as a hot day in the southern United States. However, regardless of location, athletes are at risk when exposed to temperatures and humidity to which they are unaccustomed.
Logistical support	Identify and recruit a coach or manager of a team who can serve as a team safety coach. This person will oversee proper implementation of the guidelines.
Capability and capacity	Use transition periods (eg, off-seasons, "dead" weeks) to revisit, revise, and revamp policies and procedures.

6. If a conditioning session that includes high-intensity work is planned during the heat-acclimatization period (days 1–14), it should either (a) be planned as a separate session and constitute the only training on that day or (b) occur at the beginning of practice to reduce the risk of exertional heat illness.
7. During the heat-acclimatization period, practice sessions that are solely dedicated to conditioning (rather than sport-specific skills) should occur indoors in an air-conditioned environment or during times of the day (early morning or evening) when the environmental heat is low and in conjunction with environment-based activity modifications.[13] Conditioning that is outside of the normal sport practice (eg, punishment conditioning sessions) should be prohibited.
8. Secondary school athletics associations should ensure that $\geq$14 days of heat acclimatization occur before the first sanctioned competition for sports whose seasons begin when the environmental heat is high.

Sport-Specific Considerations

1. For athletes in equipment-laden sports (eg, American football, lacrosse, field hockey), the following guidelines regarding protective equipment should be followed: (a) during days 1 and 2, only helmets or headgear are permitted; (b) during days 3 through 5, helmets and shoulder pads are permitted; and (c) full protective equipment can be worn beginning on day 6.
2. For athletes in endurance sports (eg, cross-country), training in the heat should be based on relative intensity (ie, the same perceived exertion or percentage of maximum heart rate as during training in temperate conditions) rather than absolute intensity (ie, the same pace as during training in temperate conditions).
3. The guidelines used during the heat-acclimatization period should not differ by (1) level of sport (eg, freshman, junior varsity, or varsity), (2) sex, or (3) conditioning history (eg, an individual participating versus not participating in summer conditioning activities). The guidelines for an institution should apply to all athletes independent of previous individual heat exposure.
4. Given the variability across sports with respect to mode, intensity, duration, and protective equipment worn during exercise, modifications to the heat-acclimatization guidelines should be considered (Table 2).

Athlete-Specific Considerations

1. Before the start of the heat-acclimatization protocol, approximately 2 weeks of aerobic exercise training should be conducted in a temperate (eg, climate-controlled, indoor, or cool) environment to improve the athlete's cardiorespiratory fitness and reduce the magnitude of stress imposed on the body. If a temperate environment is not available, these workouts should take

Downloaded from http://meridian.allenpress.com/jat/article-pdf/56/4/352/3019796/1062-6050-56-4-352.pdf by guest on 01 March 2024

Table 2. Sport-Specific Heat-Acclimatization (HA) Considerations

Sport	Consideration
Baseball	Catchers should adhere to recommendations for equipment-laden sports during the HA time period.
Basketball	The HA guidelines should be adhered to when using a non–air-conditioned gymnasium during warm-weather months.
Cross-country	The maximum duration of sport activity should be limited to 60 min and 90 min/ training session for wk 1 and 2, respectively, of the HA period. Training should be based on relative intensity.
Field hockey	Goalies should adhere to recommendations for equipment-laden sports during the HA time period.
Football	Teams should adhere to recommendations for equipment-laden sports during the HA time period.
Golf	Teams should adhere to HA recommendations.
Lacrosse	Goalies and male players should adhere to recommendations for equipment-laden sports during the HA time period.
Softball	Catchers should adhere to recommendations for equipment-laden sports during the HA time period.
Soccer	Goalies should adhere to recommendations for equipment-laden sports during the HA time period.
Swimming and diving	The HA guidelines should be adhered to when implementing land training in warm-weather months or when swimming events are held at outdoor facilities and water temperature is near or above 33°C.
Tennis	Teams should adhere to HA recommendations.
Track	The maximum duration of sport activity should be limited to 60 min and 90 min/training session for wk 1 and 2, respectively, of the HA period. Training should be based on relative intensity.
Volleyball	The HA guidelines should be adhered to when using a non–air-conditioned gymnasium during warm-weather months.
Wrestling	The HA guidelines should be adhered to when implementing outdoor training or when using a non–air-conditioned gymnasium during warm-weather months.

place during the times of lowest environmental heat (eg, early morning or late afternoon or evening).

2. Athletes with a recent illness or injury that required significant time loss (>5 days) may experience the loss of heat-acclimatization adaptations. Once physical fitness and function have been restored during the return-to-play process after illness or injury, these individuals may need to restart the heat-acclimatization process.
3. Recovery between training sessions should occur in a comfortable (ie, air conditioned) environment to ensure that body temperature returns to baseline before the next training session. Adequate sleep (7–9 hours) will also help optimize recovery between training sessions.

Implementation Strategies

1. Heat-acclimatization guidelines should be used in conjunction with regional (geographic) environment-based activity modifications to dictate work-to-rest ratios, hydration breaks, removal of protective equipment, and rescheduling training or competition to optimize student-athlete safety.
2. Given the risks to players and the potentially catastrophic outcomes associated with EHS, a credentialed health care provider trained in the proper management and treatment of exertional heat illness (eg, athletic trainer) should be accessible or onsite during all training sessions.
3. In case of suspected EHS, immediate ice-water immersion or other water-mediated cooling should be provided, following the principle of "cool first, transport second." If a credentialed health care provider is not onsite to initiate cooling, the coaching staff should be educated to initiate cooling while waiting on the arrival of emergency health care services.
4. Each secondary school should conduct regular training and education sessions with all stakeholders (ie, athletic trainer, team physician, coaches, administrators, emergency medical services) to review and practice the procedures regarding exertional heat illness prevention, management, and care. Each secondary school sports medicine health care team should regularly review and

Table 3. Practice Structure for the 14-Day Heat-Acclimatization Period in Secondary School Athletics

	Equipment Laden/Intermittent Aerobic Sports					Endurance/Aerobic Sports	
Day	Number of Practice Sessions Permitted	Practice Duration	Instructional Walk Through Permitted	Rest Period Between Walk-through and/or Practice Sessions	Protective Equipment	Practice Duration	Practice Intensity
1	1	120 min	1, 60 min session	3 h	Helmets/headgear only	60 min	Relative/individual (eg, percent HR maximum)
2							
3					Helmets and shoulder pads only		
4							
5							
6					Full pads permitted		
7							
8	2	150 min (5 h maximum on double session days)	No			90 min	
9	1						
10	2						
11	1						
12	2						
13	1						
14	2						

[a] Equipment-laden sports include but are not limited to American football, baseball, field hockey, lacrosse, and softball.
[b] Intermittently aerobic sports include but are not limited to basketball, soccer, swimming and diving, tennis, volleyball, and wrestling.
[c] Endurance or aerobic sports include but are not limited to cross-country and track and field.

Downloaded from http://meridian.allenpress.com/jat/article-pdf/56/4/352/3019796/i1062-6050-56-4-352.pdf by guest on 01 March 2024

update the school's policies and procedures regarding student-athlete health and safety.
5. Each secondary school should have a written policies and procedures manual that contains the current standards for the prevention, management, and care of exertional heat illness.
6. The written policies and procedures manual should be disseminated to all stakeholders involved in secondary school athletics. Stakeholders should provide written acknowledgment that the manual was received and read.

CONCLUSIONS

Given the physiological benefits afforded by heat acclimatization in optimizing human health and performance during exercise in hot environmental conditions, it is prudent that proper guidelines and protocols be in place in secondary school athletics that address equipment-laden, intermittently aerobic (eg, basketball, soccer), and endurance or aerobic (eg, cross-country) sports. The consensus recommendations from this Delphi process offer clinicians, administrators, and coaches a data-driven approach for developing and implementing heat-acclimatization procedures across all secondary school sports to mitigate the risk of exertional heat illness. Implementation of these consensus recommendations (Table 3) in conjunction with current evidence-based recommendations on the recognition, management, and care of patients with EHS permits a comprehensive approach to heat safety for secondary school athletes.

ACKNOWLEDGMENTS

We acknowledge the National Athletic Trainers' Association, Korey Stringer Institute, and American College of Sports Medicine for providing support for the roundtable meeting. We also thank the meeting attendees for their contributions at the roundtable meeting and to the Delphi voting process.

REFERENCES

1. Kucera KL, Klossner D, Colgate B, Cantu RC. *Annual Survey of Football Injury Research*. National Center for Catastrophic Sport Injury Research; 2018:1–38.
2. Kucera KL, Cantu RC. Catastrophic sports injury research thirty-sixth annual report, fall 1982–spring 2018. https://nccsir.unc.edu/files/2019/10/2018-Catastrophic-Report-AS-36th-AY2017-2018-FINAL.pdf. Published 2019. Accessed December 22, 2020.
3. Casa DJ, DeMartini JK, Bergeron MF, et al. National Athletic Trainers' Association position statement: exertional heat illnesses. *J Athl Train*. 2015;50(9):986–1000. doi:10.4085/1062-6050-50.9.07
4. Casa DJ, Guskiewicz KM, Anderson SA, et al. National Athletic Trainers' Association position statement: preventing sudden death in sports. *J Athl Train*. 2012;47(1):96–118. doi:10.4085/1062-6050-47.1.96
5. American College of Sports Medicine; Armstrong LE, Casa DJ, Millard-Stafford M, et al. American College of Sports Medicine position stand: exertional heat illness during training and competition. *Med Sci Sports Exerc*. 2007;39(3):556–572. doi:10.1249/MSS.0b013e31802fa199
6. Binkley HM, Beckett J, Casa DJ, Kleiner DM, Plummer PE. National Athletic Trainers' Association position statement: exertional heat illnesses. *J Athl Train*. 2002;37(3):329–343.
7. Casa DJ, Csillan D, Armstrong LE, et al. Preseason heat-acclimatization guidelines for secondary school athletics. *J Athl Train*. 2009;44(3):332–333. doi:10.4085/1062-6050-44.3.332
8. Casa DJ, Almquist J, Anderson SA, et al. The Inter-Association Task Force for Preventing Sudden Death in Secondary School Athletics Programs: best-practices recommendations. *J Athl Train*. 2013;48(4):546–553. doi:10.4085/1062-6050-48.4.12
9. Kerr ZY, Register-Mihalik JK, Pryor RR, et al. The association between mandated preseason heat acclimatization guidelines and exertional heat illness during preseason high school American football practices. *Environ Health Perspect*. 2019;127(4):47003. doi:10.1289/EHP4163
10. Attanasio SM, Adams WM, Stearns RL, Huggins RA, Casa DJ. Occurrence of exertional heat stroke in high school football athletes before and after implementation of evidence-based heat acclimatization guidelines [abstract]. *J Athl Train*. 2016;51(suppl 6):S–168.
11. Adler M, Ziglio E, eds. *Gazing Into the Oracle: The Delphi Method and Its Application to Social Policy and Public Health*. Jessica Kingsley Publishers; 1996.
12. Miller KC, Casa DJ, Adams WM, et al. Roundtable on preseason heat safety in secondary school athletics: prehospital care of exertional heatstroke patients [epub ahead of print]. *J Athl Train*. doi:10.4085/1062-6050-0173.20
13. Hosokawa Y, Adams WM, Casa DJ, et al. Roundtable on preseason heat safety in secondary school athletics: environmental monitoring during activities in the heat [epub ahead of print]. *J Athl Train*. doi:10.4085/1062-6050-0067.20
14. Armstrong LE, Pandolf KB. Physical training, cardiorespiratory physical fitness and exercise-heat tolerance. In: Pandolf KB, Sawka MN, Gonzalez RR, eds. *Human Performance Physiology and Environmental Medicine at Terrestrial Extremes*. Benchmark Press; 1988:199–226.
15. Wenger CB. Human heat acclimatization. In: Pandolf KB, Sawka MN, Gonzalez RR, eds. *Human Performance Physiology and Environmental Medicine at Terrestrial Extremes*. Benchmark Press; 1988:135–198.
16. Périard JD, Racinais S, Sawka MN. Adaptations and mechanisms of human heat acclimation: applications for competitive athletes and sports. *Scand J Med Sci Sports*. 2015;25 (suppl 1):20–38. doi:10.1111/sms.12408
17. Sawka MN, Wenger CB, Pandolf KB. Thermoregulatory responses to acute exercise-heat stress and heat acclimation. In: Fregly MJ, Blatteis CM, eds. *Handbook of Physiology, Section 4, Environmental Physiology*. Oxford University Press; 1996:157–185.
18. Hori S. Adaptation to heat. *Jpn J Physiol*. 1995;45(6):921–946. doi:10.2170/jjphysiol.45.921
19. Sawka MN, Young AJ, Cadarette BS, Levine L, Pandolf KB. Influence of heat stress and acclimation on maximal aerobic power. *Eur J Appl Physiol Occup Physiol*. 1985;53(4):294–298. doi:10.1007/BF00422841
20. Lorenzo S, Halliwill JR, Sawka MN, Minson CT. Heat acclimation improves exercise performance. *J Appl Physiol (1985)*. 2010;109(4):1140–1147. doi:10.1152/japplphysiol.00495.2010
21. Willmott AGB, Hayes M, James CA, Gibson OR, Maxwell NS. Heat acclimation attenuates the increased sensations of fatigue reported during acute exercise-heat stress. *Temperature (Austin)*. 2020;7(2):178–190. doi:10.1080/23328940.2019.1664370
22. Lemaire R. Considérations physiologiques sur la climatisation en milieu désertique. *Journees d'Inf Med Soc Sahariennes*. 1960:101–112.
23. Folk GE. *Textbook of Environmental Physiology*. Lea & Febiger; 1974.
24. Gonzalez RR, Gagge AP. Warm discomfort and associated thermoregulatory changes during dry, and humid-heat acclimatization. *Isr J Med Sci*. 1976;12(8):804–807.

Downloaded from http://meridian.allenpress.com/jat/article-pdf/56/4/352/3019796/1062-6050-56-4-352.pdf by guest on 01 March 2024

25. Shapiro Y, Moran D, Epstein Y. Acclimatization strategies: preparing for exercise in the heat. *Int J Sports Med*. 1998;19 (suppl 2):S161–S163. doi:10.1055/s-2007-971986
26. Racinais S, Mohr M, Buchheit M, et al. Individual responses to short-term heat acclimatisation as predictors of football performance in a hot, dry environment. *Br J Sports Med*. 2012;46(11):810–815. doi:10.1136/bjsports-2012-091227
27. Corbett J, Rendell RA, Massey HC, Costello JT, Tipton MJ. Inter-individual variation in the adaptive response to heat acclimation. *J Therm Biol*. 2018;74:29–36. doi:10.1016/j.jtherbio.2018.03.002
28. Karlsen A, Nybo L, Nrgaard SJ, Jensen MV, Bonne T, Racinais S. Time course of natural heat acclimatization in well-trained cyclists during a 2-week training camp in the heat. *Scand J Med Sci Sports*. 2015;25 (suppl 1):240–249. doi:10.1111/sms.12449
29. Nielsen B, Hales JR, Strange S, Christensen NJ, Warberg J, Saltin B. Human circulatory and thermoregulatory adaptations with heat acclimation and exercise in a hot, dry environment. *J Physiol*. 1993;460(1):467–485. doi: 10.1113/jphysiol.1993.sp019482
30. Racinais S, Périard JD, Karlsen A, Nybo L. Effect of heat and heat acclimatization on cycling time trial performance and pacing. *Med Sci Sports Exerc*. 2015;47(3):601–606. doi:10.1249/MSS.0000000000000428
31. Willmott AGB, Hayes M, James CA, Dekerle J, Gibson OR, Maxwell NS. Once- and twice-daily heat acclimation confer similar heat adaptations, inflammatory responses and exercise tolerance improvements. *Physiol Rep*. 2018;6(24):e13936. doi:10.14814/phy2.13936
32. Pryor RR, Pryor JL, Vandermark LW, et al. Exacerbated heat strain during consecutive days of repeated exercise sessions in heat. *J Sci Med Sport*. 2019;22(10):1084–1089. doi:10.1016/j.jsams.2019.06.003
33. Daanen HAM, Racinais S, Périard JD. Heat acclimation decay and re-induction: a systematic review and meta-analysis. *Sports Med*. 2018;48(2):409–430. doi:10.1007/s40279-017-0808-x
34. Weller AS, Linnane DM, Jonkman AG, Daanen HAM. Quantification of the decay and re-induction of heat acclimation in dry-heat following 12 and 26 days without exposure to heat stress. *Eur J Appl Physiol*. 2007;102(1):57–66. doi:10.1007/s00421-007-0563-z
35. Racinais S, Périard JD. Benefits of heat re-acclimation in the lead-up to the Tokyo Olympics. *Br J Sports Med*. 2020;54(16):945–946. doi:10.1136/bjsports-2020-102299
36. Racinais S, Alonso JM, Coutts AJ, et al. Consensus recommendations on training and competing in the heat. *Scand J Med Sci Sports*. 2015;25(suppl 1):6–19. doi:10.1111/sms.12467
37. Scoon GSM, Hopkins WG, Mayhew S, Cotter JD. Effect of post-exercise sauna bathing on the endurance performance of competitive male runners. *J Sci Med Sport*. 2007;10(4):259–262. doi:10.1016/j.jsams.2006.06.009
38. Zurawlew MJ, Walsh NP, Fortes MB, Potter C. Post-exercise hot water immersion induces heat acclimation and improves endurance exercise performance in the heat. *Scand J Med Sci Sports*. 2016;26(7):745–754. doi:10.1111/sms.12638
39. Zurawlew MJ, Mee JA, Walsh NP. Post-exercise hot water immersion elicits heat acclimation adaptations in endurance trained and recreationally active individuals. *Front Physiol*.2018;9:1824. doi:10.3389/fphys.2018.01824
40. Zurawlew MJ, Mee JA, Walsh NP. Post-exercise hot water immersion elicits heat acclimation adaptations that are retained for at least two weeks. *Front Physiol*. 2019;10:1080. doi:10.3389/fphys.2019.01080
41. Nelms JD, Turk J. A self-regulating method for rapid acclimatization to heat. *J Physiol*. 1972;221(1):2P–3P.
42. Armstrong LE, Hubbard RW, De Luca JP, Christensen EL. *Self-Paced Heat Acclimation Procedures*. US Army Research Institute of Environmental Medicine; 1986.
43. Buchheit M, Voss SC, Nybo L, Mohr M, Racinais S. Physiological and performance adaptations to an in-season soccer camp in the heat: associations with heart rate and heart rate variability. *Scand J Med Sci Sports*. 2011;21(6):e477–e485. doi:10.1111/j.1600-0838.2011.01378.x
44. Racinais S, Buchheit M, Bilsborough J, Bourdon PC, Cordy J, Coutts AJ. Physiological and performance responses to a training camp in the heat in professional Australian football players. *Int J Sports Physiol Perform*. 2014;9(4):598–603. doi:10.1123/ijspp.2013-0284
45. Fox RH, Goldsmith R, Kidd DJ, Lewis HE. Acclimatization to heat in man by controlled elevation of body temperature. *J Physiol*. 1963;166(4):530–547. doi:10.1113/jphysiol.1963.sp007121
46. Gibson OR, James CA, Mee JA, et al. Heat alleviation strategies for athletic performance: a review and practitioner guidelines. *Temperature (Austin)*. 2020;7(1):3–36. doi:10.1080/23328940.2019.1666624
47. Charkoudian N, Stachenfeld NS. Reproductive hormone influences on thermoregulation in women. *Compr Physiol*. 2014;4(2):793–804. doi:10.1002/cphy.c130029
48. Hertig BA, Belding HS, Kraning KK, Batterton DL, Smith CR, Sargent F II. Artificial acclimatization of women to heat. *J Appl Physiol*. 1963;18:383–386. doi:10.1152/jappl.1963.18.2.383
49. Weinman KP, Slabochova Z, Bernauer EM, Morimoto T, Sargent F II. Reactions of men and women to repeated exposure to humid heat. *J Appl Physiol*. 1967;22(3):533–538. doi:10.1152/jappl.1967.22.3.533
50. Gagnon D, Kenny GP. Does sex have an independent effect on thermoeffector responses during exercise in the heat? *J Physiol*. 2012;590(23):5963–5973. doi:10.1113/jphysiol.2012.240739
51. Nunneley SA. Physiological responses of women to thermal stress: a review. *Med Sci Sports*. 1978;10(4):250–255.
52. Shapiro Y, Pandolf KB, Avellini BA, Pimental NA, Goldman RF. Physiological responses of men and women to humid and dry heat. *J Appl Physiol Respir Environ Exerc Physiol*. 1980;49(1):1–8.
53. Anderson GS. Human morphology and temperature regulation. *Int J Biometeorol*. 1999;43(3):99–109. doi:10.1007/s004840050123
54. Havenith G. Individualized model of human thermoregulation for the simulation of heat stress response. *J Appl Physiol (1985)*. 2001;90(5):1943–1954. doi:10.1152/jappl.2001.90.5.1943
55. Gagnon D, Crandall CG, Kenny GP. Sex differences in postsynaptic sweating and cutaneous vasodilation. *J Appl Physiol (1985)*. 2013;114(3):394–401. doi:10.1152/japplphysiol.00877.2012
56. Gagnon D, Kenny GP. Sex differences in thermoeffector responses during exercise at fixed requirements for heat loss. *J Appl Physiol (1985)*. 2012;113(5):746–757. doi:10.1152/japplphysiol.00637.2012
57. Gagnon D, Kenny GP. Sex modulates whole-body sudomotor thermosensitivity during exercise. *J Physiol*. 2011;589(pt 24):6205–6217. doi:10.1113/jphysiol.2011.219220
58. Avellini BA, Kamon E, Krajewski JT. Physiological responses of physically fit men and women to acclimation to humid heat. *J Appl Physiol Respir Environ Exerc Physiol*. 1980;49(2):254–261. doi:10.1152/jappl.1980.49.2.254
59. Yanovich R, Ketko I, Charkoudian N. Sex differences in human thermoregulation: relevance for 2020 and beyond. *Physiology (Bethesda)*. 2020;35(3):177–184. doi:10.1152/physiol.00035.2019
60. Epstein Y, Yanovich R, Moran DS, Heled Y. Physiological employment standards IV: integration of women in combat units physiological and medical considerations. *Eur J Appl Physiol*. 2013;113(11):2673–2690. doi:10.1007/s00421-012-2558-7
61. Kirby NV, Lucas SJE, Lucas RAI. Nine-, but not four-days heat acclimation improves self-paced endurance performance in females. *Front Physiol*. 2019;10:539. doi:10.3389/fphys.2019.00539

Downloaded from http://meridian.allenpress.com/jat/article-pdf/56/4/352/3019796/1062-6050-56-4-352.pdf by guest on 01 March 2024

62. Mee JA, Gibson OR, Doust J, Maxwell NS. A comparison of males and females' temporal patterning to short- and long-term heat acclimation. *Scand J Med Sci Sports*. 2015;25(suppl 1):250–258. doi:10.1111/sms.12417
63. Armstrong LE, Maresh CM. Exercise-heat tolerance of children and adolescents. *Pediatr Exerc Sci*. 1995;7(3):239–252. doi:10.1123/pes.7.3.239
64. Bergeron MF. Youth sports in the heat: recovery and scheduling considerations for tournament play. *Sports Med*. 2009;39(7):513–522. doi:10.2165/00007256-200939070-00001
65. Lawrenz W. Exercise in the heat for children and adolescents. Statement from the Commission for Pediatric Sports Medicine, German Society for Sports Medicine and Prevention. *Dtsch Z Sportmed*. 2019;70(11):265–269. doi:10.5960/dzsm.2019.400
66. Rowland T. Thermoregulation during exercise in the heat in children: old concepts revisited. *J Appl Physiol (1985)*. 2008;105(2):718–724. doi:10.1152/japplphysiol.01196.2007
67. Miller BS, Sarafoglou K, Addo OY. Development of Tanner stage–age adjusted CDC height curves for research and clinical applications. *J Endocr Soc*. 2020;4(9):bvaa098. doi:10.1210/jendso/bvaa098
68. Tyler CJ, Reeve T, Hodges GJ, Cheung SS. The effects of heat adaptation on physiology, perception and exercise performance in the heat: a meta-analysis. *Sports Med*. 2016;46(11):1699–1724. doi:10.1007/s40279-016-0538-5
69. Kerr ZY, Casa DJ, Marshall SW, Comstock RD. Epidemiology of exertional heat illness among U.S. high school athletes. *Am J Prev Med*. 2013;44(1):8–14. doi:10.1016/j.amepre.2012.09.058
70. Rav-Acha M, Hadad E, Epstein Y, Heled Y, Moran DS. Fatal exertional heat stroke: a case series. *Am J Med Sci*. 2004;328(2):84–87. doi:10.1097/00000441-200408000-00003
71. Yard EE, Gilchrist J, Haileyesus T, et al. Heat illness among high school athletes—United States, 2005–2009. *J Safety Res*. 2010;41(6):471–474. doi:10.1016/j.jsr.2010.09.001
72. Kulka TJ, Kenney WL. Heat balance limits in football uniforms how different uniform ensembles alter the equation. *Phys Sportsmed*. 2002;30(7):29–39. doi:10.3810/psm.2002.07.377
73. McCullough EA, Kenney WL. Thermal insulation and evaporative resistance of football uniforms. *Med Sci Sports Exerc*. 2003;35(5):832–837. doi:10.1249/01.MSS.0000064998.48130.22
74. Armstrong LE, Johnson EC, Casa DJ, et al. The American football uniform: uncompensable heat stress and hyperthermic exhaustion. *J Athl Train*. 2010;45(2):117–127. doi:10.4085/1062-6050-45.2.117
75. Shin-ya H, Nakai S, Yoshida T, Takahashi E. Effects of sportswear on thermoregulatory responses during exercise in a hot environment. In: Tochihara Y, Ohnaka T, eds. *Elsevier Ergonomics Book Series*. Vol 3. Environmental Ergonomics. Elsevier; 2005:65–70. doi:10.1016/S1572-347X(05)80012-6
76. Adams WM, Périard JD. Returning to sport following COVID-19: considerations for heat acclimatization in secondary school athletics. *Sports Med*. 2020;50(9):1555–1557. doi:10.1007/s40279-020-01301-z
77. Kerr ZY, Register-Mihalik JK, Pryor RR, Hosokawa Y, Scarneo-Miller SE, Casa DJ. Compliance with the National Athletic Trainers' Association Inter-Association Task Force preseason heat-acclimatization guidelines in high school football. *J Athl Train*. 2019;54(7):749–757. doi:10.4085/1062-6050-373-18
78. Adams WM, Scarneo SE, Casa DJ. State-level implementation of health and safety policies to prevent sudden death and catastrophic injuries within secondary school athletics. *Orthop J Sports Med*. 2017;5(9):2325967117727262. doi:10.1177/2325967117727262
79. Adams WM, Scarneo SE, Casa DJ. Assessment of evidence-based health and safety policies on sudden death and concussion management in secondary school athletics: a benchmark study. *J Athl Train*. 2018;53(8):756–767. doi:10.4085/1062-6050-220-17
80. Kay MC, McCrae AJ, Pryor RR, et al. Barriers and facilitators faced by athletic trainers implementing NATA-IATF preseason heat-acclimatization guidelines in United States high school football [epub ahead of print]. *J Athl Train*. 2020. doi:10.4085/321-20
81. Pike AM, Adams WM, Huggins RA, Mazerolle SM, Casa DJ. Analysis of states' barriers to and progress toward implementation of health and safety policies for secondary school athletics. *J Athl Train*. 2019;54(4):361–373. doi:10.4085/1062-6050-28-18

Address correspondence to William M. Adams, PhD, ATC, Department of Kinesiology, University of North Carolina at Greensboro, 1408 Walker Avenue, 237 Coleman Building, Greensboro, NC 27412. Address email to wmadams@uncg.edu.

Downloaded from http://meridian.allenpress.com/jat/article-pdf/56/4/352/3019796/i1062-6050-56-4-352.pdf by guest on 01 March 2024