American Football and Exertional Heatstroke

What Have We Learned in the Last 50 years?

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Thank you

GREAT LAKES ATHLETIC TRAINERS ASSOCIATION

GLATA

District 4 - N.A.T.A.

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Funding Disclosure and Conflict of Interest

- 0 private companies have funded any of the studies discussed today
- The views in this presentation are my own and may not be the views of CMU or my colleagues.
- I hope to present unbiased information but participants must use discretion when using the information contained in this presentation

This Presentation will Answer the Following Questions

What can we do about it?

Learning Objectives

1. List reasons why American football players are prone to EHS including how the American football uniform contributes to uncompensable heat stress.

2. Justify situations where it may not be necessary to remove American football uniforms before initiating cold-water immersion or temperate-water immersion to treat EHS.

3. Explain why cooling vests should not be used to treat or prevent EHS in American football players.

4. Describe what happens, physiologically, to athletes that do not receive immediate treatment for EHS.

Review: Evidence-Based Medicine Hierarchy

Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence

Question	Step 1 (Level 1*)	Step 2 (Level 2*)	Step 3 (Level 3*)	Step 4 (Level 4*)	Step 5 (Level 5)
How common is the problem?	Local and current random sample surveys (or censuses)	Systematic review of surveys that allow matching to local circumstances**	Local non-random sample**	Case-series**	n/a
Is this diagnostic or monitoring test accurate? (Diagnosis)	Systematic review of cross sectional studies with consistently applied reference standard and blinding	Individual cross sectional studies with consistently applied reference standard and blinding	Non-consecutive studies, or studies without consistently applied reference standards**	Case-control studies, or "poor or non-independent reference standard**	Mechanism-based reasoning
What will happen if we do not add a therapy? (Prognosis)	Systematic review of inception cohort studies	Inception cohort studies	Cohort study or control arm of randomized trial*	Case-series or case-control studies, or poor quality prognostic cohort study**	n/a
Does this intervention help? (Treatment Benefits)	Systematic review of randomized trials or *n*-of-1 trials	Randomized trial or observational study with dramatic effect	Non-randomized controlled cohort/follow-up study**	Case-series, case-control studies, or historically controlled studies**	Mechanism-based reasoning
What are the COMMON harms? (Treatment Harms)	Systematic review of randomized trials, systematic review of nested case-control studies, *n*-of-1 trial with the patient you are raising the question about, or observational study with dramatic effect	Individual randomized trial or (exceptionally) observational study with dramatic effect	Non-randomized controlled cohort/follow-up study (post-marketing surveillance) provided there are sufficient numbers to rule out a common harm. (For long-term harms the duration of follow-up must be sufficient.)**	Case-series, case-control, or historically controlled studies**	Mechanism-based reasoning
What are the RARE harms? (Treatment Harms)	Systematic review of randomized trials or *n*-of-1 trial	Randomized trial or (exceptionally) observational study with dramatic effect			
Is this (early detection) test worthwhile? (Screening)	Systematic review of randomized trials	Randomized trial	Non -randomized controlled cohort/follow-up study**	Case-series, case-control, or historically controlled studies**	Mechanism-based reasoning

1 Strongest

2

3

4

5 Weakest

Review: PEDro Scale

PEDro SCALE			
Eligibility criteria were specified	No ❑	Yes ❑	Where:
Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	No ❑	Yes ❑	Where:
Allocation was concealed	No ❑	Yes ❑	Where:
The groups were similar at baseline regarding the most important prognostic indicators	No ❑	Yes ❑	Where:
There was blinding of all subjects	No ❑	Yes ❑	Where:
There was blinding of all therapists who administered the therapy	No ❑	Yes ❑	Where:
There was blinding of all assessors who measured at least one key outcome	No ❑	Yes ❑	Where:
Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	No ❑	Yes ❑	Where:
All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat"	No ❑	Yes ❑	Where:
The results of between-group statistical comparisons are reported for at least one key outcome	No ❑	Yes ❑	Where:
The study provides both point measures and measures of variability for at least one key outcome	No ❑	Yes ❑	Where:

Basics of PEDro:

- Used to grade RCTs*
- 11 criteria (only 10 scored)
- The higher the PEDro score, the better the study

Question #1: Is EHS a Concern for American Football Athletes?

EHI Epidemiology in American Football Athletes

Kerr Z, Casa D, Marshall S, Comstock R. Epidemiology of exertional heat illness among U.S. high school athletes. *Am J Prev Med*. 2013;44:8-14.

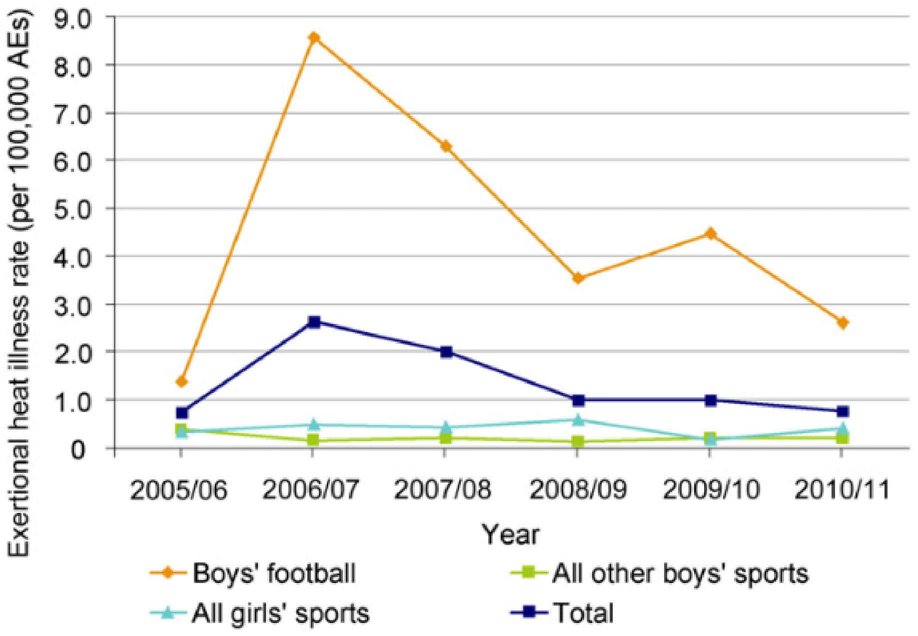


Figure 1. Rates of exertional heat illness among U.S. high school athletes, by year

Note: Data are from the High School Sports-Related Injury Surveillance System, U.S., 2005/2006–2010/2011. AE is defined as one athlete participating in one athletic practice or competition.

AE, athlete exposure

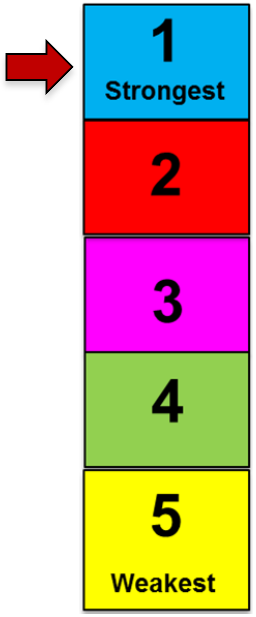
<u>Correspondence with Dr. Kerr (Feb 2017):</u>

American Football: 4.4 / 100,000 athlete exposures

All Other sports = 0.4 / 100,000 athlete-exposures

11x Higher Risk of EHI in Football!

EBM Tier



PEDro Score

N/A

EHS Epidemiology in American Football Athletes

Kucera KL, Klossner D, Colgate B, Cantu RC. Annual survey of football injury research: 1931-2015. 2016:1-36.

EHS Deaths: 1931-1978		EHS Deaths: 1979-1998		EHS Deaths: 1999-2015	
1931-1954[1]	0	1979	2	1999	2
1955	1	1980	1	2000	3
1956-1958	0	1981	2	2001	3
1959	4	1982	2	2002	0
1960-1964	16	1983	1	2003	0
1965	6	1984	3	2004	3
1966	1	1985	0	2005	3
1967	2	1986	0	2006	5
1968	5	1987	1	2007	2
1969	5	1988	2	2008	6
1970	8	1989	2	2009	4
1971	4	1990	1	2010	5
1972	7	1991	0	2011	6
1973	3	1992	1	2012	1
1974	1	1993	0	2013	0
1975	0	1994	0	2014	2
1976	1	1995	5	2015	2
1977	1	1996	2		
1978	4	1997	1		
		1998	4		
Total = 68		Total = 31		Total = 47	

50 Years

Total for Last 84 Years = 146 Last 50 Years = 119

EBM Tier

1 Strongest

2

3

4

5 Weakest

PEDro Score

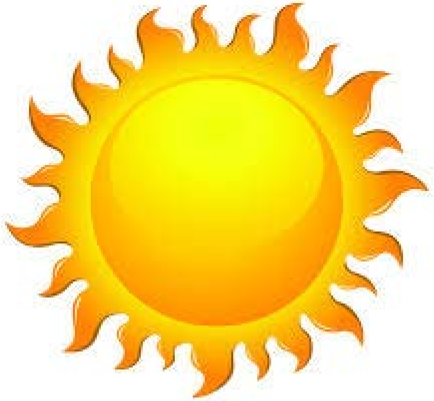
N/A

Question #2: Why are American Football Players at a Higher Risk of EHS than other Athletes?

Reasons for EHS in Football

1. Equipment
   - ⬇ Evaporative BSA
   - ⬆ Metabolism
2. Anthropometrics
3. Time of the Year
4. Environmental Conditions

7	very, very light
8	
9	very light
10	
11	fairly light
12	
13	somewhat hard
14	
15	hard
16	
17	very hard
18	
19	very, very hard
20	



Reasons for EHS: Equipment & BSA

McCullough E, Kenney W. Thermal insulation and evaporative resistance of football uniforms. *Med Sci Sports Exerc*. 2003;35:832-837.

TABLE 3. Evaporative resistance data for football uniform ensembles.

Ensemble Tested	Total Evaporative Resistance $R_{e,t}$ ($m^2 \cdot kPa \cdot W^{-1}$)	Evaporative Resistance of Clothing $R_{e,cl}$ ($m^2 \cdot kPa \cdot W^{-1}$)[a]	Moisture Permeability Index i_m (unitless)[b]	Evaporative Transmissibility i_m/I_t (clo)
G1: game uniform (warm weather)	0.032	0.022	0.37	0.29
G2: game uniform (temperate)	0.038	0.028	0.36	0.25
G3: game uniform (cold weather)	0.039	0.029	0.36	0.24
P1: practice uniform (with hip girdle)	0.030	0.020	0.38	0.31
P2: practice uniform (shorts only)	0.027	0.017	0.40	0.35
Reference ensemble (T-shirt and shorts)	0.020	0.009	0.42	0.47

[a] $R_{e,cl}$ was calculated with an $R_{e,a}$ value of 0.012 $m^2 \cdot kPa \cdot W^{-1}$ and the f_{cl} values shown in Table 2.
[b] i_m for the nude manikin was 0.47.

Evaporative Resistance Goes Up with PADS = Harder to Evaporate Sweat

Permeability Index Goes Down with PADS = Harder to Evaporate Sweat

EBM Tier

1 Strongest
2
3
4
5 Weakest

PEDro Score

N/A

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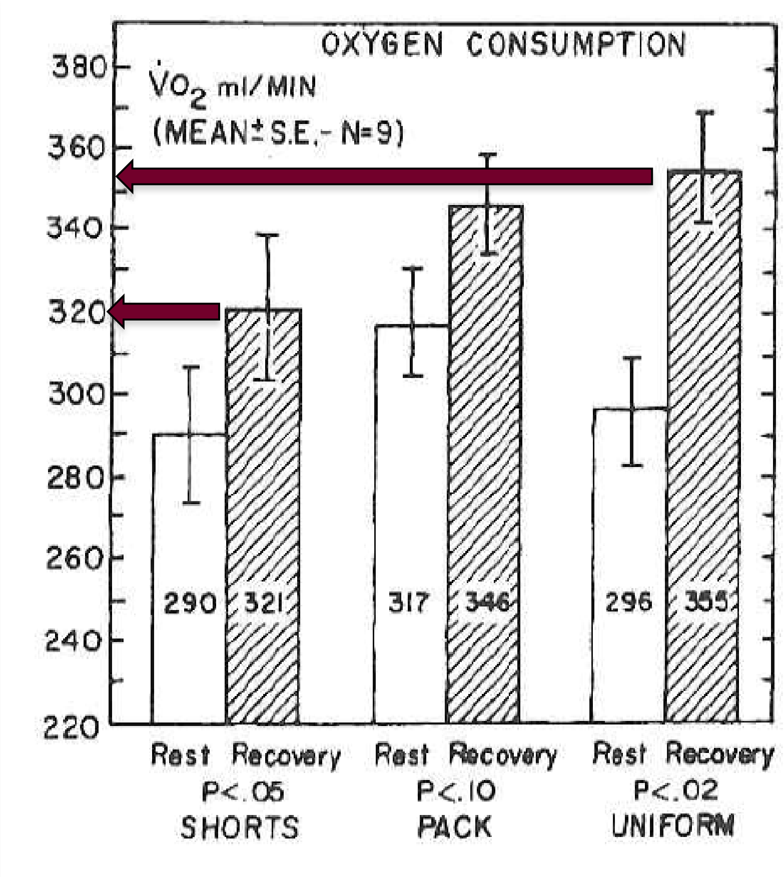
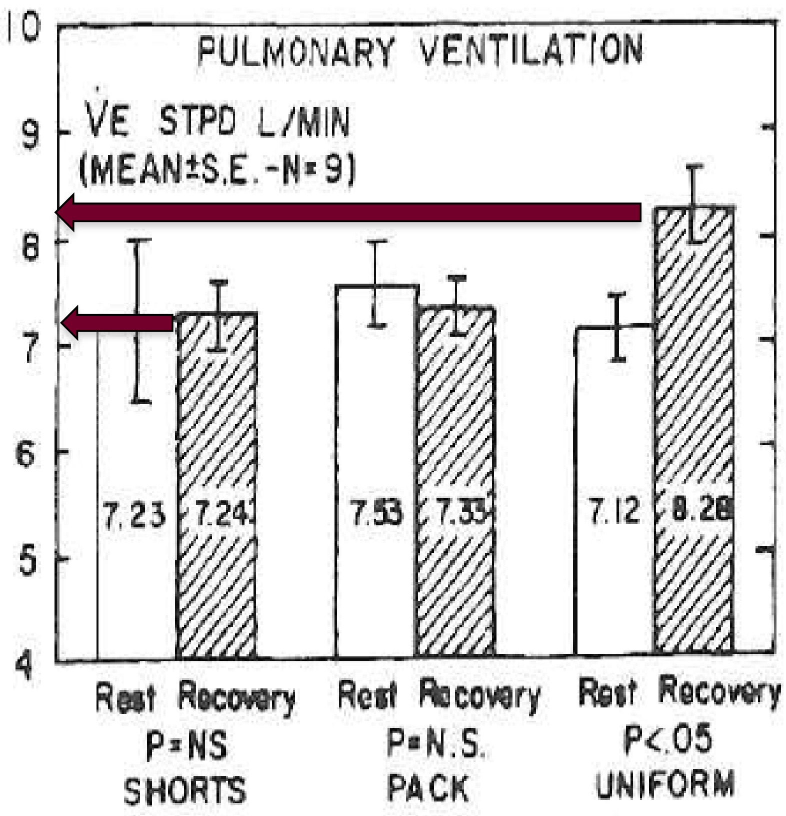
Reasons for EHS: Equipment & Metabolism

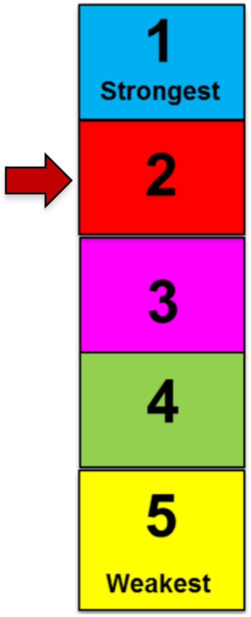
Mathews D, Fox E, Tanzi D. Physiological responses during exercise and recovery in a football uniform. *J Appl Physiol*. 1969;26:611-615.



Metabolism & Ventilation remain elevated during recovery!



EBM Tier



PEDro Score

6/10

Reasons for EHS: Anthropometrics

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: 11-20.

Table 2 Characteristics of football hyperthermia fatalities. Percent of High School (*HS*) linemen is rounded to the nearest percent and based on data in Laurson and Eisenmann (2007)

Age	*n*	Weight (kg)	*n*	BMI	All linemen *n*	Linemen ≤18 years *n* (%/%HS linemen)	Position	*n*	Clothing	*n*
11	1	<70	2	<20	1	1 (4/1)	Lineman	32	Full uniform	4[a]
12	0	70–<80	1	20–24	1	0 (0/28)	Backs	4	Practice uniform	8
13	4	80–<90	1	Overweight (25–29)	7	2 (9/41)	Other	1	Shorts only	8
14	4	90–<100	8	Obese Class I (30–34)	18	8 (35/21)	Unknown	21	Unknown	38
15	7	100–<110	5	Obese Class II (35–39)	9	8 (35/7)				
16	10	110–<120	7	Obese Class III (≥40)	6	4 (17/2)				
17	18	120–<130	10	Unknown		3				
18	4	130–<140	5							
19	1	140–<150	0							
20	1	150–<160	2							
21	2	160–<170	1							
22	1	Unknown	16							

[a] Only two deaths with the athlete in full uniform had corresponding data on time of death and were within 50 km of a meteorological observing station

- 60% of fatalities (known data) weighed >110 kg (242.5 lb)
- 79% were considered obese.

EBM Tier

1 Strongest
2
3
4
5 Weakest

PEDro Score

N/A

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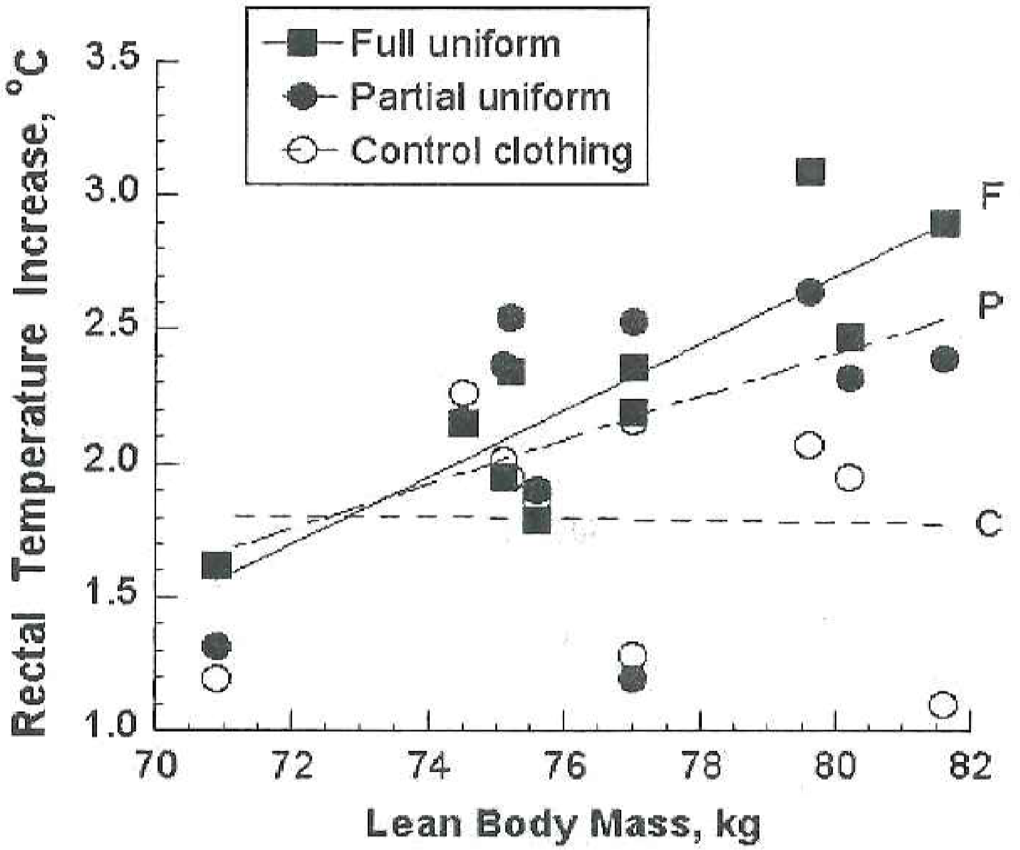
Reasons for EHS: Anthropometrics

Armstrong LE, Johnson EC, Casa DJ, et al. The American football uniform: uncompensable heat stress and hyperthermic exhaustion. *J Athl Train*. 2010;45:117-127.



T_{rec} increases faster as LBM increases and athletes wear PADS

EBM Tier

1 Strongest

2

3

4

5 Weakest

PEDro Score

6/10

Reasons for EHS: Time of Year

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: 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		

LDT Local daylight time

- 58% of deaths (known data) happen at <u>Morning</u> Practice!
- 86% of deaths (known data) happen in first 2 practices!
- 64% of deaths happen in August

EBM Tier

1 Strongest

2

3

4

5 Weakest

PEDro Score

N/A

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Reasons for EHS: Time of Year

Cooper E, Ferrara M, Broglio S. Exertional heat illness and environmental conditions during a single football season in the Southeast. *J Athl Train*. 2006;41:332-336.

Table 5. August Exertional Heat Injuries

Date	Cramps	Exhaustion	Syncope	Total Exertional Heat Illnesses	Exposures	Incidence Rate/ 1000 Athlete-Exposures
Week 1	37	7	5	49	3205	15.29
Week 2	27	8	0	35	4514	7.75
Week 3	18	11	3	32	3634	8.81
Week 4	4	2	0	6	2272	2.64
Total	86	28	8	122	13 625	8.95
Incidence rate/1000 athlete-exposures	6.31	2.06	0.58			
Percentage	70	23	7	100		

EBM Tier

1 Strongest

2

3

4

5 Weakest

PEDro Score

N/A

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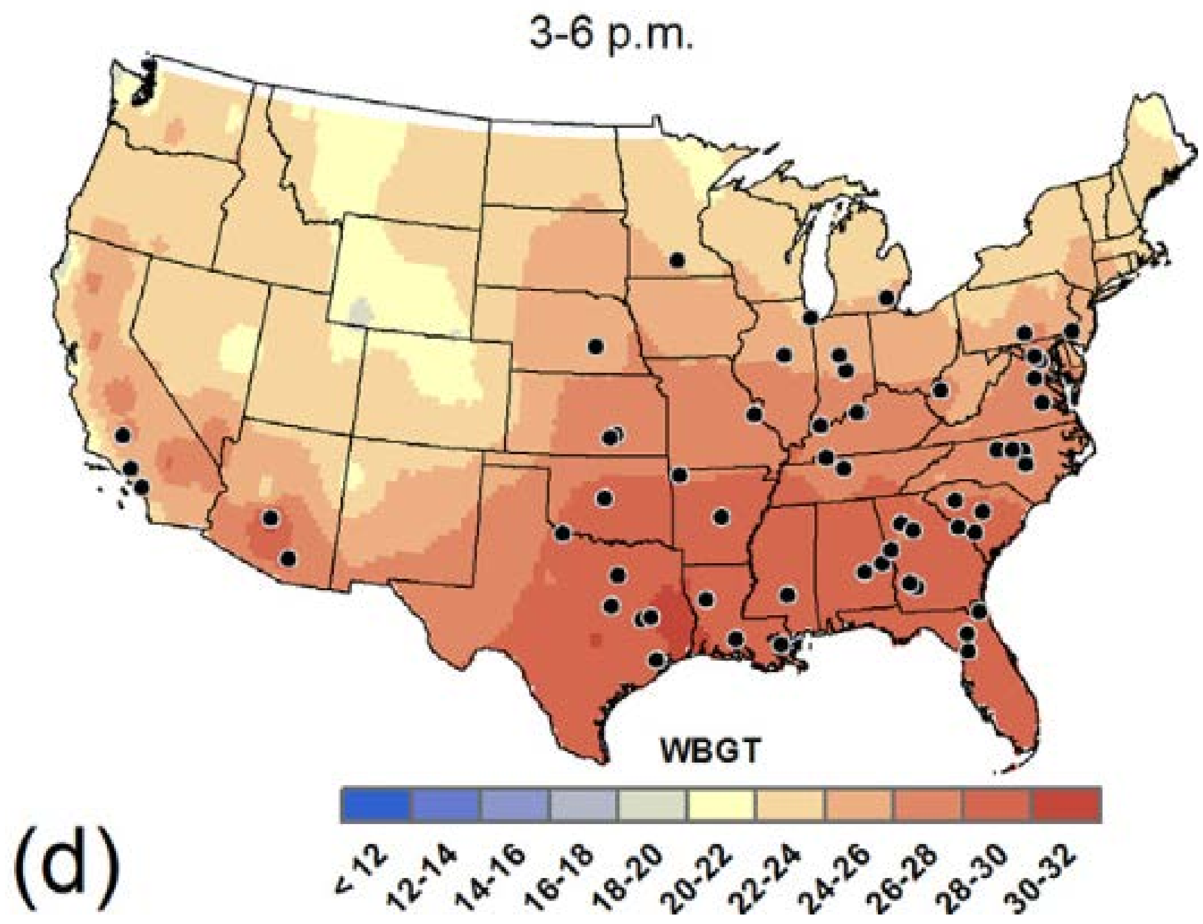
Reasons for EHS: Environmental Conditions

Grundstein AJ, Cooper E, Ferrara M, Knox JA. The geography of extreme heat hazards for American football players. *Appl Geogr.* 2014; 46: 53-60.



80% of deaths occurred in locations with WBGT >26° C (79° F)

EBM Tier

1 Strongest
2
3
4
5 Weakest

PEDro Score

N/A

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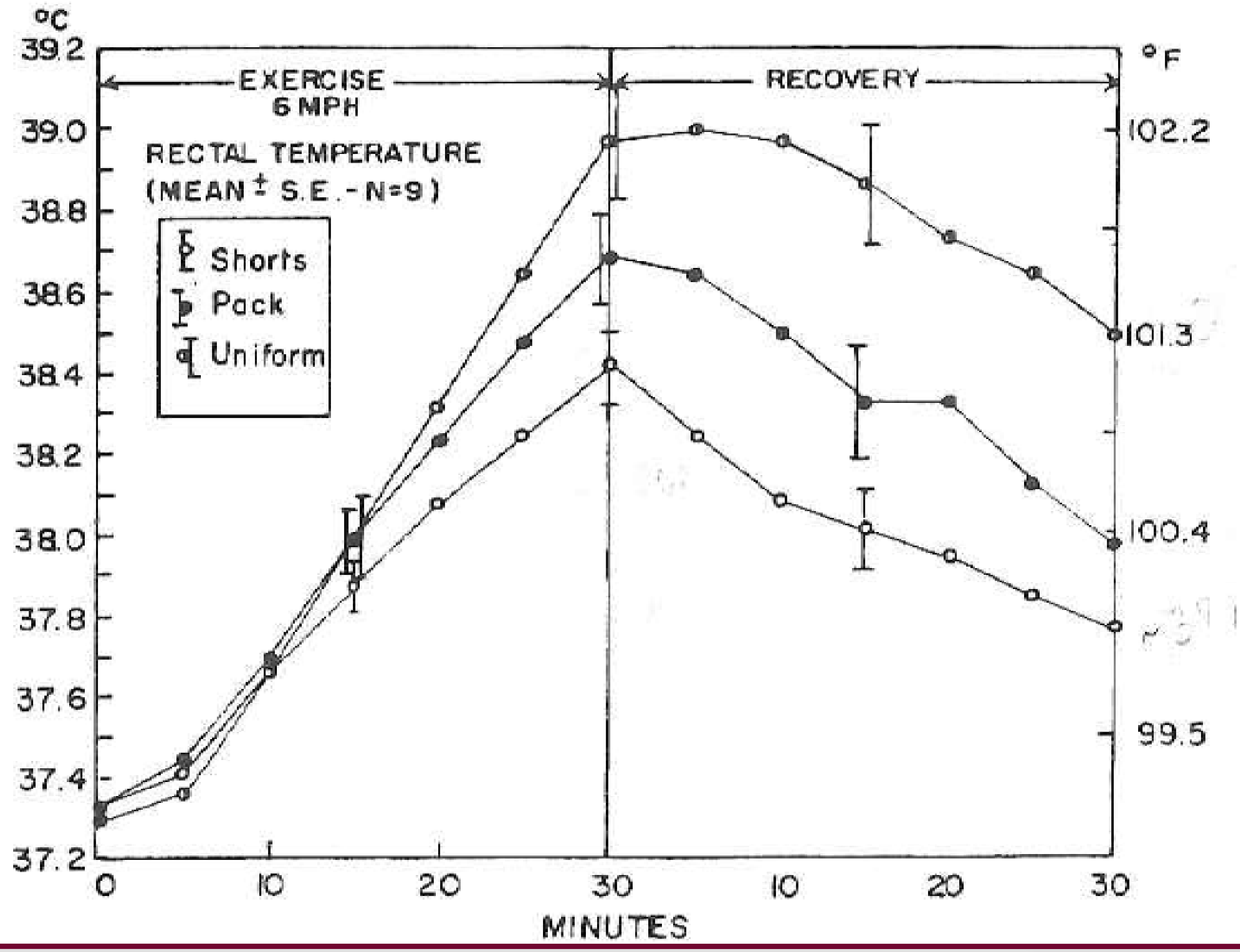
Overall…

Mathews D, Fox E, Tanzi D. Physiological responses during exercise and recovery in a football uniform. *J Appl Physiol*. 1969;26:611-615.



T_{rec} higher when full uniforms worn during exercise

EBM Tier

1 Strongest

2

3

4

5 Weakest

PEDro Score

6/10

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Overall…

Armstrong LE, Johnson EC, Casa DJ, et al. The American football uniform: uncompensable heat stress and hyperthermic exhaustion. *J Athl Train*. 2010;45:117-127.

Table 4. Rate of Rectal Temperature Increase During Treadmill Exercise (Mean ± SD), N = 10

Experimental Condition	Rate of Rectal Temperature Rise, °C/min
Control clothing	0.037 ± 0.015
Partial uniform	0.052 ± 0.012
Full uniform	0.071 ± 0.032[a]

[a] Indicates greater than control clothing and partial uniform conditions (*P* < .001).

T_{rec} increases ~0.25° C/min faster when full football uniforms are worn

EBM Tier

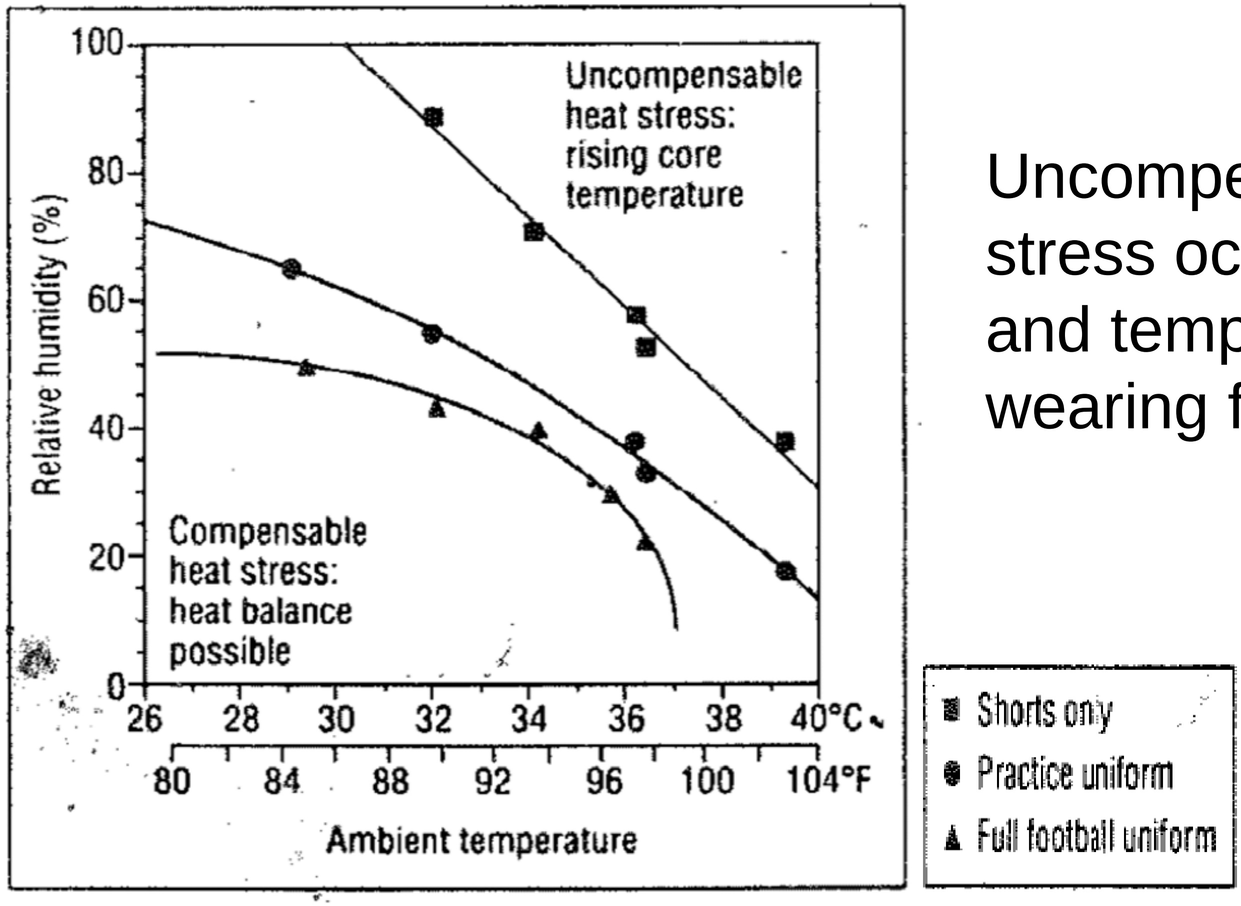
1 Strongest
2
3
4
5 Weakest

PEDro Score

6/10

Overall…

Kulka T, Kenney W. Heat balance limits in football uniforms: how different uniform ensembles alter the equation. *Physician Sportsmed*. 2002;30:29-39.



Uncompensable heat stress occurs at lower rH and temperatures when wearing full PADS

EBM Tier

1 Strongest

2

3

4

5 Weakest

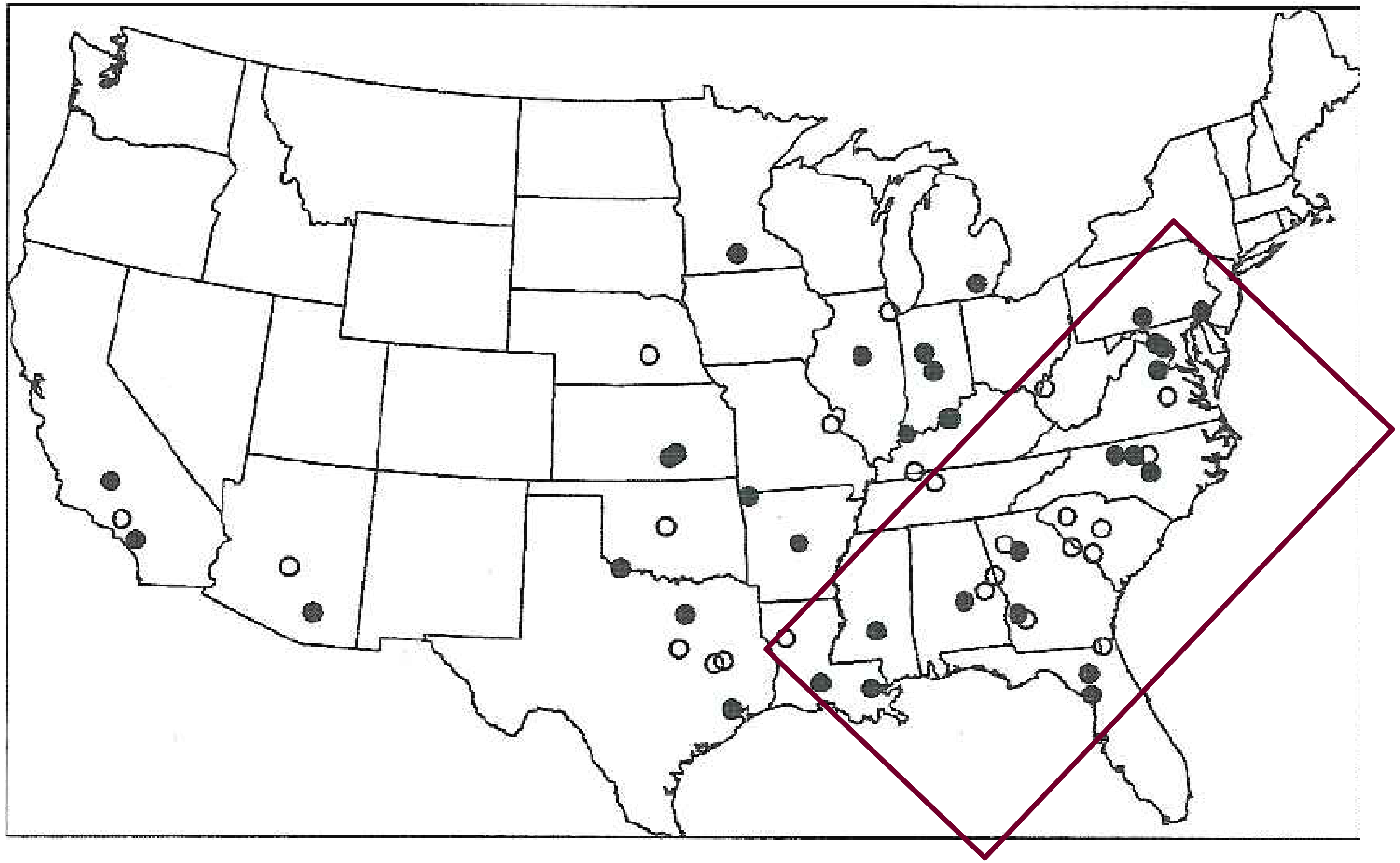
PEDro Score

6/10

Question #3: Which, When, and Where are American football Players at the highest risk of EHS?

Where are American Football Players Dying?

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: 11-20.



Of the 58 deaths between 1980-2009:

- 5 (9%) were in California/Arizona
- 0 in New England
- 30 (52%) in Eastern US

EBM Tier

1 Strongest
2
3
4
5 Weakest

PEDro Score

N/A

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Question #4: Do American football uniforms or anthropometrics impact EHS treatment?

Football Equipment's Effect on Body Core Temperature Cooling

We Did 3 Different Studies on PADS Effect on Cooling

1. Miller KC, Swartz EE, Long BC. Cold-water immersion for hyperthermic humans wearing football uniforms. *J Athl Train.* 2015;50:792-799.

2. Miller KC, Long BC, Edwards JE. Necessity of removing American football uniforms from hyperthermic humans before cold-water immersion. *J Athl Train.* 2015;50:1240-1246.

3. Miller KC, Truxton TT, Long BC. Temperate water immersion as a treatment for hyperthermic humans wearing American football uniforms. *J Athl Train*. 2016: In press.

EBM Tier

1 Strongest

2

3

4

5 Weakest

PEDro Score

5/10

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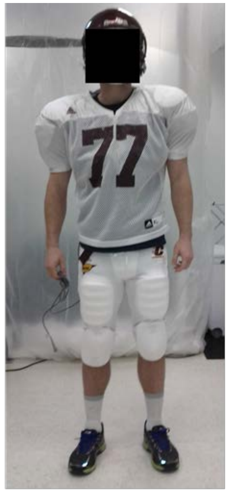
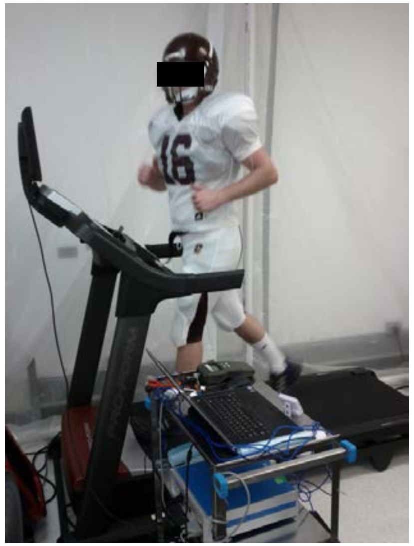
General Methods for the 3 Studies

Start



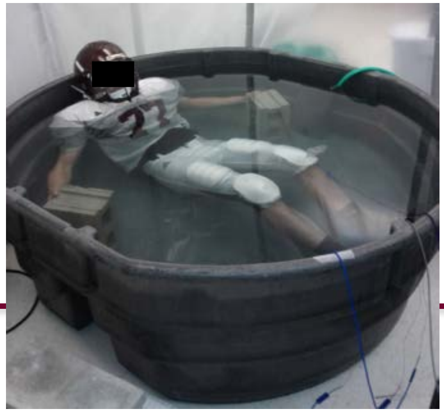
Full Uniform



Exercise in PADS in the heat until T_{rec} = 39.5° C

Remove PADS or Not

Wear PADS or shorts during CWI or TWI (10° -20° C) until $T_{rec} \leq$ 38° C



Results from 3 PADS Studies

Research Study	T_{rec} Cooling Rate	
	PADS	NO Pads (Control)
• Miller et al, 2015 (Cold-water immersion for…)	•0.28 ± 0.12° C/min	•0.23 ± 0.11° C/min
• Miller et al, 2015 (Necessity of removing…)	•0.21 ± 0.11° C/min	•0.28 ± 0.14° C/min
• Miller et al, 2016 (Temperate water immersion…)	•0.13 ± 0.05° C/min	•0.12 ± 0.05° C/min

Average Cooling Rate for PADS in Cold Water =

0.22° C/min!

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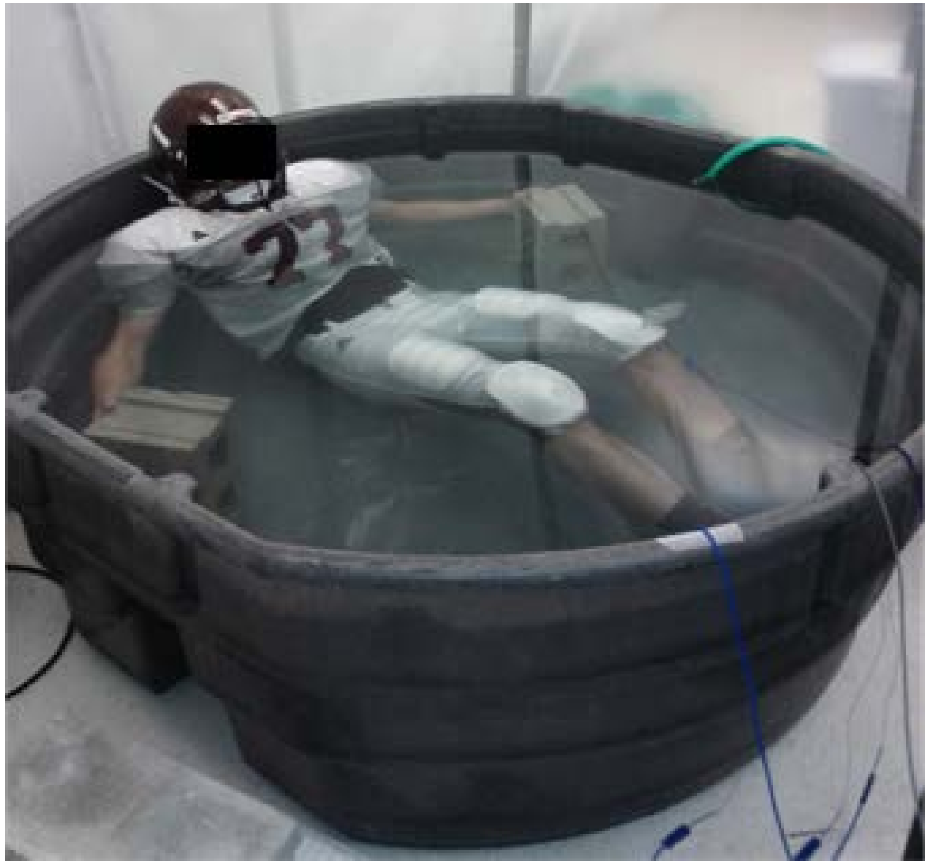
Why is CWI Effective with Equipment On?

1. A lot of BSA is still being treated
2. PADS do not interfere with water access to the body (i.e., conductive cooling still occurs)
3. PADS do not interfere much with convective cooling
4. Less shivering with PADS on



So What?

1. PADS should be removed before CWI when:
   – individuals knowledgeable in equipment removal are present,
   – removal tools (e.g., scissors) are immediately available,
   – PADS can be easily removed,
   – PADS interfere with the ability to fully immerse the athlete.
2. If CWI has been delayed or the above are not met, immerse the football athlete with PADS on.
3. Cool first, transport second.

NATA Position Statement (c. 2015)

Journal of Athletic Training 2015;50(9):986–1000
doi: 10.4085/1062-6050-50.9.07

www.natajournals.org

position statement

National Athletic Trainers' Association Position Statement: Exertional Heat Illnesses

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*University of Connecticut, Storrs; †Sacred Heart University, Fairfield, CT; ‡Youth Sports of the Americas, Birmingham, AL; §Ewing High School, NJ; ||University of Oklahoma Health Sciences Center, Oklahoma City; ¶University of South Florida, Tampa; #University of New Hampshire, Durham; **Central Michigan University, Mount Pleasant; ††Uniformed Services University, Bethesda, MD; ‡‡Georgia Institute of Technology, Atlanta; §§University of South Carolina, Columbia

Objective: To present best-practice recommendations for the prevention, recognition, and treatment of exertional heat illnesses (EHIs) and to describe the relevant physiology of thermoregulation.

Background: Certified athletic trainers recognize and treat athletes with EHIs, often in high-risk environments. Although the proper recognition and successful treatment strategies are well documented, EHIs continue to plague athletes, and exertional heat stroke remains one of the leading causes of sudden death during sport. The recommendations presented in this document provide athletic trainers and allied health providers with an integrated scientific and clinically applicable approach to the prevention, recognition, treatment of, and return-to-activity guidelines for EHIs. These recommendations are given so that proper recognition and treatment can be accomplished in order to maximize the safety and performance of athletes.

Recommendations: Athletic trainers and other allied health care professionals should use these recommendations to establish onsite emergency action plans for their venues and athletes. The primary goal of athlete safety is addressed through the appropriate prevention strategies, proper recognition tactics, and effective treatment plans for EHIs. Athletic trainers and other allied health care professionals must be properly educated and prepared to respond in an expedient manner to alleviate symptoms and minimize the morbidity and mortality associated with these illnesses.

Key Words: heat cramps, heat syncope, heat exhaustion, heat injury, heat stroke, dehydration

The prevention, recognition, and treatment of exertional heat illnesses (EHIs) are core components of sports medicine services at all levels of sport. The risk of EHI is ever present during exercise in the heat but can also occur in "normal" environmental conditions. Our current knowledge base has allowed us to greatly enhance the level of care that can be provided for athletes with these medical conditions. This document serves as the current position statement for the National Athletic Trainers' Association (NATA) and replaces the document that was published in 2002.[1]

The care of exertional heat-stroke (EHS) patients has come a long way in the past millennia. We now possess the knowledge to nearly assure survival from this potentially fatal injury if EHS is quickly and appropriately recognized and treated at the time of collapse.[2,3] Additionally, our knowledge base and proven management protocols allow us to establish effective prevention and management strategies to minimize the risk of and improve the outcome

37. When EHS is suspected, the patient's body (trunk and extremities) should be quickly immersed in a pool or tub of cold water. Removing excess clothing and equipment will enhance cooling by maximizing the surface area of the skin. However, because removing excess clothing and equipment can be time consuming, CWI should begin immediately and equipment should be removed while the patient is in the tub (or while temperature is being assessed or the tub is being prepared).[59] Rectal temperature and other vital signs should be monitored during cooling every 5 to 10 minutes if a continuous monitoring device is not available.[20,60] *Strength of recommendation: B*

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Anthropometrics on Body Core Temperature Cooling

Lemire BB, Gagnon D, Jay O, Dorman L, Ducharme MB, Kenny GP. Influence of adiposity on cooling efficiency in hyperthermic individuals. *Eur J Appl Physiol*. 2008;104:67-74.

Body Fat Doesn't Impact Cooling Rates

(13% BF vs. 22% BF)

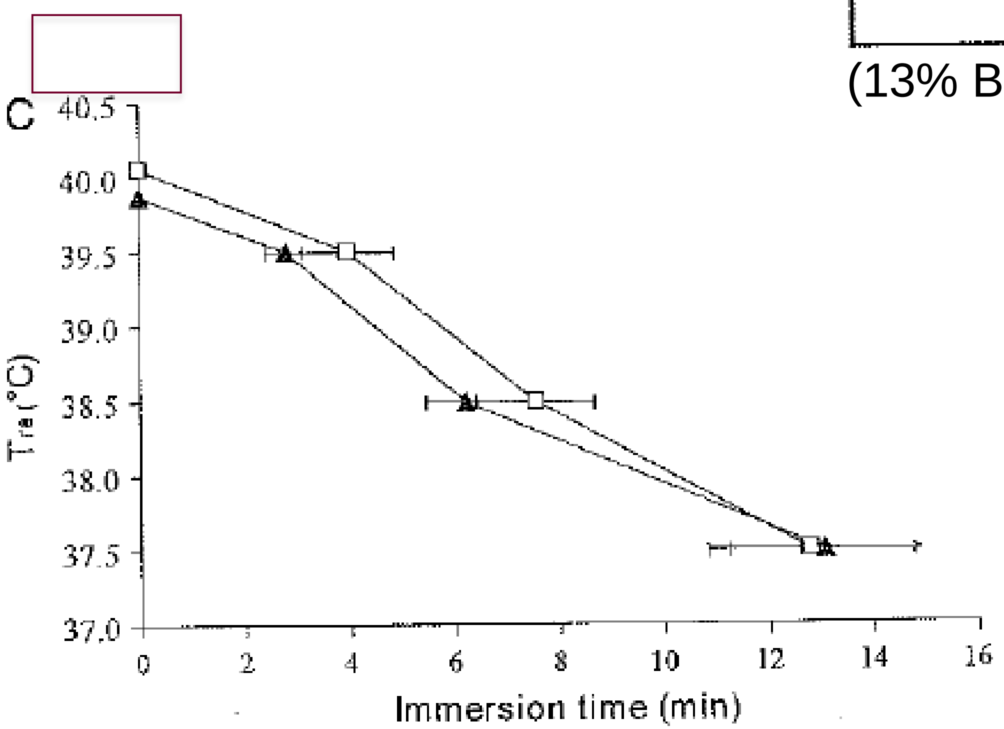


Fig. 2 Time to reach 39.5, 38.5 and 37.5°C for esophageal (T_{es}, **a**), aural canal (T_{ac}, **b**) and rectal (T_{re}, **c**) temperatures for the low fat (*open square*) and high fat (*filled triangle*) group. Values are mean ± SE

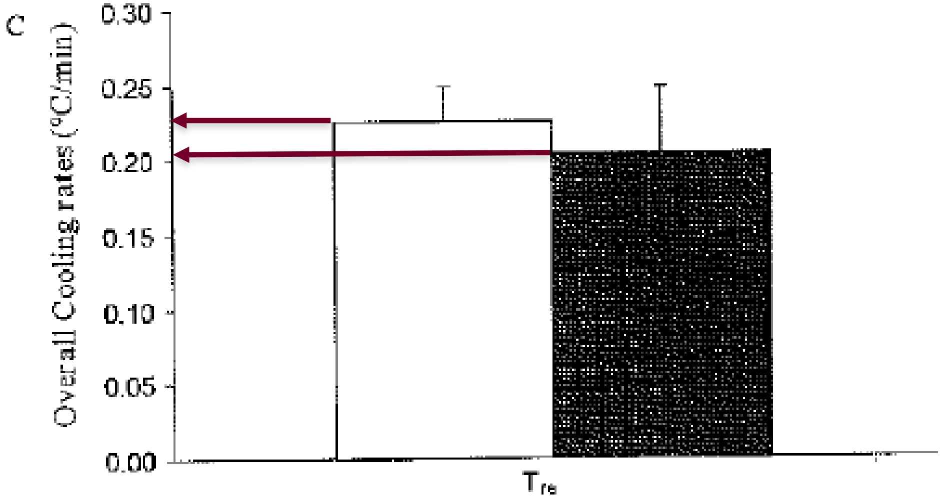


Fig. 3 Overall cooling rates for esophageal (T_{es}, **a**), aural canal (T_{ac}, **b**) and rectal (T_{re}, **c**) temperatures for the low fat (*open square*) and high fat (*filled square*) group. Values are mean ± SE

EBM Tier

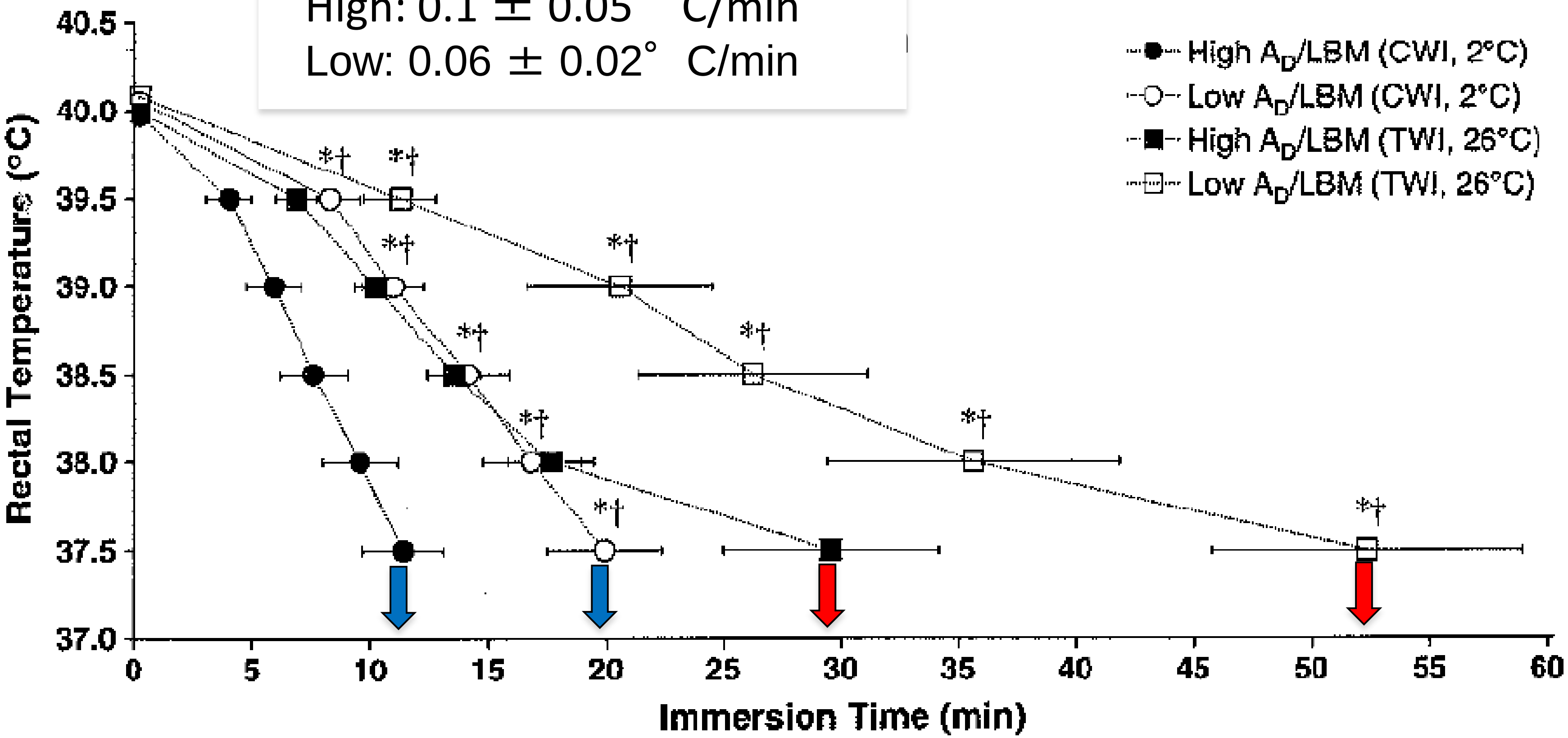
1 Strongest
2
3
4
5 Weakest

PEDro Score

4/10

Friesen BJ, Carter MR, Poirier MP, Kenny GP. Water immersion in the treatment of exertional hyperthermia: Physical determinants. *Med Sci Sports Exerc*. 2014;46:1727-1735.

TWI:
High: 0.1 ± 0.05° C/min
Low: 0.06 ± 0.02° C/min



Δ = ~8 min in CWI

Δ = ~22 min in TWI

EBM Tier

1 Strongest
2
3
4
5 Weakest

PEDro Score

4/10

Question #5: What Happens, Physiologically, to American football Players if They Become Severely Hyperthermic but Treatment is Delayed?

Treatment of EHS

- The 2 MOST important factors influencing the prognosis of EHS are:

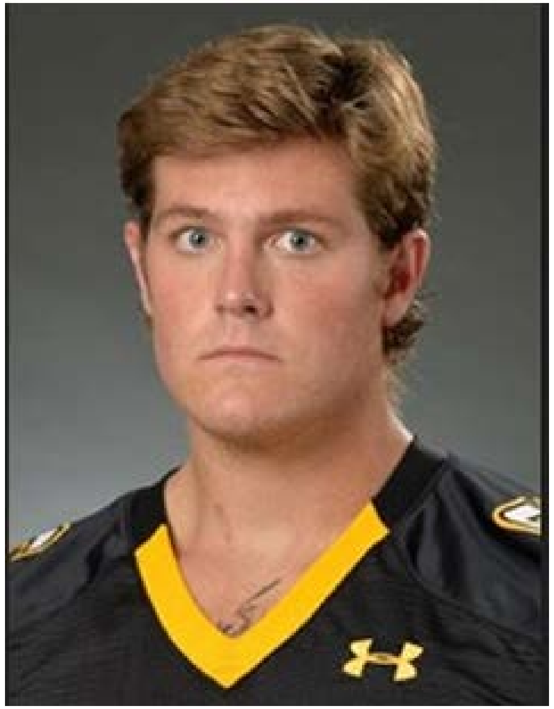
1. Degree of Hyperthermia

Most important

2. **Length of Time the Individual is Hyperthermic**

Case Study: Gavin Class

- Water immersion within 5 min of symptoms (Awesome!)
- EMS called (Great so far!)
- No T_{rec} taken (uh oh…)
- EMS take Gavin out of the tub after 5 min (double uh oh…)
- 30 min later at hospital. T_{rec} = 108° F (42.2° C) (this is not going to end well…)



Gavin Class (Towson)

EBM Tier

1 Strongest

2

3

4

5 Weakest

PEDro Score

N/A

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Outcome of the Gavin Class Case

- Emergency liver transplant
- Almost dies

Gavin Class files lawsuit, seeks to rejoin Towson football team

PHOTO GALLERY

Photos of Gavin Class, a Towson offensive lineman who almost died from heat stroke suffered at a preseason practice last year. These days, he's trying to get back in shape and hopes to eventually return to the football field.

By Mike Klingaman · Contact Reporter
The Baltimore Sun

August 2013 = EHS
August 2015 = suing to play football

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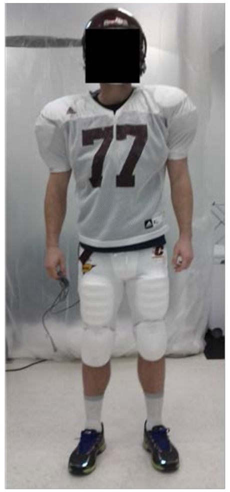
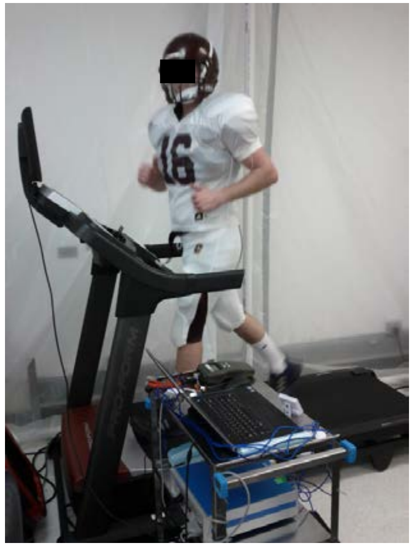
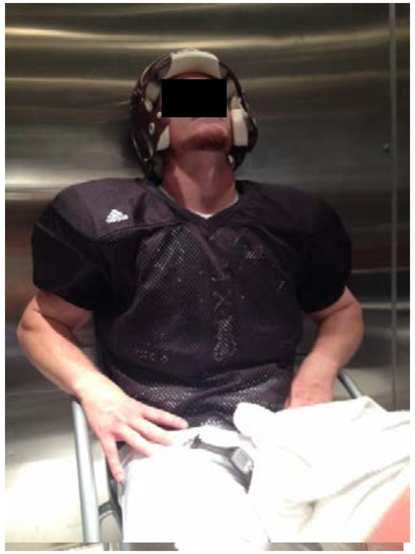
Miller KC, Katt GE, DiMango TA. Cooling rates of hyperthermic humans wearing American football uniforms when treatment is delayed. *Manuscript in process*.



Full Uniform

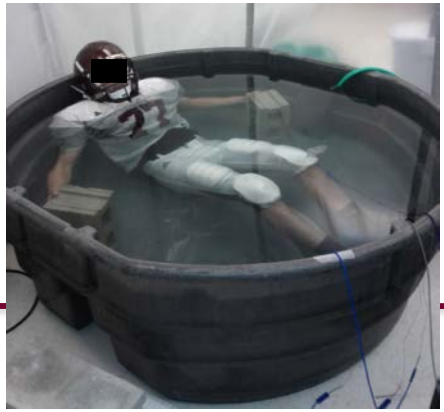


Exercise in PADS in the heat till T_{rec} = 39.75° C



Sit for 5 mins or 30 mins with PADS on

Wear PADS during CWI (10.5° C) until T_{rec} =37.75° C



EBM Tier

1 Strongest

2

3

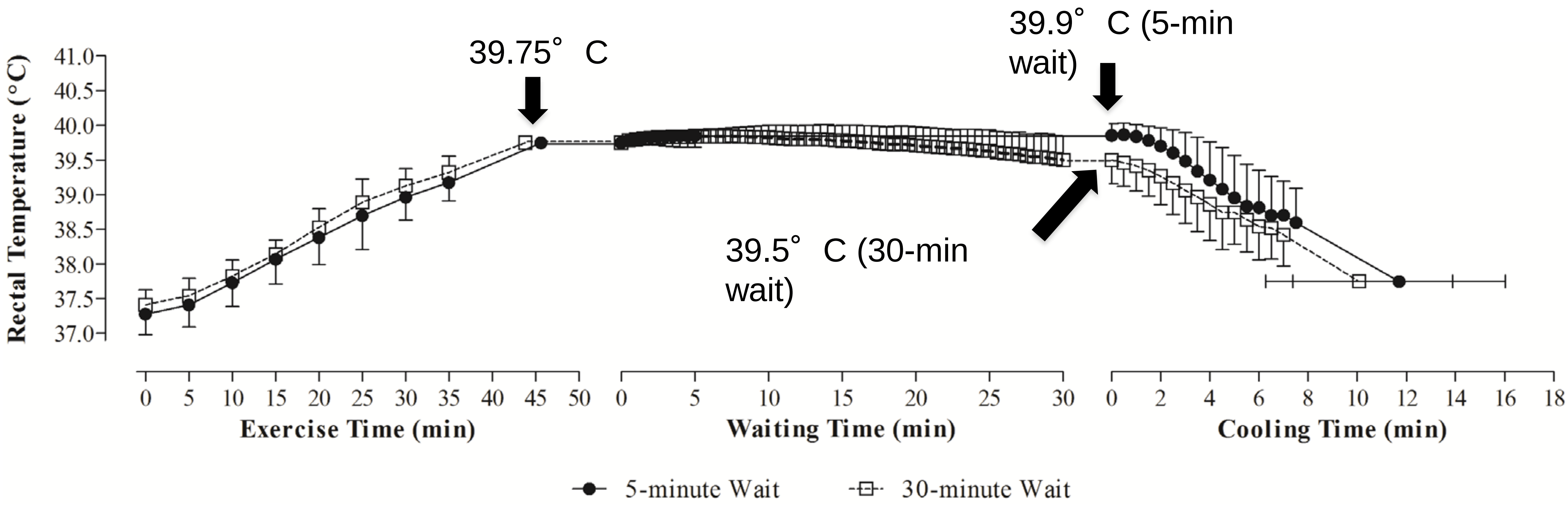
4

5 Weakest

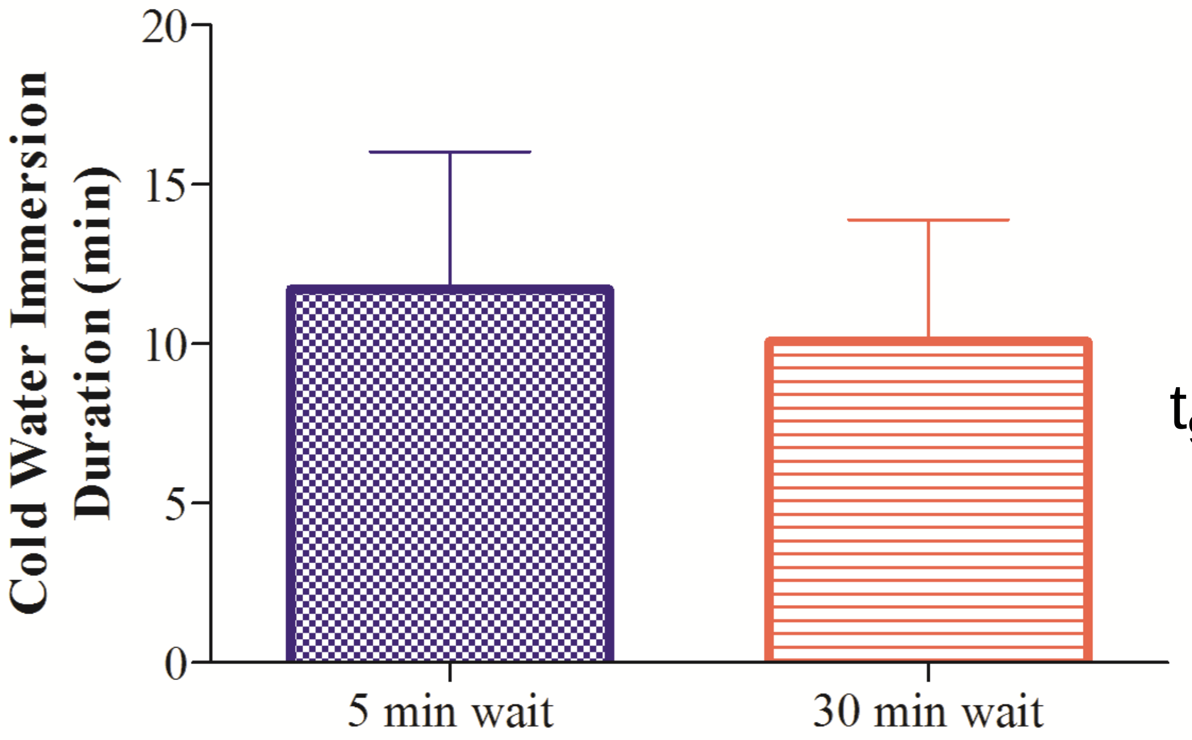
PEDro Score

6/10

Miller KC, Katt GE, DiMango TA. Cooling rates of hyperthermic humans wearing American football uniforms when treatment is delayed. *Manuscript in process*.



Miller KC, Katt GE, DiMango TA. Cooling rates of hyperthermic humans wearing American football uniforms when treatment is delayed. *Manuscript in process*.



t_9=1.5, P=0.16

5-min wait cooling rate = 0.20 ± 0.07° C/min

30-min wait cooling rate = 0.19 ± 0.05° C/min

t_9=0.9, P=0.4

Miller KC, Katt GE, DiMango TA. Cooling rates of hyperthermic humans wearing American football uniforms when treatment is delayed. Manuscript in process.

Table 3. Environmental Symptoms Questionnaire (ESQ) Responses Before and After a Delay in Cold-water Immersion.

	5-min Wait			30-min Wait		
	Pre-Exercise	Post-Wait	Post-CWI	Pre-Exercise	Post-Wait	Post-CWI
Total	2 ± 2 [a]	27 ± 15 [b,c]	7 ± 6	2 ± 1 [d]	16 ± 12 [e]	5 ± 4

Data are means ± SD (n=10). The ESQ is rated on a 5-point Likert scale with scores ranging from 0 (not at all) to 5 (extreme). CWI = cold-water immersion. ESQ scores at each time point were summed to create a total symptom score which was then statistically analyzed. [a] = 5-min pre-exercise < 5-min post-wait; [b] = 5-min post-wait > 5-min post-CWI; [c] = 5-min post-wait > 30-min post-wait; [d] = 30-min pre-exercise < 30-min post-wait; [e] = 30-min post-wait > 30-min post-CWI. All suprascripted numerals indicate P<0.05.

Feel better after a 30-minute wait…but their T_{rec} were still near EHS temperatures!

So What?

1. If CWI has been delayed, immerse the football athlete with PADS on.

2. Don’t rely on patient perceptions of how hot they feel or the number of symptoms they present—especially if there’s been a delay in treatment! Use T_{rec} to diagnose EHS!

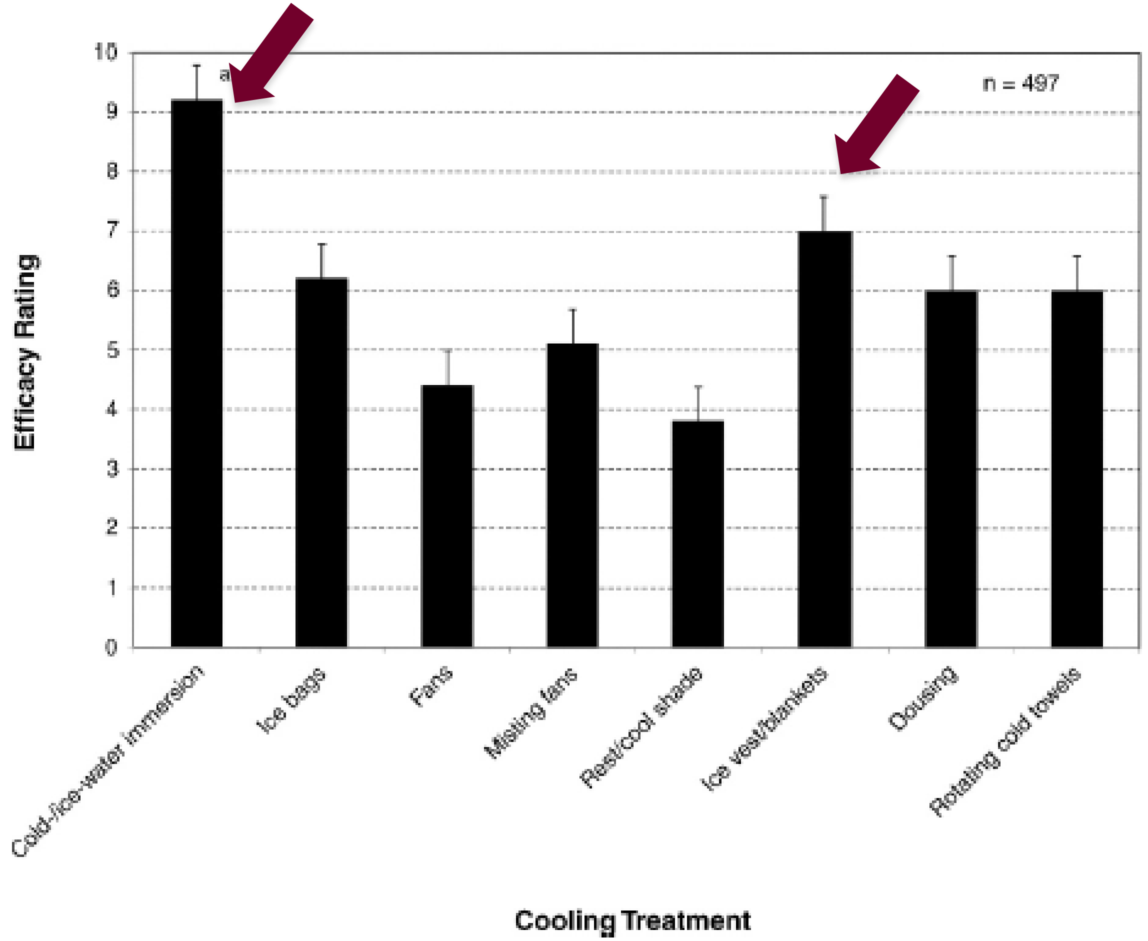
Question #6: Can Cooling Vests Be Used to Treat EHS in American Football Players?

Mazerolle S, Scruggs I, Casa D, et al. Current knowledge, attitudes, and practices of certified Athletic Trainers regarding recognition and treatment of exertional heat stroke. *J Athl Train*. 2010;2:170-180.

ATs perceived effectiveness of cooling methods for EHS

#1 = Cold-water Immersion

#2 = Ice vests/blankets?????



EBM Tier

1 Strongest

2

3

4

5 Weakest

PEDro Score

3/10

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So We Did a CAT

PIO Question = Are T_{Core} cooling rates acceptable (i.e., >0.08° C·min^{-1}) when hyperthermic humans are treated with cooling vests post-exercise?

Research studies in English (2005-2015) Examining Cooling Vests to Treat Hyperthermia (Core Temp >38° C)
n = 12

Studies excluded for not having PEDro score >5, Oxford EBP Category Level 2 or higher, or core temp did not exceed 38° C
n = 8

Studies Included in CAT
n = 4

EBM Tier

1 Strongest
2
3
4
5 Weakest

PEDro Score

n/a

CAT Articles

Keen ML, Miller KC. Should cooling vests be used to treat exertional heatstroke?: A critically-appraised topic. *J Sport Rehabil*. 2015; In press.

Table 1. Summary of study designs of articles retrieved

Author	Study Design	Level of evidence	PEDro Score
Brade et al.[2]	Randomized Controlled Trial	2	6 of 10
DeMartini et al.[4]	Randomized Controlled Trial	2	5 of 10
Holster et al.[3]	Randomized Controlled Trial	2	6 of 10
Lopez et al.[1]	Randomized Controlled Trial	2	6 of 10

Keen ML, Miller KC. Should cooling vests be used to treat exertional heatstroke?: A critically-appraised topic. *J Sport Rehabil*. 2015; In press.

Table 2. Characteristics of included studies

Authors	Patients, n	Experimental Design & Methods	Cooling Intervention	Results	Conclusions
Brade et al.[2]	12 males (age=21.3±1.1 y, ht=182.7±7.1 cm, mass=76.2±9.5 kg, BSA=1.98±0.14 m^2)	-Cross-over study. -Cycled on a bicycle ergometer at 75% VO_2max in heat for 30 min (35°C±1.4°C, 52%±4% humidity). -Wore one of two vests or no vest for 30 min in a comfortable room (24.9±1.8°C, 39±10%)	(1) dry PC17 vest with 4 anterior and posterior pockets; (2) a gel vest (4 anterior and posterior pockets); or (3) no vest	PC17 vest T_C pre-cooling = 38.44±0.42°C Gel vest T_C pre-cooling = 38.49±0.43°C No vest T_C pre-cooling = 38.5±0.4°C PC17 vest cooling rate = 0.038±0.007°C/min Gel vest cooling rate = 0.040±0.009°C/min No vest cooling rate = 0.034±0.010°C/min	-No significant differences between both cooling vests and no vest. -Both cooling vests did not meet the acceptable cooling rate for EHS victims. (i.e., >0.08 C/min)
DeMartini et al.[4]	9 males and 7 females (age=24±6 y, ht=182±7 cm, mass=74.03±9.17 kg, BSA[a] = ~1.9 m^2)	-Cross-over study. -Played soccer, ultimate frisbee and bree-ball outside (26.64±4.71°C) for 45-60 min. - Wore one of two vests or no vest for 10 min with or without shade.	(1) Game Ready Active vest with 14°C circulating water with shade; (2) Nike Ice Vest™ with 22 pouches with shade; or (3) no vest without shade.	T_C pre-cooling = 38.73±0.12°C (average all trials) Game Ready Active vest cooling rate = 0.043±0.025°C/min Nike Ice Vest™ cooling rate = 0.053±0.022°C/min No vest cooling rate = 0.042±0.015°C/min	-No significant differences between both cooling vests and no vest. -Both cooling vests did not meet the acceptable cooling rate for EHS victims. (i.e., >0.08°C/min)

Keen ML, Miller KC. Should cooling vests be used to treat exertional heatstroke?: A critically-appraised topic. *J Sport Rehabil*. 2015; In press.

Table 2. Characteristics of included studies, continued.

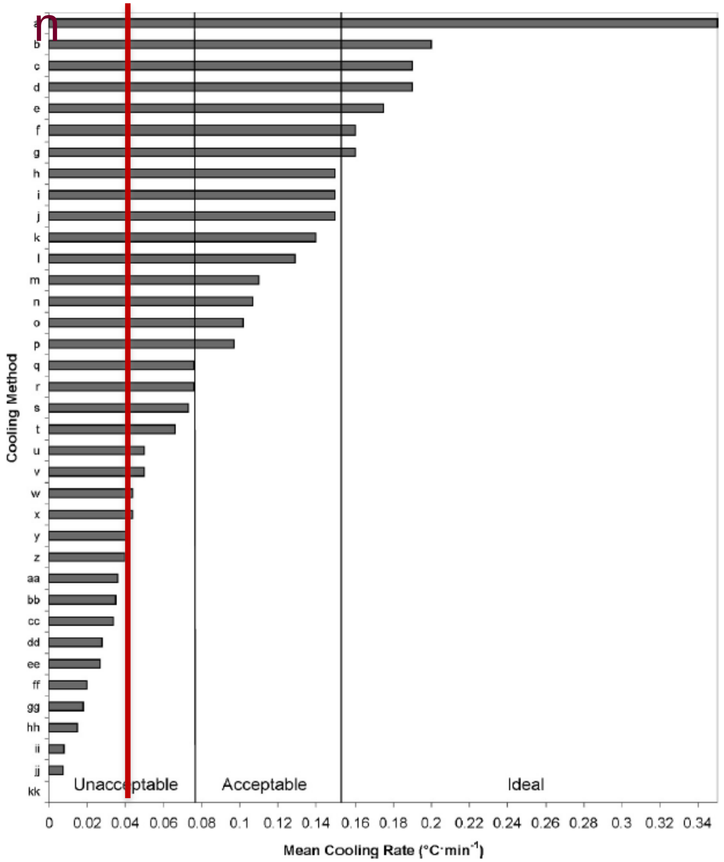
Authors	Patients, n	Experimental Design & Methods	Cooling Intervention	Results	Conclusions
Holster et al.[3]	14 males (age=31.1±7.6 y, ht=176.2±5.5 cm, mass=80.2±12.2 kg, BSA[a] = ~2.0 m²) and 4 females (age=25.5±5.2 y, ht=157.7±2.9 cm, mass=58.5±6.7 kg, BSA[a] = ~1.6 m²)	-Cross-over study. -Exercised on a treadmill for 50 min in the heat (35.1±2.7°C). -Wore vest or no vest for 20 min in a comfortable room (24.0°C±1.4°C)	(1) water-perfused cooling vest; or (2) no vest.	T_C pre-cooling = 38.25±1.0°C (average both trials) Vest cooling rate = 0.041±0.022°C/min No vest cooling rate = 0.047±0.031°C/min	-No significant differences between cooling vest and no vest. -Cooling vest did not meet the acceptable cooling rate for EHS victims (i.e., >0.08°C/min)
Lopez et al.[1]	10 males (age=25.6±1.6 y, mass=80.3±13.7 kg)[b]	-Cross-over study. -Ran on a treadmill for 67.0±10.6 min in the heat (33.3±3.1°C; humidity=55.1±8.9%) -Wore vest or no vest for 30 min in a comfortable room (26.6±2.2°C; 55.4±5.8% humidity).	(1) INDURA Heat Shield Vest (vest temp = 21.1°C); or (2) no vest	T_C pre-cooling = 38.8±0.3°C (average both trials) INDURA Heat Shield Vest cooling rate = 0.03±0.007°C/min No vest cooling rate = 0.028±0.0074°C/min	-No significant differences between INDURA Heat Shield Vest and no vest. -Cooling vest did not meet the acceptable cooling rate for EHS victims (i.e., >0.08°C/min)

ht = height, BSA = body surface area, T_C = core body temperature, VO_2max = maximum volume of oxygen consumed (ml/kg/min), PC17 = phase-change material cooling vest, EHS = exertional heatstroke. [a] = We calculated BSA with the original author's descriptive information using the following equation: $weight^{0.425} \cdot height^{0.725} \cdot 0.007184$. [b] = Height was not provided in article so BSA could not be calculated.

Average Cooling rate for all vests in CAT = **0.04° C/min**

McDermott B, Casa D, Ganio M, et al. Acute whole-body cooling for exercise-induced hyperthermia: A systematic review. *J Athl Train.* 2009;44:84-93.

0.04° C/mi n



Unacceptable cooling rates for EHS victims.

Cooling vests have similar cooling rates as:

1. Dousing with water while fanning (0.035° C/min)
1. Ice packs covering the body (0.034° C/min)
2. Ice packs at major arteries and dousing with fanning (0.036° C/min)
3. Fanning and compressed air (0.04° C/min)
4. Chilled IVs (0.05-0.1° C/min)

EBM Tier

1 Strongest

2

3

4

5 Weakest

PEDro Score

n/a

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Why are Cooling Vests Ineffective?

1. Don’t cover a lot of BSA
2. Require frequent changing of ice packs/water to optimize cooling
3. Rely <u>only</u> on conduction for cooling
4. Material between vest and skin
5. Need to remove PADS

What Does This Mean for EHS Victims?

- If T_{core} was 42° C and cooling vests were used, it would take **<u>100 minutes</u>** to reduce T_{core} to a safe level (i.e., 38° C)

- Goal is to reduce T_{core} within 30 minutes of collapse

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So What Can You Do Right Now?

2 Practical Steps

1. Ensure you have the necessary equipment ready and available (rectal thermometer, water tub)

2. Make EAP Region Specific for EHS

$950 for thermometer;
$72 for reusable probes

http://www.advindsys.com/Products/4600PrecisionThermistor.htm

$150-300

$275 for thermometer; $12 for disposable probes

http://rgmd.com/datatherm2.html

Current Georgia HS WBGT Guidelines

$$WBGT = 0.7*WB + 0.2*GT + 0.1*DB$$

WBGT (°C)	WBGT READING	ACTIVITY GUIDELINES & REST BREAK GUIDELINES
< 27.7	Under 82.0	Normal activities--Provide at least three separate rest breaks each hour of minimum duration of 3 minutes each during workout
27.7 – 30.5	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
30.5 – 32.2	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
32.2 – 33.3	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
>33.3	Over 92.1	No outdoor workouts; Cancel exercise; delay practices until a cooler WBGT reading occurs

One-size fits all?

Southern states would never play football!

Current ACSM Guidelines

Armstrong LE, Casa DJ, Millard-Stafford ML, Moran D, Pyne S, Roberts WO. American College of Sports Medicine position stand: Exertional heat illness during training and competition. *Med Sci Sports Exerc*. 2007;39:556-572.

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

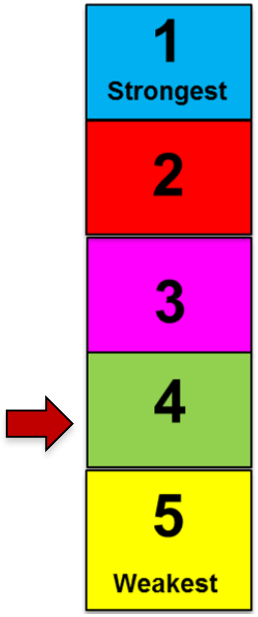
WBGT[b]			Training and Noncontinuous Activity	
°F	°C	Continuous Activity and Competition	Nonacclimatized, Unfit, High-Risk Individuals[c]	Acclimatized, Fit, Low-Risk Individuals[c,d]
≤50.0	≤10.0	Generally safe; EHS can occur associated with individual factors	Normal activity	Normal activity
50.1–65.0	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]

Why Regional vs. National WBGT Guidelines?

Grundstein A, Williams C, Phan M, Cooper E. Regional heat safety thresholds for athletics in the continuous United States. *Appl Geogr*. 2015;56:55-60.

Fig. 1. 90th percentile warm season maximum daily wet-bulb globe temperatures (°C).

EBM Tier



PEDro Score

N/A

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“Revised” ACSM WBGT Standards using Regional System

Grundstein A, Williams C, Phan M, Cooper E. Regional heat safety thresholds for athletics in the continuous United States. *Appl Geogr*. 2015;56:55-60.

Cat 1 (° C)	Current ACSM Standards (° C)	Activity Guideline
≤6.7	≤10.0	Normal Activity
6.8 – 15.0	10.1 – 18.3	Normal Activity
15.1 – 18.9	18.4 – 22.2	Normal Activity
19.0 – 22.3	22.3 – 25.6	Normal Activity. Monitor fluid intake
22.4 – 24.5	25.7 – 27.8	Normal Activity. Monitor fluid intake
24.6 – 26.7	27.9 – 30.0	Plan intense or prolonged exercise with discretion; watch at risk individuals closely.
26.8 – 28.9	30.1 – 32.2	Limit Intense exercise and total daily exposure to heat & humidity
≥29	≥32.3	Cancel exercise

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“Revised” ACSM WBGT Standards using Regional System

Grundstein A, Williams C, Phan M, Cooper E. Regional heat safety thresholds for athletics in the continuous United States. *Appl Geogr*. 2015;56:55-60.

Cat 2 (° C)	Current ACSM Standards (° C)	Activity Guideline
≤8.7	≤10.0	Normal Activity
8.8 – 17.0	10.1 – 18.3	Normal Activity
17.1 – 20.9	18.4 – 22.2	Normal Activity
21.0 – 24.3	22.3 – 25.6	Normal Activity. Monitor fluid intake
24.4 – 26.5	25.7 – 27.8	Normal Activity. Monitor fluid intake
26.6 – 28.7	27.9 – 30.0	Plan intense or prolonged exercise with discretion; watch at risk individuals closely.
28.8 – 30.9	30.1 – 32.2	Limit Intense exercise and total daily exposure to heat & humidity
≥31	≥32.3	Cancel exercise

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“Revised” ACSM WBGT Standards using Regional System

Grundstein A, Williams C, Phan M, Cooper E. Regional heat safety thresholds for athletics in the continuous United States. *Appl Geogr*. 2015;56:55-60.

Cat 3 (° C)	Current ACSM Standards (° C)	Activity Guideline
≤10.0	≤10.0	Normal Activity
10.1 – 18.3	10.1 – 18.3	Normal Activity
18.4 – 22.2	18.4 – 22.2	Normal Activity
22.3 – 25.6	22.3 – 25.6	Normal Activity. Monitor fluid intake
25.7 – 27.8	25.7 – 27.8	Normal Activity. Monitor fluid intake
27.9 – 30.0	27.9 – 30.0	Plan intense or prolonged exercise with discretion; watch at risk individuals closely.
30.1 – 32.2	30.1 – 32.2	Limit Intense exercise and total daily exposure to heat & humidity
≥32.3	≥32.3	Cancel exercise

“Revised” Georgia HS WBGT Standards using Regional System

Grundstein A, Williams C, Phan M, Cooper E. Regional heat safety thresholds for athletics in the continuous United States. *Appl Geogr*. 2015;56:55-60.

Cat 1 (° C)	Current Georgia Standard (° C)	Activity Guideline
≤24.5	≤27.7	Normal Activity. Provide at least 3 separate rest breaks each hour of a minimum duration of 3 min.
24.6 – 27.2	27.8 – 30.5	Use discretion for intense or prolonged exercise; watch at-risk players carefully. Provide at least 3 separate rest breaks each hour of a minimum duration of 4 min.
27.3 – 28.9	30.6 – 32.2	Maximum practice time is 2 hours. **For Football**: players restricted to helmet, shoulder pads, and shorts during practice. All protective equipment must be removed for conditioning. **All Sports**: Provide at least 4 separate rest breaks each hour of a minimum of 4 min each.
29.0 – 30.0	32.3 – 33.3	Maximum length of practice is 1 hour, no protective equipment may be won during practice and there may be no conditioning activities. There must be 20-minutes of rest breaks provided during the 1 of practice.
≥30.1	≥33.4	No outdoor workouts; Cancel exercise; delay practices until a cooler WBGT reading occurs.

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“Revised” Georgia HS WBGT Standards using Regional System

Grundstein A, Williams C, Phan M, Cooper E. Regional heat safety thresholds for athletics in the continuous United States. *Appl Geogr*. 2015;56:55-60.

Cat 2 (° C)	Current Georgia Standard (° C)	Activity Guideline
≤26.5	≤27.7	Normal Activity. Provide at least 3 separate rest breaks each hour of a minimum duration of 3 min.
26.6 – 29.2	27.8 – 30.5	Use discretion for intense or prolonged exercise; watch at-risk players carefully. Provide at least 3 separate rest breaks each hour of a minimum duration of 4 min.
29.3 – 30.9	30.6 – 32.2	Maximum practice time is 2 hours. **For Football**: players restricted to helmet, shoulder pads, and shorts during practice. All protective equipment must be removed for conditioning. **All Sports**: Provide at least 4 separate rest breaks each hour of a minimum of 4 min each.
31.0 – 32.0	32.3 – 33.3	Maximum length of practice is 1 hour, no protective equipment may be won during practice and there may be no conditioning activities. There must be 20-minutes of rest breaks provided during the 1 of practice.
≥32.1	≥33.4	No outdoor workouts; Cancel exercise; delay practices until a cooler WBGT reading occurs.

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“Revised” Georgia HS WBGT Standards using Regional System

Grundstein A, Williams C, Phan M, Cooper E. Regional heat safety thresholds for athletics in the continuous United States. *Appl Geogr*. 2015;56:55-60.

Cat 3 (° C)	Current Georgia Standard (° C)	Activity Guideline
≤27.7	≤27.7	Normal Activity. Provide at least 3 separate rest breaks each hour of a minimum duration of 3 min.
27.8 – 30.5	27.8 – 30.5	Use discretion for intense or prolonged exercise; watch at-risk players carefully. Provide at least 3 separate rest breaks each hour of a minimum duration of 4 min.
30.6 – 32.2	30.6 – 32.2	Maximum practice time is 2 hours. **For Football**: players restricted to helmet, shoulder pads, and shorts during practice. All protective equipment must be removed for conditioning. **All Sports**: Provide at least 4 separate rest breaks each hour of a minimum of 4 min each.
32.3 – 33.3	32.3 – 33.3	Maximum length of practice is 1 hour, no protective equipment may be won during practice and there may be no conditioning activities. There must be 20-minutes of rest breaks provided during the 1 of practice.
≥33.4	≥33.4	No outdoor workouts; Cancel exercise; delay practices until a cooler WBGT reading occurs.

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Your Questions or Comments?

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