# Weather Monitoring and Guidelines for Safety in Physically Active Populations

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# Korey Stringer Institute

## MISSION STATEMENT

The mission of the Korey Stringer Institute (KSI) is to provide first-rate education, information, resources, assistance, and advocacy for the prevention of sudden death in sport and physical activity.

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# Korey Stringer Institute

- Summer pre-season of 2001
  - Korey Stringer
- Founded April 23, 2011
- International leader in sport safety advocacy and application of evidence-based medicine to practice
  - Exercise scientists
  - Certified athletic trainers

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- **Advocacy and policy change**
  - State high school association
  - Sports medicine
  - Professional and youth sports
  - Military
  - International organizations
- **Education**
  - CEU courses
  - Books
- **Research**
  - Heat and hydration
- **Mass-media outreach**
- **Consultations**
  - Return to play
  - Optimizing performance
- **Athlete-testing**

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Workshop on the Development of Climate Information Systems for
Heat Health Early Warning: Assessing Knowledge, Needs and the Path Forward

# WEATHER MONITORING AND GUIDELINES FOR SAFETY IN PHYSICALLY ACTIVE POPULATIONS

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# Heat and Public Health Concern

- Elderly and infants
- Urban poor
- Under developed countries
- Laborers

**Health issue**

- Classic vs. Exertional heat stroke

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# Heat and Public Health Concern

July 13th- 19th, 2015 in Japan

6,165 patients were admitted to emergency room due to exertional heat illness

- Almost twice as many compared to the previous week
- Approx. 10,000 patients within 2 weeks

- <u>Lack of institutional policies and guidelines</u>

All Nippon News Network. July 22nd, 2015. 11:56:00. http://headlines.yahoo.co.jp/videonews/ann?a=20150722-00000022-ann-pol

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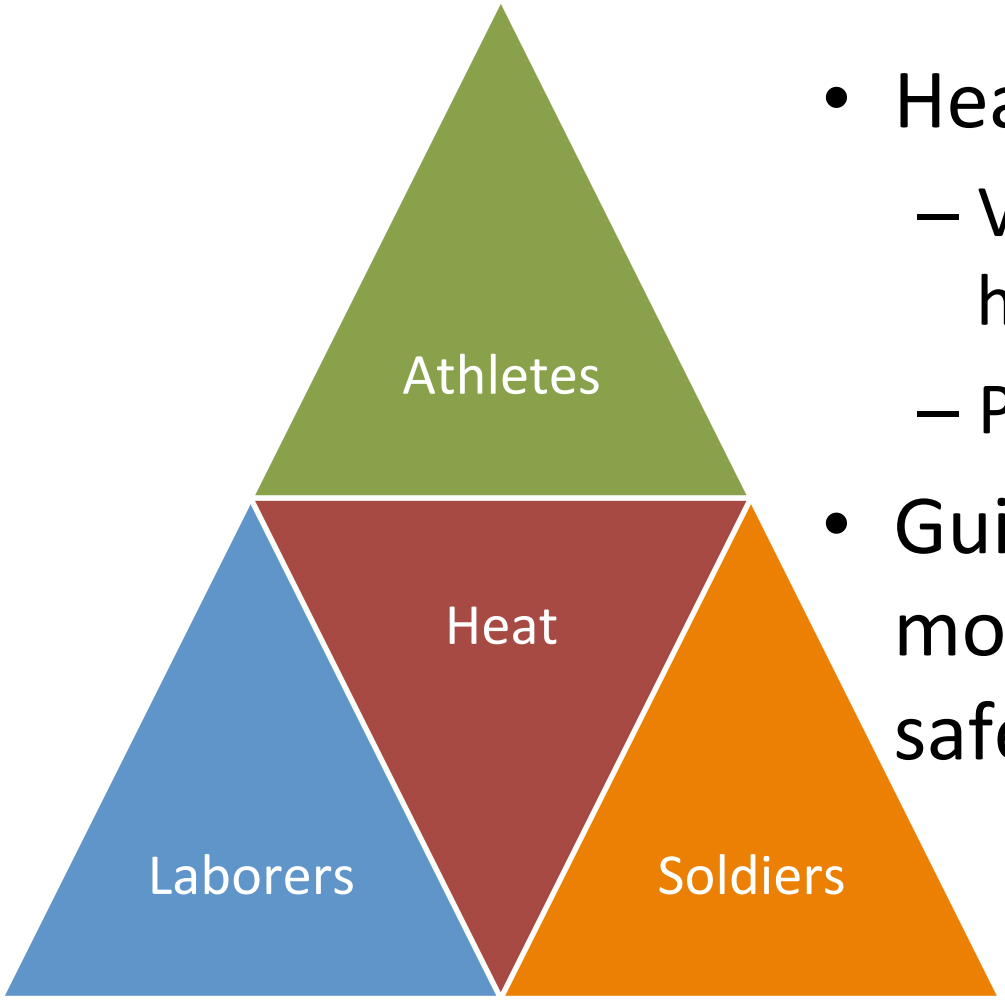
# Heat and Physically Active Populations




- Healthy, active population
  - Voluntarily exercise in the heat
  - Part of the work
- Guidelines and modifications to ensure safety

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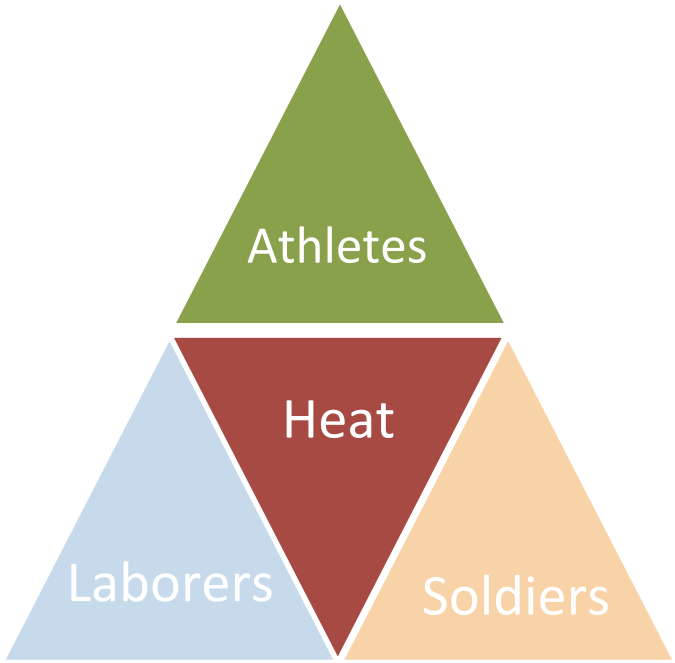
# Impacts of Weather on…

- **Athletes**
  - Youth athletes
    - Football preseason
  - Professional athletes
    - FIFA World Cup
  - Weekend warriors
    - Ironman triathlon
    - Falmouth road race

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# Football Preseason

- Heat acclimatization guidelines
  - State High School Associations
- Body's adaptation to tolerate exercise in heat
- Gradually building back the duration and intensity of exercise


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# Induction of Acclimatization:
## Variables Influenced

- Thermoregulatory
  - ↑ skin blood flow
  - ↑
  - ↓
    onset of sweating
  - ↓ core temperature
    - 5-8 days
  - ↓ skin temperature
  - ↓ risk of heat illnesses

**60 minutes of sustained exercise at 38.5°C**

- Cardiovascular
  - ↓ HR
    - 3-6 days
  - omy
  - ↑ plasma volume
    - 3-6 days

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# FIFA- Hydration Break Rules

- Previously: “At FIFA matches, additional cooling breaks are considered when WBGT is above 31°C.”
- Currently: “Additional cooling breaks (after the 30th minute of the first and second halves of the game) will be granted if the WBGT exceeds 32 °C.”

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# Falmouth Road Race, Cape Cod, MA

*Journal of Athletic Training* 2014;49(3):000–000
doi: 10.4085/1062-6050-49.3.26

www.natajournals.org

*original research*

## Environmental Conditions and the Occurrence of Exertional Heat Illnesses and Exertional Heat Stroke at the Falmouth Road Race

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*Korey Stringer Institute, University of Connecticut, Storrs; †Falmouth Hospital, MA

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# Purpose of the Study

1. Observe the incidence rates of EHI and EHS at the FRR
2. Examine the relationship between environmental condition and EHI or EHS during the FRR
3. Examine the effect of environmental conditions on the occurrence of EHI and EHS

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# Environmental Conditions

**Table 2. Falmouth Road Race Environmental Conditions**

| Year | Ambient Temperature, °C | Relative Humidity, % | Heat Index, °C |
|---|---|---|---|
| 1984 | 22.2 | 55 | 22 |
| 1989 | 23.9 | 79 | 24 |
| 1992 | 17.2 | | |
| 1993 | 19.6 | | |
| 1994 | 24.2 | | |
| 1996 | 24.0 | | |
| 1997 | 26.7 | | |
| 1998 | 24.5 | 69 | 25 |
| 2001 | 23.3 | 98 | 25 |
| 2003 | 27.7 | 87 | 33 |
| 2004 | 22.0 | 57 | 22 |
| 2005 | 26.0 | 87 | 28 |
| 2006 | 21.3 | 47 | 21 |
| 2007 | 25.3 | 57 | 26 |
| 2008 | 23.7 | 65 | 24 |
| 2009 | 22.3 | 49 | 22 |
| 2010 | 22.7 | 53 | 22 |
| 2011 | 23.0 | 78 | 23 |
| Mean ± SD | 23.3 ± 2.5 | 70 ± 16 | 24 ± 3.5 |

2014 Falmouth
Average Ambient Temperature: 25.3°C
Relative Humidity: 73.9%
HI: 26°C

# Ambient Temperature

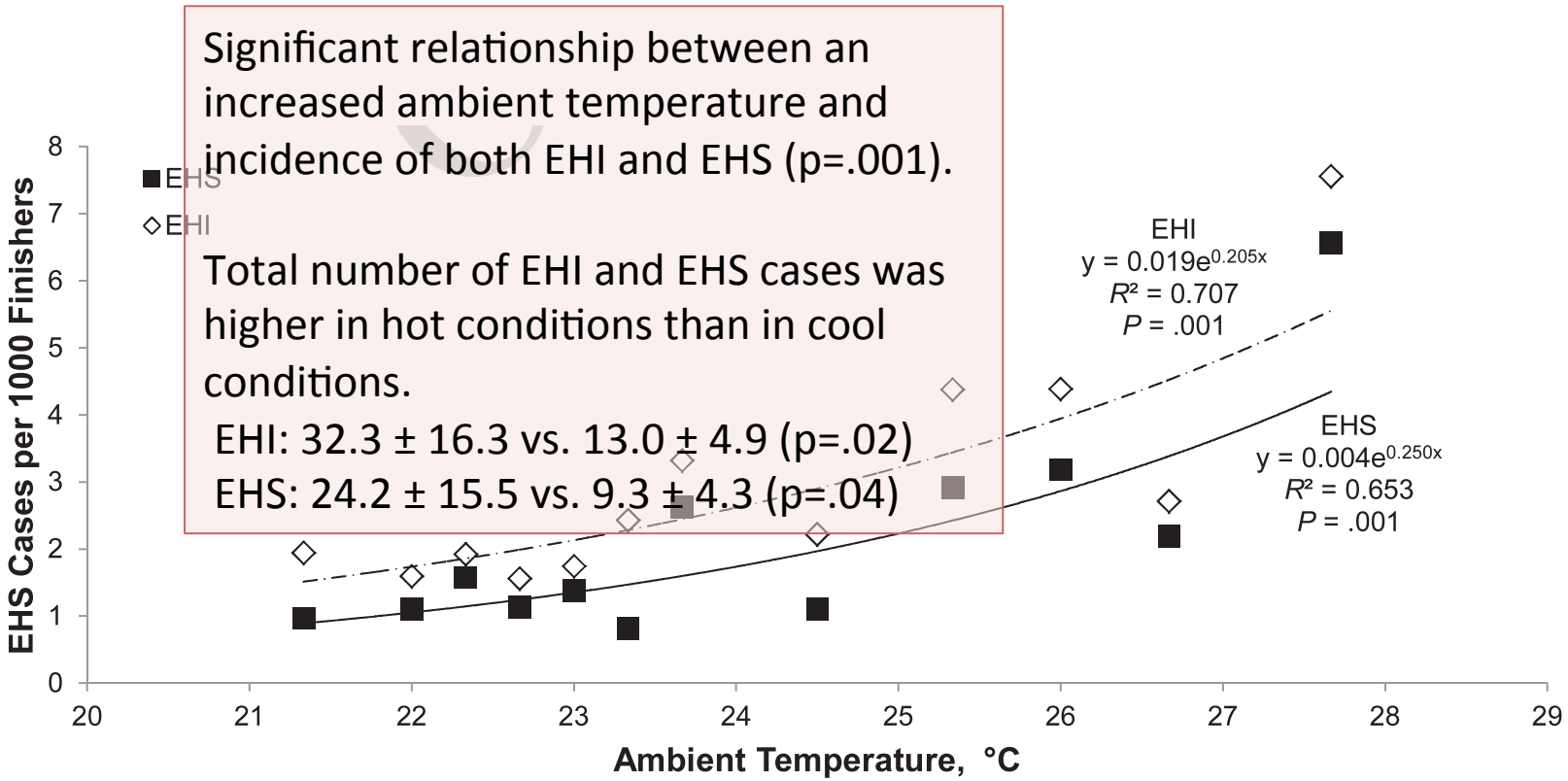



**Figure 2. Relationship of the incidence rate (per 1000 finishers) of exertional heat illness (EHI; white diamonds, dashed line) and exertional heat stroke (EHS; black squares, solid line) versus ambient temperature during the Falmouth Road Race.**

# Humidity

No significant relationship between the relative humidity and incidence of EHI and EHS (p>.05).

Total number of EHI and EHS cases was similar.

EHI: 27.0 ± 18.7 vs. 53.7 ± 5.2 (p >.05)

EHS: 18.0 ± 19.0 vs. 13.8 ± 6.6 (p >.05)

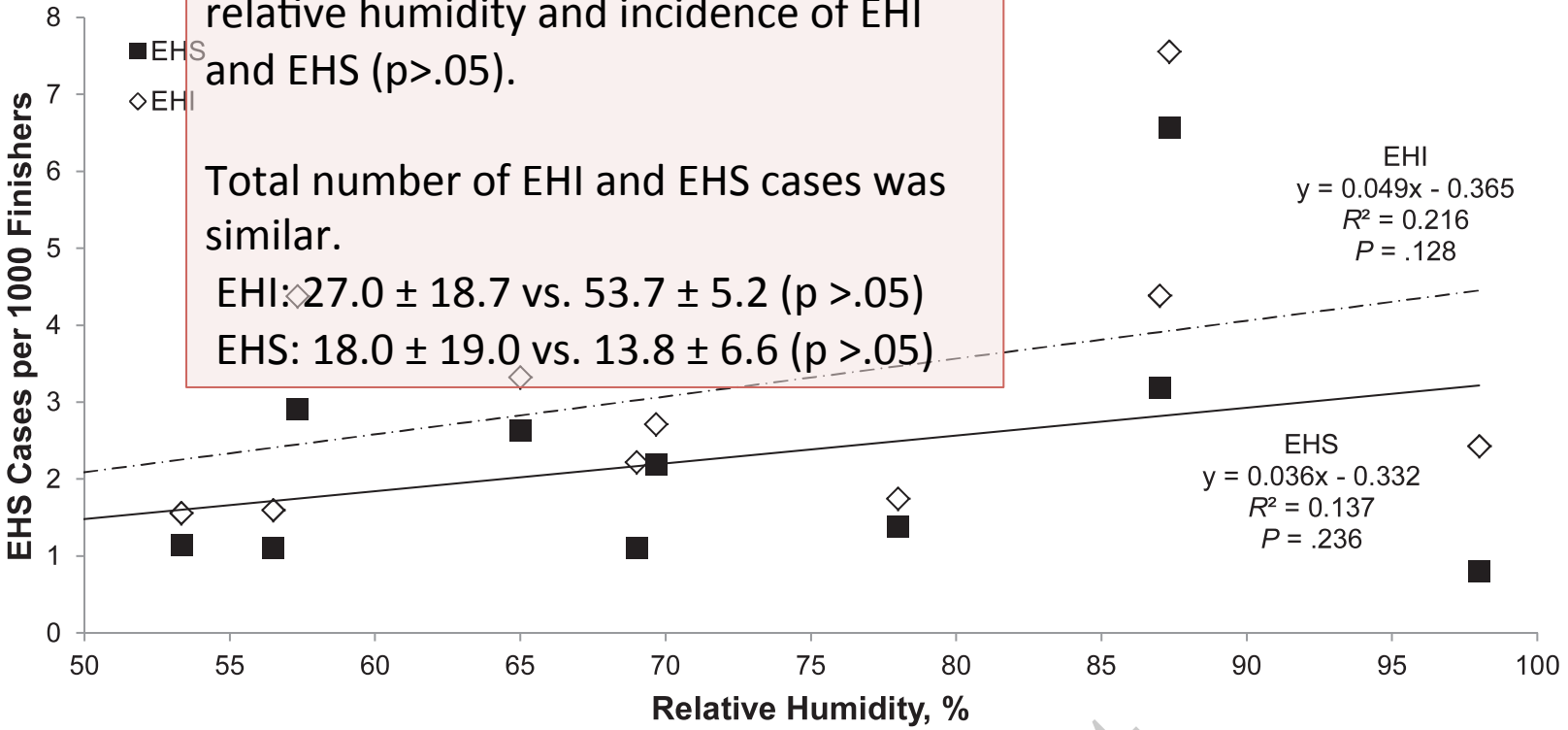



**Figure 3. Relationship of the incidence rate (per 1000 finishers) of exertional heat illness (EHI; white diamonds, dashed line) and exertional heat stroke (EHS; black squares, solid line) versus relative humidity during the Falmouth Road Race.**

# Heat Index

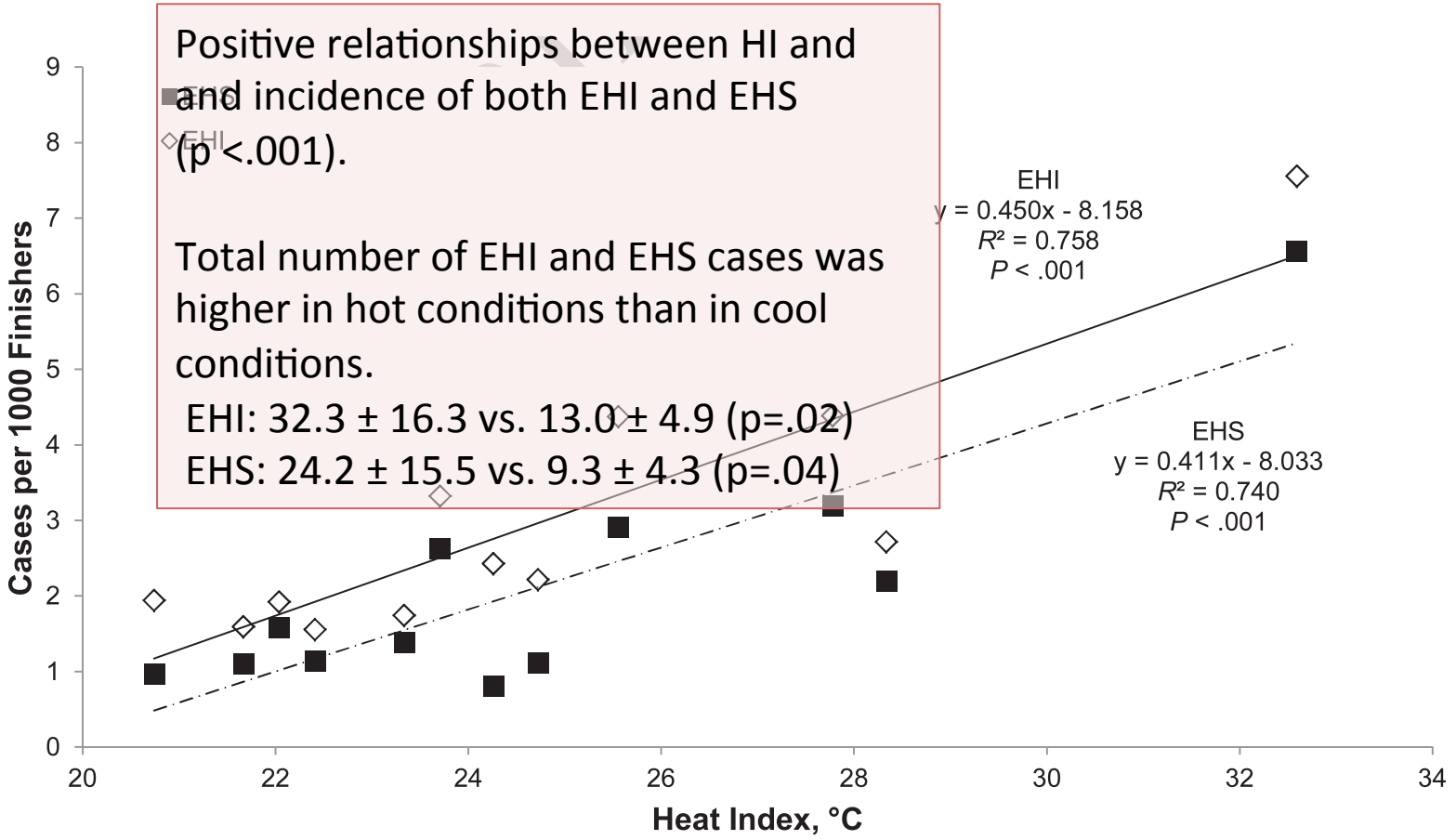
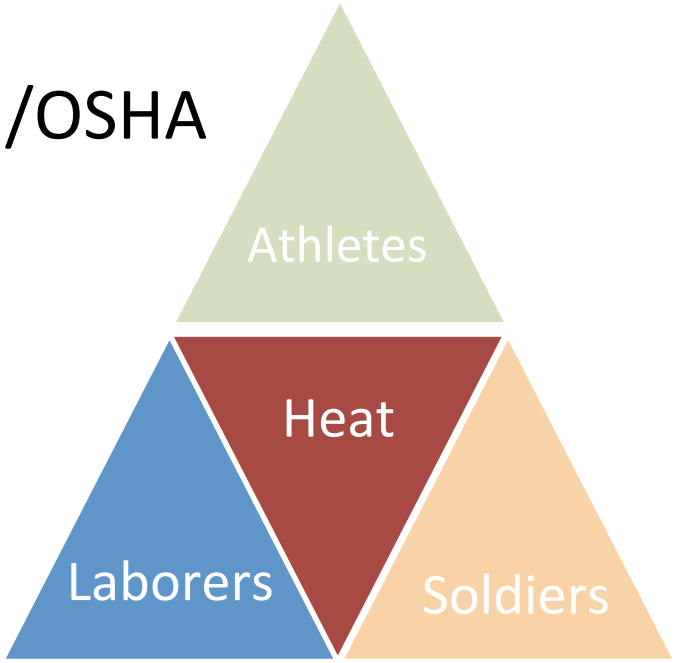



**Figure 4. Relationship of the incidence rate (per 1000 finishers) of exertional heat illness (EHI; white diamonds, dashed line) and exertional heat stroke (EHS; black squares, solid line) versus heat index during the Falmouth Road Race.**

# Impacts of Weather on…

- Laborers
  - Heat Illness Prevention by Cal/OSHA
  - Special considerations:
    - Microenvironment
      - Protective gear
      - Facility
      - Radiant heat

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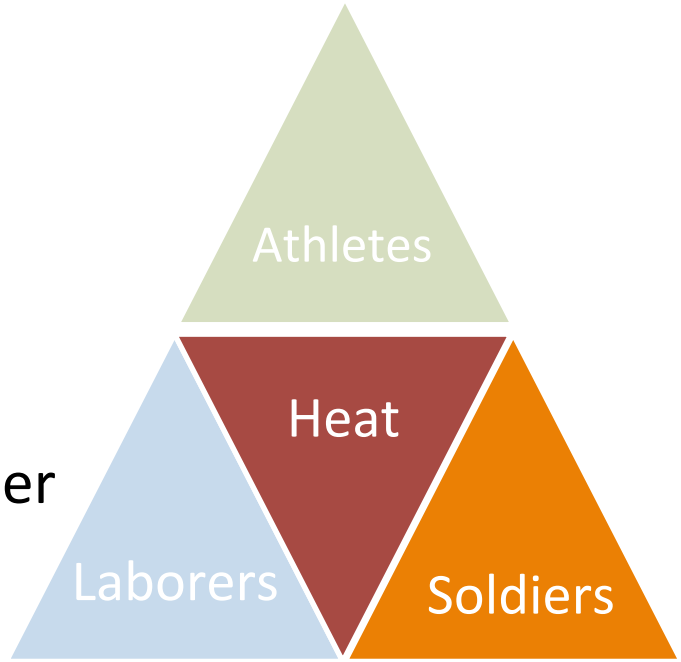
# Impacts of Weather on…

- Soldiers
  - Basic training
  - Active service
  - Special considerations:
    - Accessibility to shelter and water
    - Regiment oriented
      - Fort Bragg
      - Fort Benning
      - Army Ranger

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# Things are getting worse…

| Year | Fatal EHS Cases |
|---|---|
| 1975-1979 | 8 |
| 1980-1984 | 9 |
| 1985-1989 | 5 |
| 1990-1994 | 2 |
| 1995-1999 | 13 |
| 2000-2004 | 11 |
| 2005-2009 | 18 |
| 2010-2014 | 19 |

- Fatal EHS cases in high school and collegiate level organized sports
- Advance in medicine, but why?
  - Increased competitiveness
  - Global warming

National Center For Catastrophic Sports Injury Research

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# HEAT GUIDELINES
# EXAMPLES

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# American College of Sports Medicine

TABLE 2. WBGT levels for modification or cancellation of workouts or athletic competition for healthy adults.[a,f]

| WBGT [b] | | | Training and Noncontinuous Activity | |
|---|---|---|---|---|
| °F | °C | Continuous Activity and Competition | Nonacclimatized, Unfit, High-Risk Individuals [c] | Acclimatized, Fit, Low-Risk Individuals [c,d] |
| ≤50.0 | ≤10.0 | Generally safe; EHS can occur associated with individual factors | Normal activity | Normal activity |
| 50.1–65.0 | 10.1–18.3 | Generally safe; EHS can occur | Normal activity | Normal activity |
| 65.1–72.0 | 18.4–22.2 | Risk of EHS and other heat illness begins to rise; high-risk individuals should be monitored or not compete | Increase the rest:work ratio. Monitor fluid intake. | Normal activity |
| 72.1–78.0 | 22.3–25.6 | Risk for all competitors is increased | Increase the rest:work ratio and decrease total duration of activity. | Normal activity. Monitor fluid intake. |
| 78.1–82.0 | 25.7–27.8 | Risk for unfit, nonacclimatized individuals is high | Increase the rest:work ratio; decrease intensity and total duration of activity. | Normal activity. Monitor fluid intake. |
| 82.1–86.0 | 27.9–30.0 | Cancel level for EHS risk | Increase the rest:work ratio to 1:1, decrease intensity and total duration of activity. Limit intense exercise. Watch at-risk individuals carefully | Plan intense or prolonged exercise with discretion[f]; watch at-risk individuals carefully |
| 86.1–90.0 | 30.1–32.2 | | Cancel or stop practice and competition. | Limit intense exercise[f] and total daily exposure to heat and humidity; watch for early signs and symptoms |
| ≥90.1 | >32.3 | | Cancel exercise. | Cancel exercise uncompensable heat stress[e] exists for all athletes[f] |

[a] revised from reference (38).
[b] wet bulb globe temperature.
[c] while wearing shorts, T-shirt, socks and sneakers.
[d] acclimatized to training in the heat at least 3 wk.
[e] internal heat production exceeds heat loss and core body temperature rises continuously, without a plateau.
[f] Differences of local climate and individual heat acclimatization status may allow activity at higher levels than outlined in the table, but athletes and coaches should consult with sports medicine staff and should be cautious when exceeding these limits.

# National Athletic Trainers' Association

**Table 3. Wet-Bulb Globe Temperature Risk Chart[62–67]***

| WBGT | Flag Color | Level of Risk | Comments |
|---|---|---|---|
| <18°C (<65°F) | Green | Low | Risk low but still exists on the basis of risk factors |
| 18–23°C (65–73°F) | Yellow | Moderate | Risk level increases as event progresses through the day |
| 23–28°C (73–82°F) | Red | High | Everyone should be aware of injury potential; individuals at risk should not compete |
| >28°C (82°F) | Black | Extreme or hazardous | Consider rescheduling or delaying the event until safer conditions prevail; if the event must take place, be on high alert |

*Adapted with permission from Roberts.[67]

- Careful control of all activity should be undertaken when the **WBGT** is **higher than 82˚F**

- Follow **ACSM's guidelines** for conducting athletic activities in the heat

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.

*Journal of Athletic Training* 2009;44(3):332–333

www.nata.org/jat

*consensus statement*

# Preseason Heat-Acclimatization Guidelines for Secondary School Athletics

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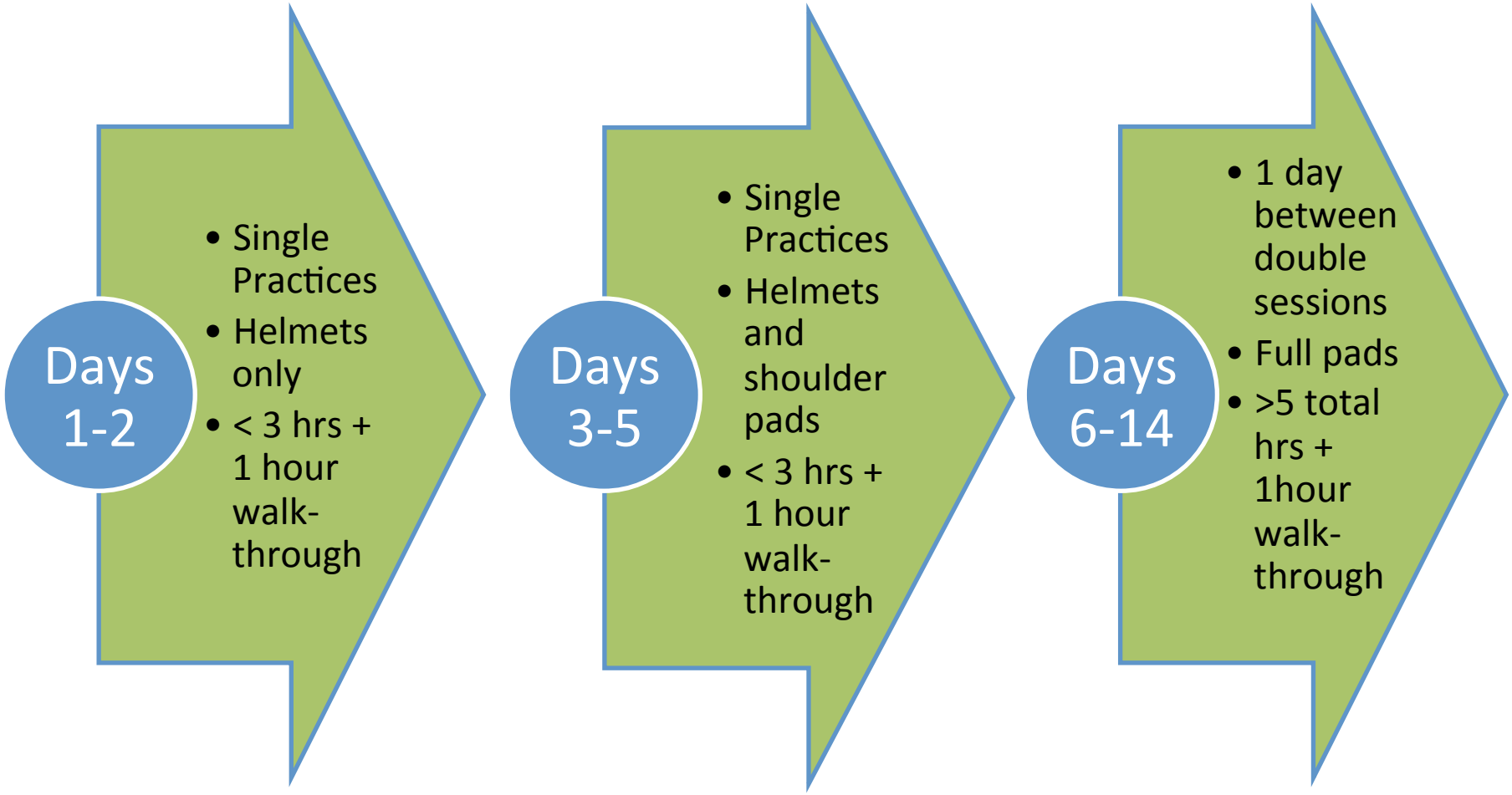
*Co-Chairs; †Individual Representatives; ‡Gatorade Sports Science Institute; §American College of Sports Medicine; ‖National Athletic Trainers' Association; ¶National Strength and Conditioning Association; #United States Army Research Institute of Environmental Medicine; **American Orthopaedic Society for Sports Medicine; ††American Medical Society for Sports Medicine; ‡‡American Academy of Pediatrics

Casa DJ, Csillan D, Inter-Association Task Force for Preseason Secondary School Athletics Participants, et al. Preseason heat-acclimatization guidelines for secondary school athletics. *J Athl Train*. 2009;44(3):332-333.

# Heat Acclimatization Guidelines: High Schools

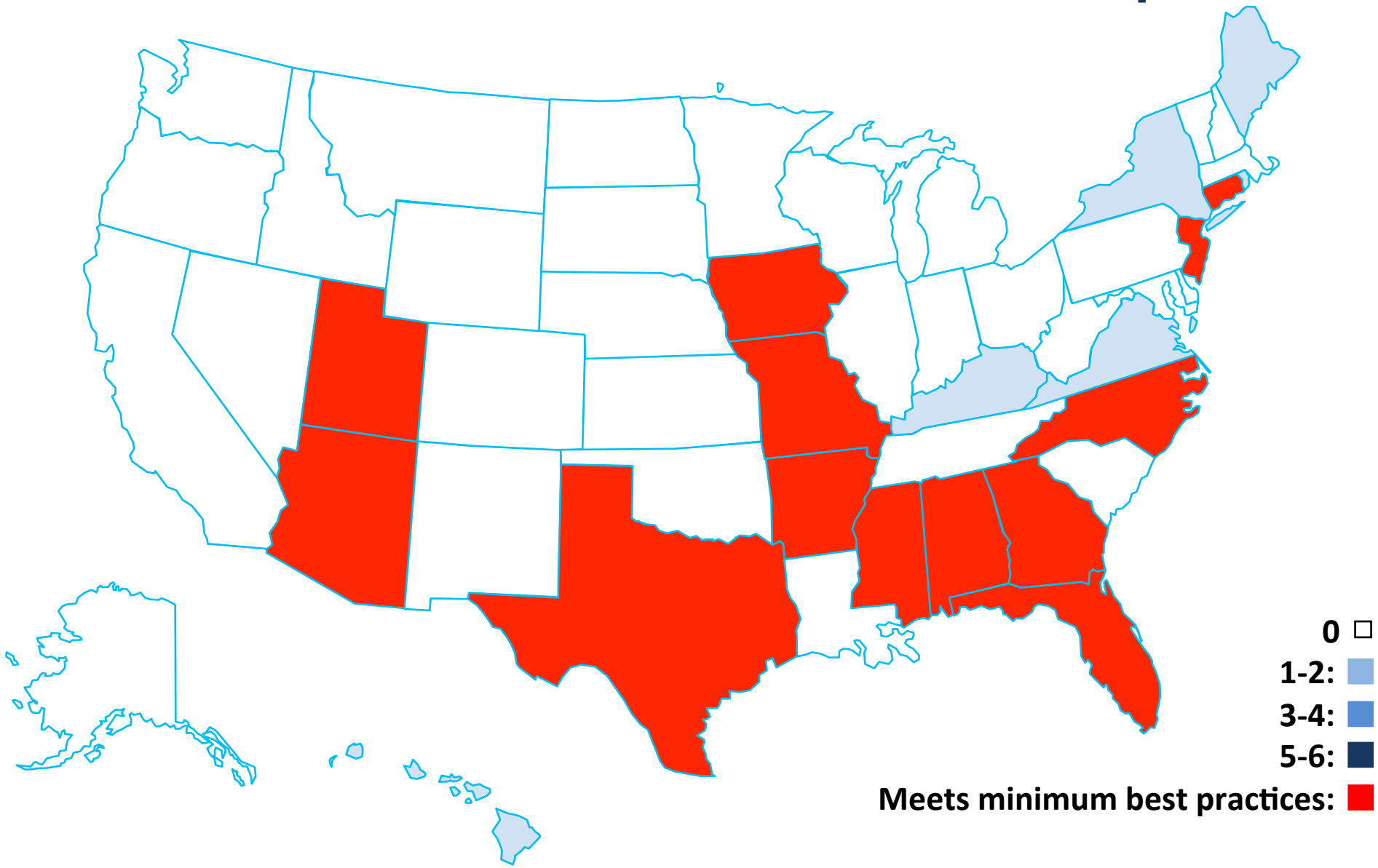



Casa DJ, Csillan D, Inter-Association Task Force for Preseason Secondary School Athletics Participants, et al. Preseason heat-acclimatization guidelines for secondary school athletics. *J Athl Train*. 2009;44(3):332-333.

# HA requirements

1. Days 1-5 are the first formal practices. No more than 1 practice occurs per day.
2. Total practice time should not exceed 3 hours in any 1 day.
3. 1-hour maximum walk-through is permitted on days 1-5; however, there must be a 3 hours minimum break between practice and walk-through (or vice versa).
4. Football only: on days 3-5, contact with blocking sleds and talking dummies may be initiated. Full contact sports: 100% life contact drills should begin no earlier than day 6.
5. Day 6-14, double practice days must be followed by a single-practice day. On single-practice days, 1 walk through is permitted, separated from the practice by at least 3 hours of continuous rest. When a double-practice day is followed by a rest day, another double practice day is permitted after the rest day.
6. On a double-practice day, neither practice should exceed 3 hours in duration, with no more than 5 total hours of practice in the day. Warm-up, stretching, cooling down, walk-through, conditioning, and weight-room activities are included as part of the practice time. The 2 practices should be separated by at least 3 continuous hours in a cool environment.
7. Because of the high risk for exertional heat illness during the preseason heat acclimatization period, we strongly recommend an athletic trainer be onsite before, during and after all practices.

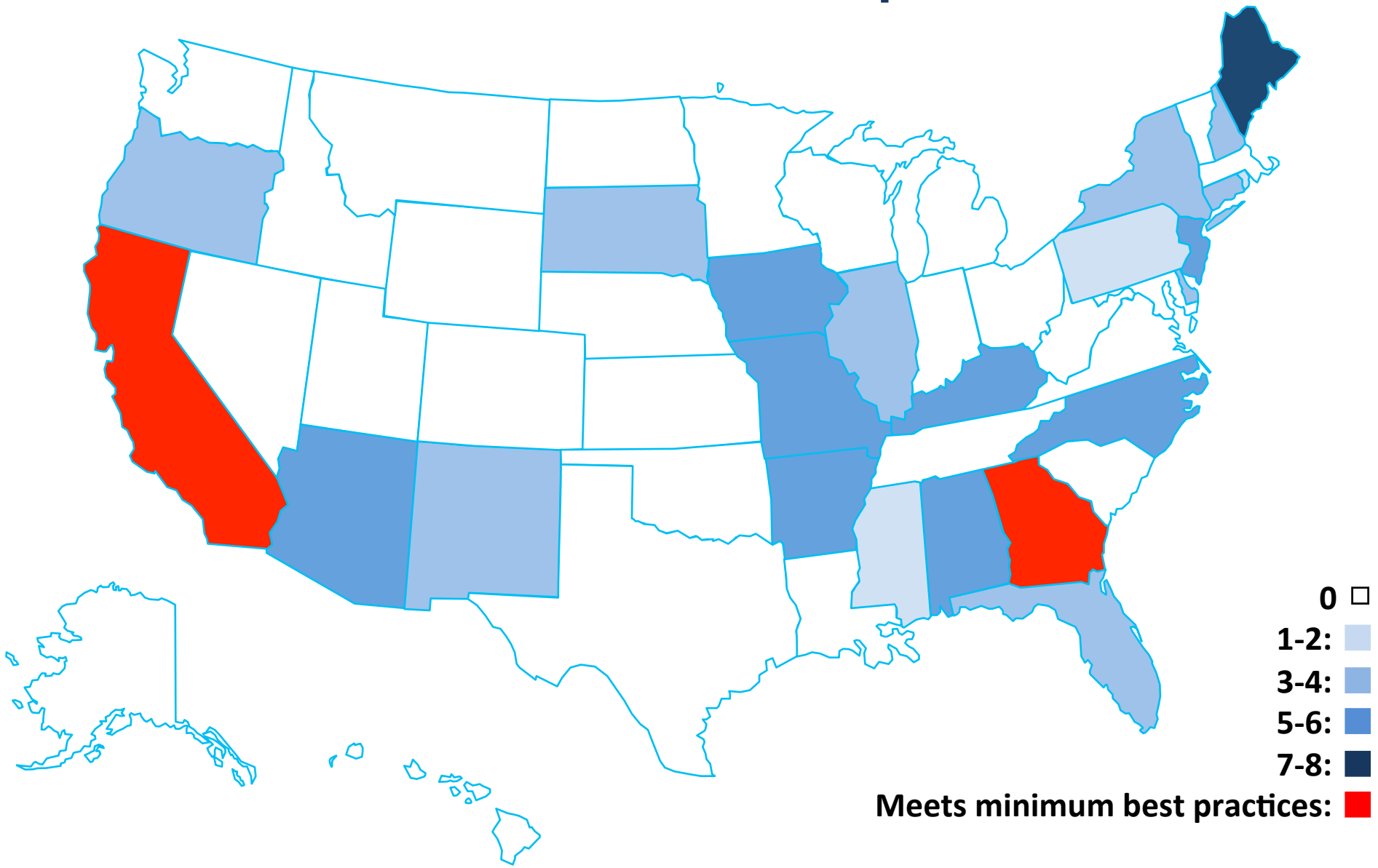
# Heat Acclimatization Map



# WBGT requirements

1. Organization requires all divisions to have a heat modification policy for any sanctioned activity.
2. The recommended heat policy is based off of WBGT (not heat index or any other methods) Heat Index is only acceptable for organizations without funding for WBGT, and the organization is actively petitioning for funding to supply a WBGT.
3. The WBGT temperature guidelines are based off of epidemiological data specific to that state/region (for bigger states a more comprehensive analysis may be needed). Organization required to seek alternative ways to obtain WBGT for their area via weather station WBGT or other valid local sources.
4. The heat policy has at least a 4-step progression of modifications (does not include the limit that dictates normal practice).
5. Policy includes specific modification of equipment (if applicable to the sport).
6. Policy includes specific modification of work : rest ratios.
7. Policy includes specific modification of total practice time.
8. Policy includes specific modification of water breaks.
9. Policy mentions the use of a shaded area for rest breaks.

# WBGT Map



# OSHA

**TABLE III:4-2. PERMISSIBLE HEAT EXPOSURE THRESHOLD LIMIT VALUE**

| | ---------- Work Load* ---------- | | |
|---|---|---|---|
| **Work/rest regimen** | **Light** | **Moderate** | **Heavy** |
| Continuous work | 30.0°C (86°F) | 26.7°C (80°F) | 25.0°C (77°F) |
| 75% Work, 25% rest, each hour | 30.6°C (87°F) | 28.0°C (82°F) | 25.9°C (78°F) |
| 50% Work, 50% rest, each hour | 31.4°C (89°F) | 29.4°C (85°F) | 27.9°C (82°F) |
| 25% Work, 75% rest, each hour | 32.2°C (90°F) | 31.1°C (88°F) | 30.0°C (86°F) |

*Values are in °C and °F, WBGT.

These TLV's are based on the assumption that nearly all acclimatized, fully clothed workers with adequate water and salt intake should be able to function effectively under the given working conditions without exceeding a deep body temperature of 38°C (100.4° F). They are also based on the assumption that the WBGT of the resting place is the same or very close to that of the workplace. Where the WBGT of the work area is different from that of the rest area, a time-weighted average should be used (consult the ACGIH *1992-1993 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* (1992).

These TLV's apply to physically fit and acclimatized individuals wearing light summer clothing. If heavier clothing that impedes sweat or has a higher insulation value is required, the permissible heat exposure TLV's in Table III:4-2 must be reduced by the corrections shown in Table III:4-3.

# U.S. ARMY

## Work/Rest and Water Consumption Table

***Applies to average sized, heat-acclimated Soldier wearing ACU, hot weather. (See TB MED 507 for further guidance.)***

| Easy Work | Moderate Work | Hard Work |
|---|---|---|
| • Weapon Maintenance<br>• Walking Hard Surface at 2.5 mph, < 30 lb Load<br>• Marksmanship Training<br>• Drill and Ceremony<br>• Manual of Arms | • Walking Loose Sand at 2.5 mph, No Load<br>• Walking Hard Surface at 3.5 mph, < 40 lb Load<br>• Calisthenics<br>• Patrolling<br>• Individual Movement Techniques, i.e., Low Crawl or High Crawl<br>• Defensive Position Construction | • Walking Hard Surface at 3.5 mph, ≥ 40 lb Load<br>• Walking Loose Sand at 2.5 mph with Load<br>• Field Assaults |

| Heat Category | WBGT Index, F° | Easy Work | | Moderate Work | | Hard Work | |
|---|---|---|---|---|---|---|---|
| | | *Work/Rest (min)* | *Water Intake (qt/hr)* | *Work/Rest (min)* | *Water Intake (qt/hr)* | *Work/Rest (min)* | *Water Intake (qt/hr)* |
| 1 | 78° - 81.9° | NL | ½ | NL | ¾ | 40/20 min | ¾ |
| 2 (green) | 82° - 84.9° | NL | ½ | 50/10 min | ¾ | 30/30 min | 1 |
| 3 (yellow) | 85° - 87.9° | NL | ¾ | 40/20 min | ¾ | 30/30 min | 1 |
| 4 (red) | 88° - 89.9° | NL | ¾ | 30/30 min | ¾ | 20/40 min | 1 |
| 5 (black) | > 90° | 50/10 min | 1 | 20/40 min | 1 | 10/50 min | 1 |

- The work/rest times and fluid replacement volumes will sustain performance and hydration for at least 4 hrs of work in the specified heat category. Fluid needs can vary based on individual differences (± ¼ qt/hr) and exposure to full sun or full shade (± ¼ qt/hr).
- **NL** = no limit to work time per hr.
- **Rest** = minimal physical activity (sitting or standing) accomplished in shade if possible.
- ***CAUTION: Hourly fluid intake should not exceed 1½ qts.***

  ***Daily fluid intake should not exceed 12 qts.***
- If wearing body armor, add **5°F** to WBGT index in humid climates.
- If doing Easy Work and wearing NBC (MOPP 4) clothing, add **10°F** to WBGT index.
- If doing Moderate or Hard Work and wearing NBC (MOPP 4) clothing, add **20°F** to WBGT index.

*For additional copies, contact: U.S. Army Public Health Command Health Information Operations Division at (800) 222-9698 or USAPHC - Health Information Operations@apg.amedd.army. mil.*
*For electronic versions, see http://chppm-www.apgea.army.mil/heat. Distribution unlimited. Local reproduction is authorized.*
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THE
BOX

# Epidemiology and Weather

**A retrospective analysis of American football hyperthermia deaths in the United States**

**Andrew J. Grundstein · Craig Ramseyer · Fang Zhao · Jordan L. Pesses · Pete Akers · Aneela Qureshi · Laura Becker · John A. Knox · Myron Petro**

- 123 reported fatalities (1960-2009)
- 58 well-documented cases (1980-1995) were examined
  - Demographics of victims
  - Geography
  - Timing
  - Meteorological conditions

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# Epidemiology and Weather

- Almost all August
- Lineman (>85%)
- WBGT high or extreme (better than heat index)
- First few days
- Equipment dramatically increases prediction of WBGT
- >50% in morning

Grundstein AJ, Ramseyer C, Zhao F, et al. A retrospective analysis of American football hyperthermia deaths in the United States. *Int J Biometeorol*. 2012;56(1): 11-20.

**Table 1** Temporal patterns of football hyperthermia fatalities

| Time of day | *n* | Time of season | *n* | Month | *n* | Sub-month (Jul–Sep) | *n* |
|---|---|---|---|---|---|---|---|
| Morning (8:00 am–12:00 pm LDT) | 21 | 1st practice | 9 | Jan–May | 1 | Jul 1–15 | 7 |
| Afternoon (2:00–6:00 pm LDT) | 15 | 2nd practice | 3 | Jun | 0 | Jul 16–31 | 9 |
| Unknown | 22 | 3rd practice | 1 | Jul | 10 | Aug 1–15 | 27 |
| | | 1st practice with pads | 1 | Aug | 37 | Aug 16–31 | 11 |
| | | Unknown | 44 | Sep | 9 | Sep 1–15 | 4 |
| | | | | Oct | 1 | Sep 16–30 | 2 |
| | | | | Nov–Dec | 0 | | |

**Table 4** Statistics on football hyperthermia fatalities by risk category

| American College of Sports Medicine and Sports Medicine Australia | Count (%) | American Academy of Pediatrics | Count (%) | NWS Heat Index | Count (%) | Uncompensable heat stress | Above/ below |
|---|---|---|---|---|---|---|---|
| Low (<18°C) | 0 (0) | No limits (<24°C) | 1 (3) | No warning (<26.7°C) | 5 (15) | Full uniform (24.7–28.4°C) | 1/1 |
| Moderate (18–23°C) | 0 (0) | Longer rest periods (24–25.9°C) | 5 (15) | Caution (26.7–32.2°C) | 10 (30) | Practice uniform (28–29.6°C) | 5/3 |
| High (23–28°C) | 13 (39) | Stop activity if not acclimatized (26–29°C) | 13 (35) | Extreme caution (32.3–40.6°C) | 18 (55) | Shorts only (31.6–33.1°C) | 1/6 |
| Extreme/Cancel event (>28°C) | 20 (61) | Cancel event (>29°C) | 14 (42) | Danger (40.7–54.4°C) | 0 | | |
| | | | | Extreme danger (>54.4°C) | 0 | | |

Grundstein AJ, Ramseyer C, Zhao F, et al. A retrospective analysis of American football hyperthermia deaths in the United States. *Int J Biometeorol*. 2012;56(1):11-20.

# Football hyperthermia deaths, 1980-2009

Grundstein AJ, Ramseyer C, Zhao F, et al. A retrospective analysis of American football hyperthermia deaths in the United States. *Int J Biometeorol*. 2012;56(1):11-20.

# Exertional Heat Illness and Exertional Heat Stroke Occurrence

- Prospective epidemiologic study
- Daily the occurrence of EHI and Wet Bulb Globe Temperature (WBGT) readings
- 60 universities/colleges representing from five geographical regions of the Unites States.
- Occurrences within 2-months (August-September) of American collegiate football practice sessions over 4 years

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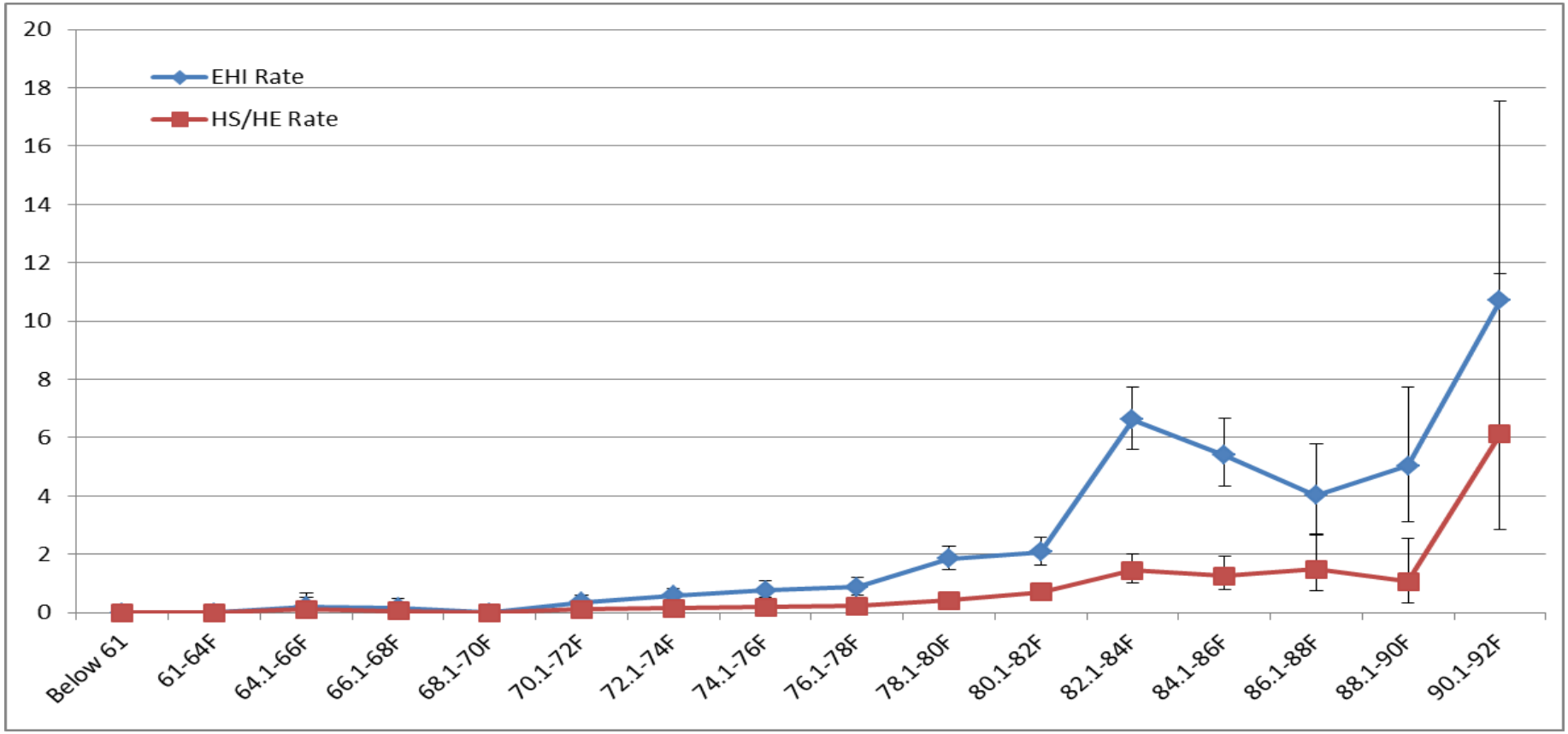
Ferrara, Casa et al. JAT, In review.

# Exertional Heat Illness and Exertional Heat Stroke Occurrence


Ferrara, Casa et al. JAT, in review.

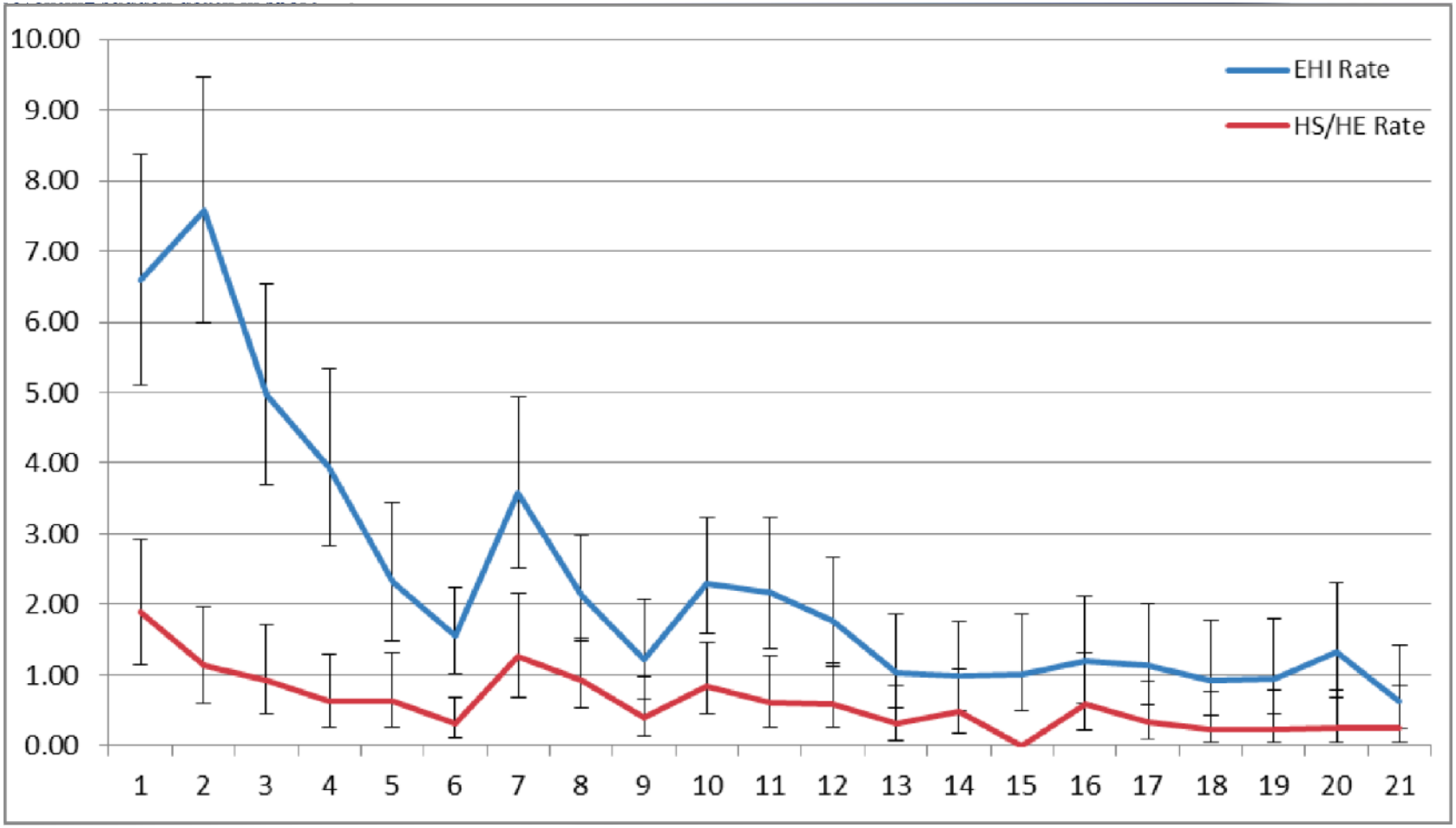
# WBGT Data

- EHI risk was greatest when the WBGT was above $82^0$F




Ferrara, Casa et al. JAT, in review.

# EHI Injury Rate by Day
## (First 21 Days Only)




Ferrara, Casa et al. JAT, in review.

# EXAMPLE FROM GEORGIA STATE HIGH SCHOOL ASSOCIATION

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# Georgia State High School Association

| WBGT READING | ACTIVITY GUIDELINES & REST BREAK GUIDELINES |
|---|---|
| Under 82.0 | Normal activities--Provide at least three separate rest breaks each hour of minimum duration of 3 minutes each during workout |
| 82.0 - 86.9 | Use discretion for intense or prolonged exercise; watch at-risk players carefully; Provide at least three separate rest breaks each hour of a minimum of four minutes duration each |
| 87.0 - 89.9 | Maximum practice time is two hours. For Football: players restricted to helmet, shoulder pads, and shorts during practice. All protective equipment must be removed for conditioning activities. For all sports: Provide at least four separate rest breaks each hour of a minimum of four minutes each |
| 90.0 - 92.0 | Maximum length of practice is one hour, no protective equipment may be worn during practice and there may be no conditioning activities. There must be 20-minutes of rest breaks provided during the hour of practice |
| Over 92.1 | No outdoor workouts; Cancel exercise; delay practices until a cooler WBGT reading occurs |

# Acclimatization in Georgia Interscholastic Football Players: A Three-Year Perspective

Jessica Dysart Miles, MAE, ATC/L
Michael S. Ferrara, PhD, ATC/L
Earl "Bud" Cooper, EdD, ATC/L
Patrick Curry, MS, ATC/L
Andrew J. Grundstein, PhD
Doug Casa, Ph.D., ATC
John W. Powell, Ph.D., ATC

# Methods

- 25 Schools were recruited for participation in 2009-2011 FB seasons
- Certified Athletic Trainer performed daily data collection:
  - Practice data (no. exposures, session type, etc)
  - Environmental data (QuestTemp QT34)
  - Injury data (eg, height, weight, position, etc…)
- Weekly data transmissions to a web database system

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# Methods

**Instrumentation**

- Quest Technologies QT-34 Environmental Stress monitor (Oconomowoc, WI).
- Each unit was turned on 15 minutes prior to practice and 15 minutes following practice.

**Data**

- Practice start and end times.
- WBGT and heat index recordings were made every 15 minutes.
- WBGT/Heat Index average values were calculated for each practice session.

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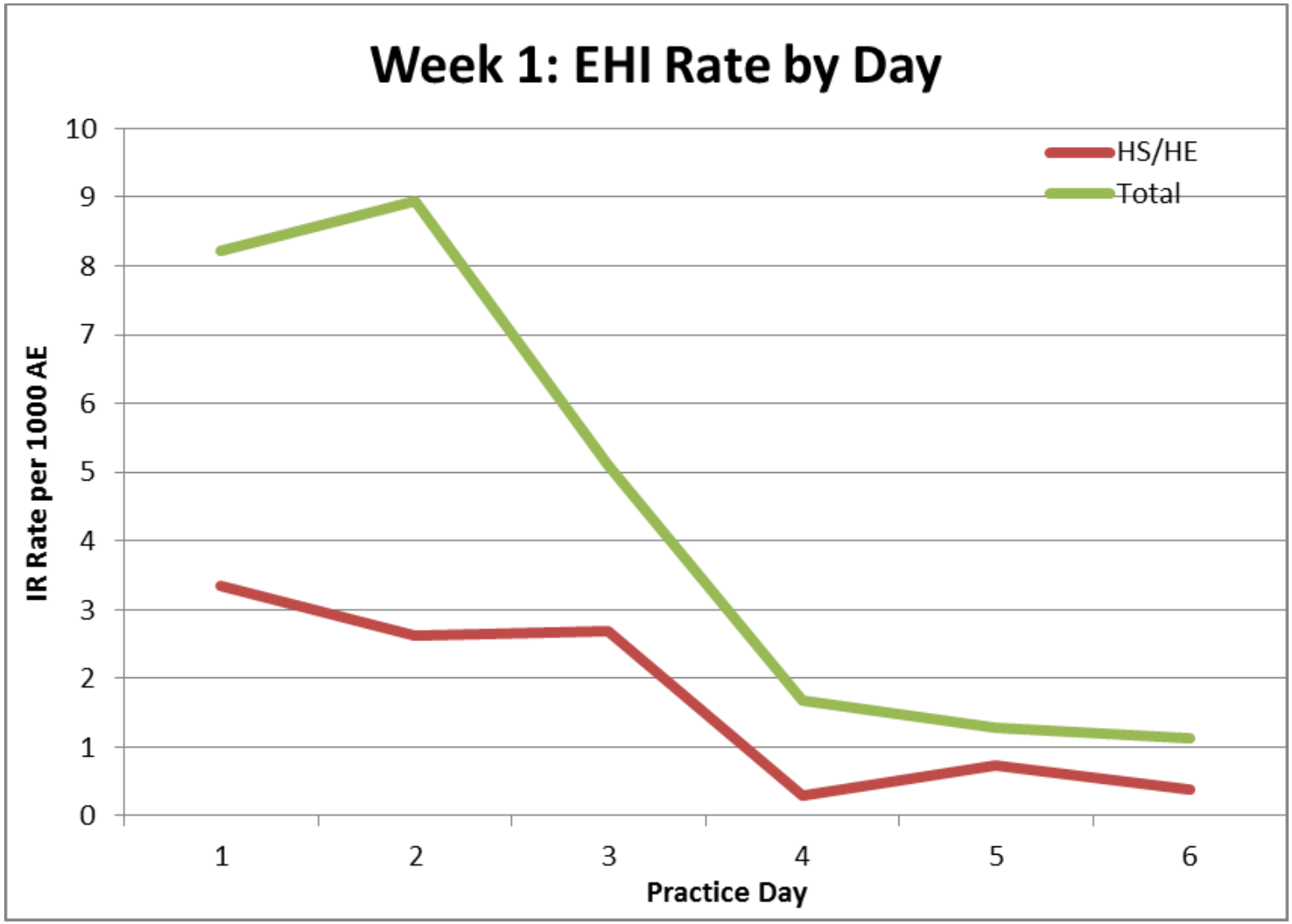
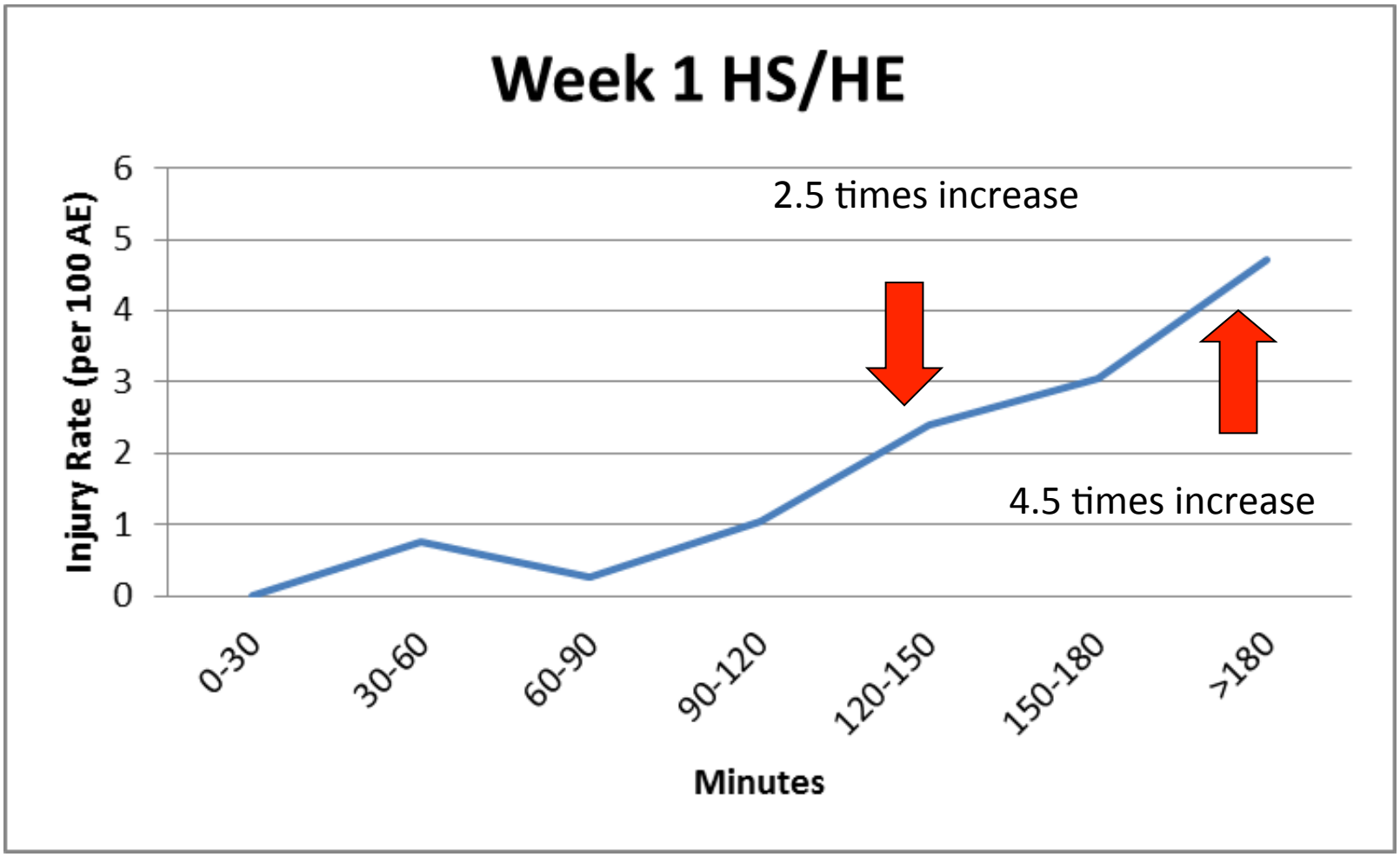
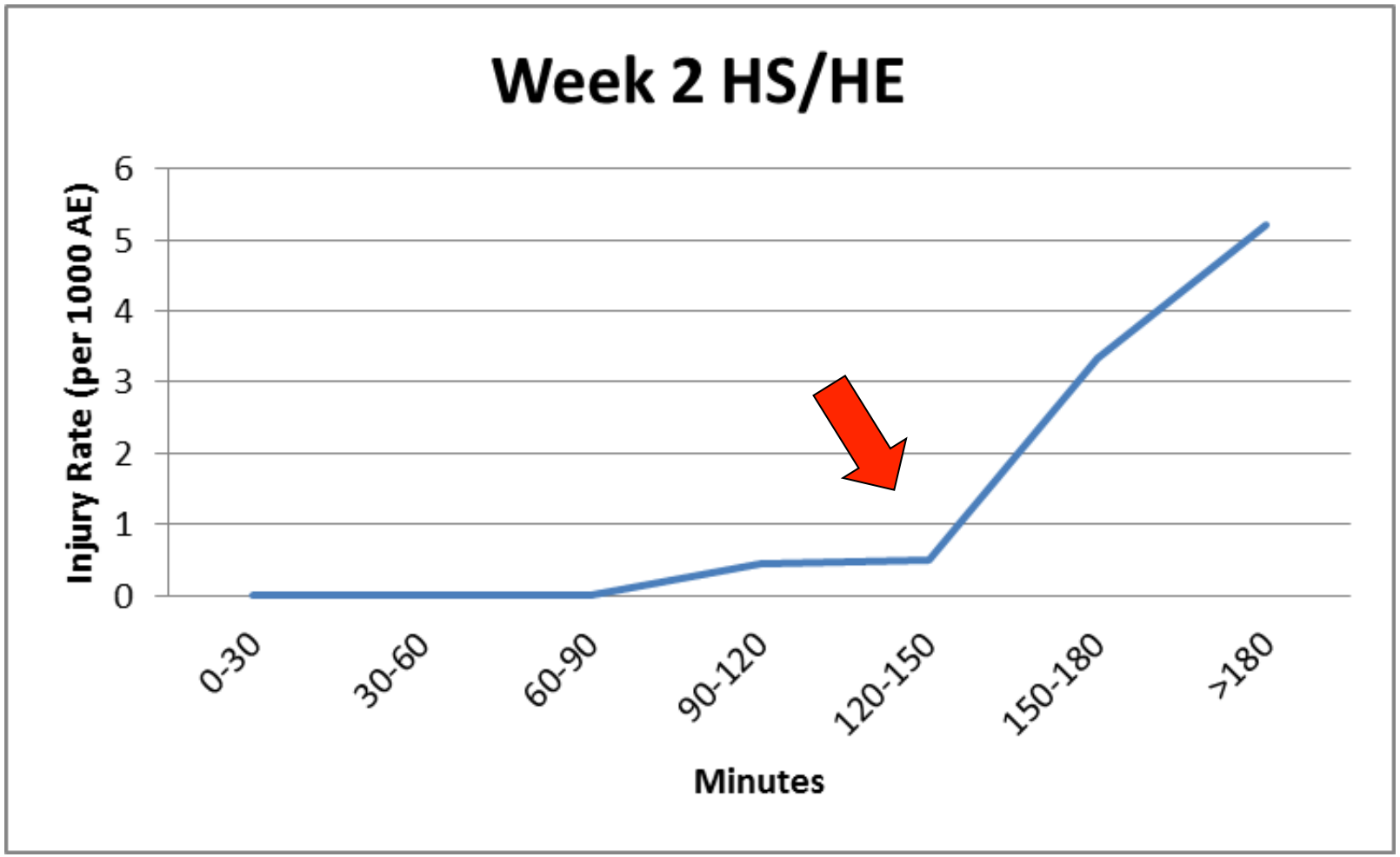
# IR for 1st Week



# IR by Week and Length of Practice for August



# IR by Week and Length of Practice for August



# APPLICATION OF CLIMATOLOGY IN SPORT SAFETY

# Exceedance of wet bulb globe temperature safety thresholds in sports under a warming climate

**Andrew Grundstein[1,*], Nellie Elguindi[2], Earl Cooper[3], Michael S. Ferrara[4]**

- Present and future frequency of days that exceed the most extreme ACSM category (>32.3°C)
- Latitudinal shift in the frequency of oppressive days is predicted
- Range for oppressive conditions is predicted to expand beyond the summer months

Grundstein A, Elguindi N, Cooper E, Ferrara MS. Exceedance of wet bulb globe temperature safety thresholds in sports under a warming climate. *Clim Res*. 2013;58(2):183-191.

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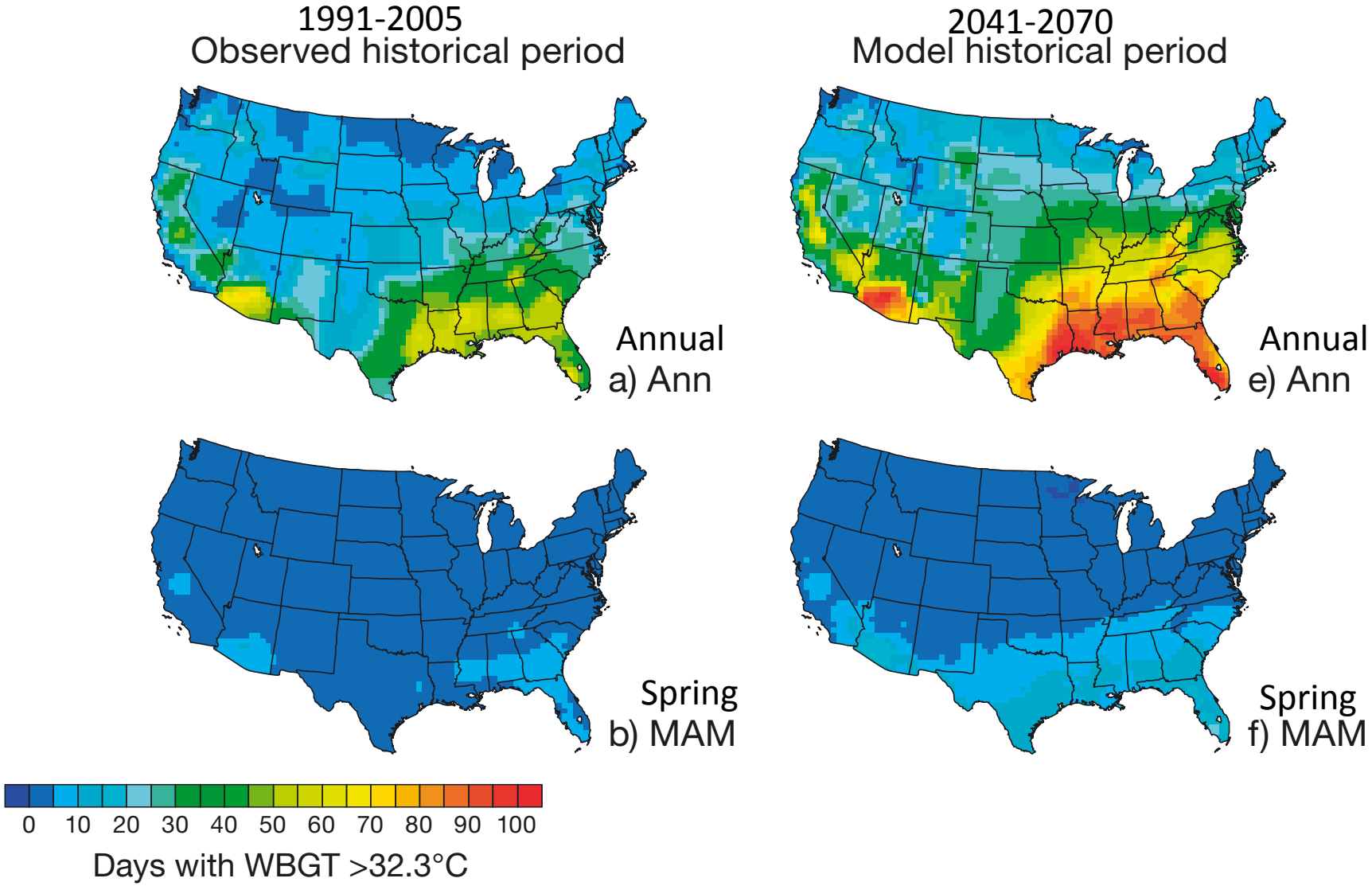
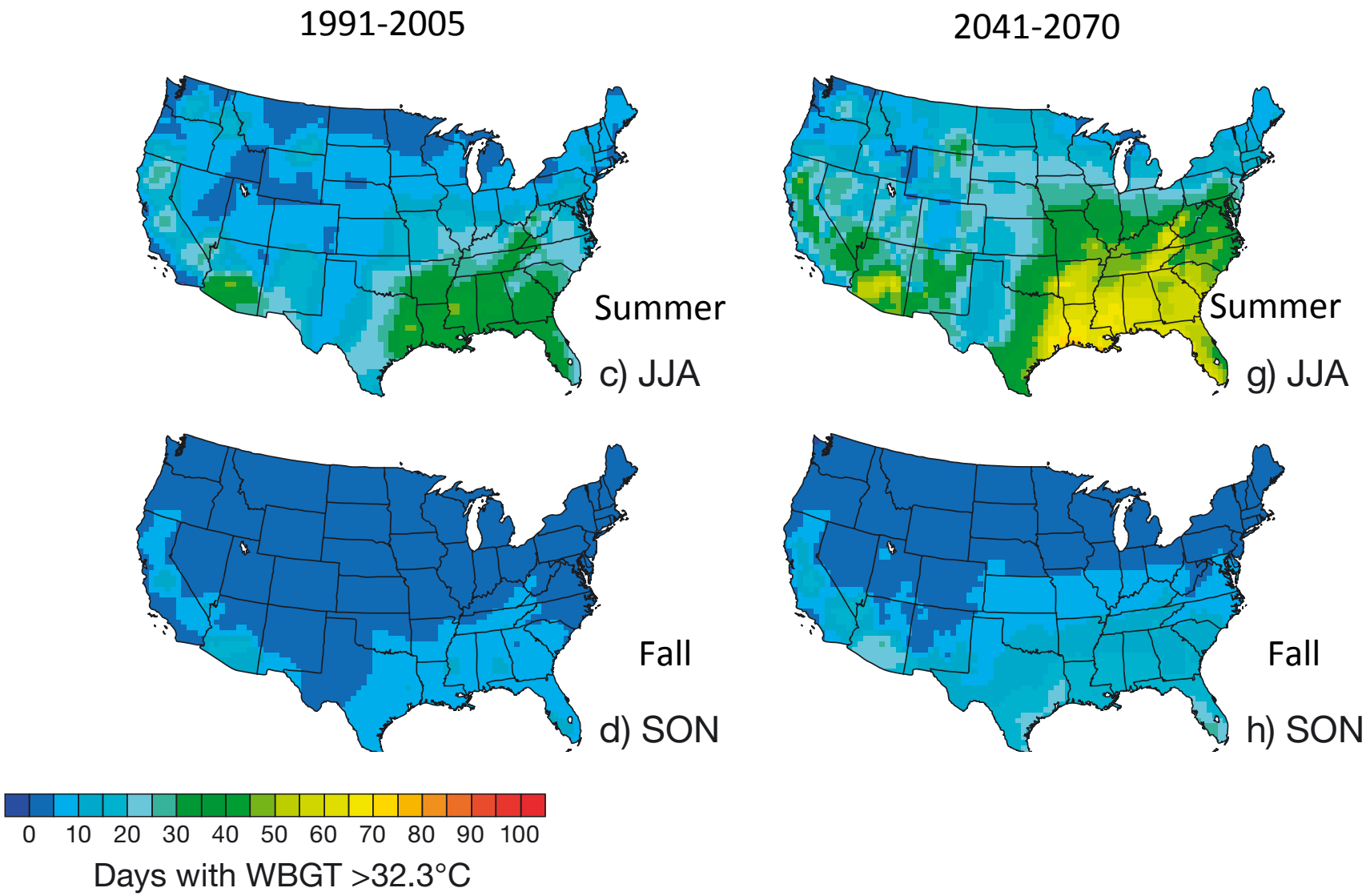
# Frequency of days with WBGT >32.3°C



# Frequency of days with WBGT >32.3°C



# Frequency of exceedance of 32.3°C WBGT in days per year for historical and future periods by time of day (LDT)

| | Morning | | Late morning-noon | | Afternoon | | Late afternoon-evening | | Evening | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 8:00 h | | 11:00 h | | 14:00 h | | 17:00 h | | 20:00 h | |
| EASTERN | Historical | Future | Historical | Future | Historical | Future | Historical | Future | Historical | Future |
| Atlanta, GA | 0 | 0 | 4 | 19 | 7 | 30 | 3 | 31 | 0 | 15 |
| Boston, MA | 0 | 0 | 1 | 2 | 0 | 6 | 0 | 2 | 0 | 0 |
| Gainesville, FL | 0 | 2 | 12 | 30 | 14 | 34 | 5 | 32 | 0 | 10 |
| Richmond, VA | 0 | 0 | 5 | 16 | 7 | 26 | 2 | 24 | 0 | 5 |
| Indianapolis, IN | 0 | 0 | 2 | 12 | 3 | 20 | 1 | 12 | 0 | 0 |
| | 7:00 h | | 10:00 h | | 13:00 h | | 16:00 h | | 19:00 h | |
| CENTRAL | Historical | Future | Historical | Future | Historical | Future | Historical | Future | Historical | Future |
| Dallas, TX | 0 | 0 | 2 | 28 | 10 | 24 | 11 | 27 | 1 | 24 |
| Huron, SD | 0 | 0 | 0 | 3 | 2 | 15 | 2 | 16 | 0 | 12 |
| Kansas City, MO | 0 | 0 | 1 | 8 | 5 | 21 | 6 | 23 | 1 | 18 |
| Minneapolis, MN | 0 | 0 | 0 | 3 | 2 | 13 | 1 | 14 | 0 | 6 |
| Nashville, TN | 0 | 0 | 7 | 21 | 8 | 26 | 3 | 29 | 0 | 20 |
| New Orleans, LA | 0 | 1 | 8 | 14 | 17 | 36 | 11 | 36 | 0 | 13 |
| | 9:00 h | | 12:00 h | | 15:00 h | | 18:00 h | | | |
| WEST | Historical | Future | Historical | Future | Historical | Future | Historical | Future | | |
| Albuquerque, NM | 0 | 0 | 5 | 19 | 4 | 25 | 0 | 5 | | |
| Billings, MT | 0 | 0 | 1 | 7 | 1 | 13 | 0 | 6 | | |
| Cheyenne, WY | 0 | 0 | 1 | 9 | 0 | 9 | 0 | 1 | | |
| Phoenix, AZ | 0 | 0 | 18 | 24 | 26 | 27 | 6 | 21 | | |
| Salt Lake City, UT | 0 | 0 | 2 | 0 | 1 | 6 | 0 | 2 | | |
| | 8:00 h | | 11:00 h | | 14:00 h | | 17:00 h | | 20:00 h | |
| PACIFIC | Historical | Future | Historical | Future | Historical | Future | Historical | Future | Historical | Future |
| Fresno, CA | 0 | 0 | 7 | 8 | 13 | 22 | 4 | 19 | 0 | 0 |
| Las Vegas, NV | 0 | 0 | 9 | 21 | 11 | 22 | 5 | 22 | 0 | 0 |
| Los Angeles, CA | 0 | 1 | 1 | 4 | 0 | 3 | 0 | 0 | 0 | 0 |
| Portland, OR | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 2 | 0 | 0 |
| Spokane, WA | 0 | 0 | 0 | 1 | 1 | 5 | 1 | 3 | 0 | 0 |

# Regional Specific Guidelines

**"I live in the northeast so I don't need to worry about heat issues for my athletes."**

*–Anonymous Athletic Trainer*

- EHS occur when the environment is above regional extreme
  - 85°F in Connecticut vs. Arkansas
- Should the safety guideline take in consideration of differences observed in various geographical regions?
  - Limitation to "one size fits all" approach

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# Regional Specific Thresholds

Regional heat safety thresholds for athletics in the contiguous United States

Andrew Grundstein [a, *], Castle Williams [a], Minh Phan [a], Earl Cooper [b]

[a] *Department of Geography, Climatology Research Laboratory, The University of Georgia, Athens, GA, USA*
[b] *Department of Kinesiology, The University of Georgia, Athens, GA, USA*

- Quantifying locally oppressive days by creating locally defined extreme conditions
  - 3 categories based on extreme WBGTs

Grundstein A, Williams C, Phan M, et al. Regional heat safety thresholds for athletics in the contiguous United States. *Appl Geog*. 2015;56:55-60.

# Regional Specific Thresholds

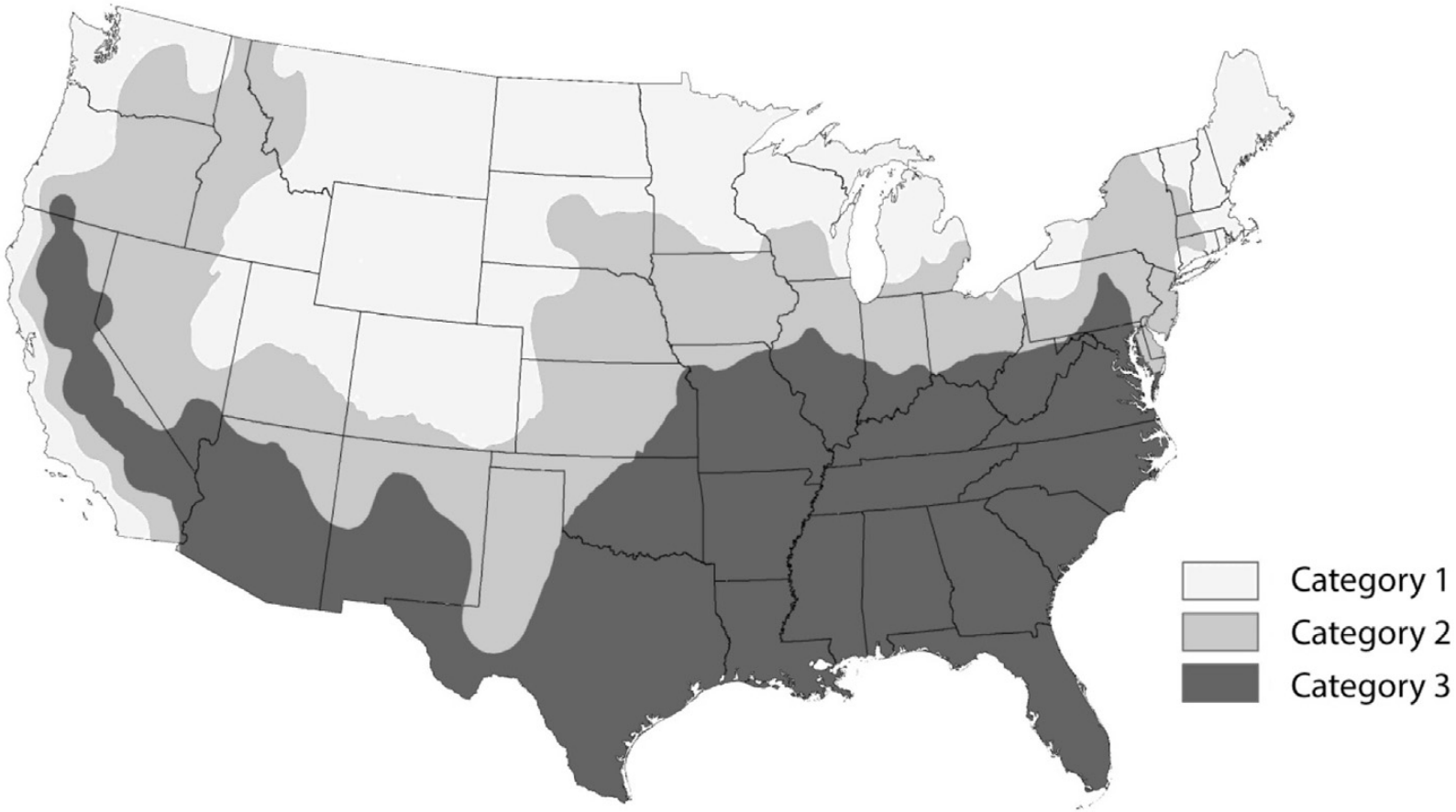


**Fig. 2.** Heat safety regions.

# Regional Specific Thresholds

- ACSM recommendations were adjusted based on the difference between the ACSM critical WBGT maximum (32.3°C) and the categorical median 90th percentile WBGT
- WBGT cutoffs between categories in the ACSM table were adjusted downward by:
  - 1.3 °C for Category 2
  - 3.3°C Category 3

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# Modified ACSM Activity Guidelines

**Table 2**
Regional heat safety guidelines for low-risk acclimatized individuals based on American College of Sports Medicine guidelines. Values are wet-bulb globe temperatures (°C).

| Cat 3 | Cat 2 | Cat 1 | Activitiy guidelines |
|---|---|---|---|
| ≤10.0 | ≤8.7 | ≤6.7 | Normal activity |
| 10.1–18.3 | 8.8–17.0 | 6.8–15.0 | Normal activity |
| 18.4–22.2 | 17.1–20.9 | 15.1–18.9 | Normal activity |
| 22.3–25.6 | 21.0–24.3 | 19.0–22.3 | Normal activity, monitor fluids |
| 25.7–27.8 | 24.4–26.5 | 22.4–24.5 | Normal activity, monitor fluids |
| 27.9–30.0 | 26.6–28.7 | 24.6–26.7 | Plan intense or prolonged exercise with discretion |
| 30.1–32.2 | 28.8–30.9 | 26.8–28.9 | Limit intense exercise and total daily exposure to heat and humidity |
| >32.3 | >31.0 | >29.0 | Cancel exercise |

# WEATHER TRACKING, MONITORING, AND FORECASTING

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# Alert System

- When the environmental condition is forecasted/ recorded to exceed the average value by certain standard deviation
- Consecutive days of heat stress
  - Cumulative heat stain
- Traveling and performing in geographically different region
  - Considerations for international events

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# Sharing Data

- On-site environmental data logger
  - Transmits data to tablets
  - Stores data
  - Real-time sharing of the data
  - Archiving
  - Confirmation for forecasts
- Weather News, Japan
  - Tablet App allows people to submit the weather condition
  - Creates integrative, real-time weather map
    - Subjective but informative data


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# Weather modifies our behavior…?

- Confounding factors
  - Social economic reason
  - Lack of infrastructure
  - Work expectations
  - "Warrior mentality"
- Use of weather forecasting as prevention
  - Institute guidelines to cause behavioral modification
  - Courage to "stop"
  - Develop alternative way to safely participate the activity

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