Heat Illness Prevention in Athletics

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Background Concerns

- Athletes exercising in the heat lose tremendous amounts of fluid and salt
  - Godek SF, Bartolozzi AR, Godek JJ, Sweat Rate and Fluid Turnover in American Football Players Compared with Runners in a Hot and Humid Environment, British Journal of Sports Mediciine, Vol. 39, 205-211, 2005.
- Crampers seem to lose more salt than non-crampers
  - Stofan JR, Zachwieja JJ, Horswill CA, Murray R, Anderson SA, Eichner ER, *Sweat and Sodium Losses in NCAA Football Players: A Precursor to Heat Cramps?,* International Journal of Sport Nutrition & Exercise Metabolism. Vol. 15(6): 641-652, Dec 2005.
- Schedules, uniforms, hydration protocols, monitoring, and emergency response systems must be tailored to your environment
  - Coris EE, Ramirez AM, VanDurme DJ, *Heat Illness in Athletes: The Dangerous Combination of Heat, Humidity, and Exercise*, Sports Medicine, Vol. 34 (1), pp. 9-16.
  - Coris EE, Walz SM, Duncanson R, Ramirez AM, Roetzheim RG, Heat Illness Symptom Index (HISI): A Novel Instrument for the Assessment of Heat Illness in Athletes, Southern Medical Journal, Vol. 99, No. 4, April 2006.

The Problem?

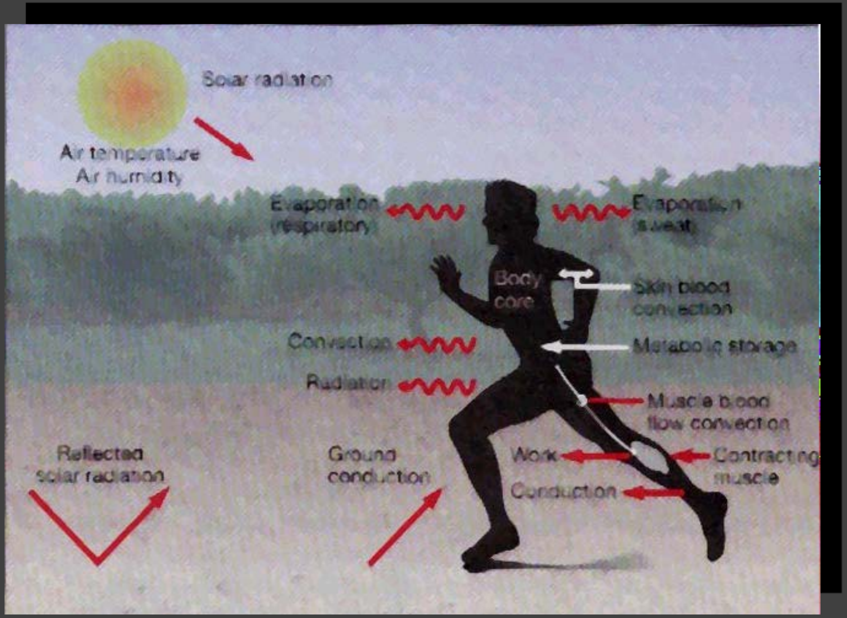
Hypohydration

- **Sweat output exceeds water intake**
- **Net loss of body fluid**, typically from the extracellular compartment
- Compromised thermoregulation, even in acclimated individuals
- With greater degrees of dehydration, increased losses from intracellular compartment
- Seen with exercise in the heat, febrile illness, gastrointestinal disorders
- Result of losses due to
  - evaporation, nausea and vomiting, diarrhea, urination, sputum, insensible losses

Sawka MN[1], Montain SJ. **Fluid and electrolyte supplementation for exercise heat stress.** Am J Clin Nutr. 2000 Aug;72(2 Suppl):564S-72S.

Pathophysiology

- Exercise generates metabolic heat from substrate metabolism
- Increase in body core temperature via convective conduction



Pathophysiology - Hypohydration

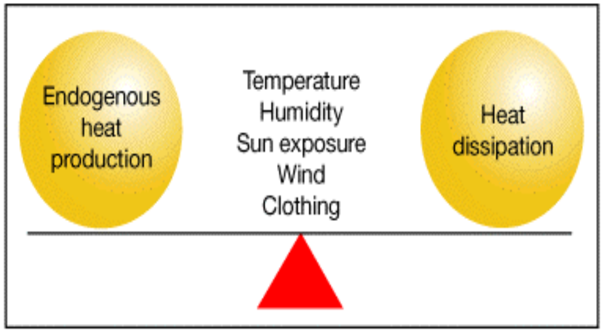


Figure 1. This schematic diagram illustrates heat balance. Heat production is balanced, in most cases, by heat dissipation. The environmental factors in the center can increase or decrease heat dissipation or add to the endogenous heat load.

- Once "set point" exceeded, thermoregulatory mechanisms activate
- Anterior hypothalamus controls heat dissipation "warm receptors" trigger cutaneous vasodilation
- Hypothalamic "osmoreceptors" sense increase in osmolality

Epidemiology - Team Sports

- Football
  - Collegiate
    - 4.0 to 3.5 L during a typical 2.5 hr two a day practice
      - Stofan JR, Zachwieja JJ, Horswill CA, Murray R, Anderson SA, Eichner ER, *Sweat and Sodium Losses in NCAA Football Players: A Precursor to Heat Cramps?,* International Journal of Sport Nutrition & Exercise Metabolism. Vol. 15(6): 641-652, Dec 2005.
  - Professional
    - 2.14 L/hr
    - 4.83l am practice
    - 4.8L pm practice
    - 9.4L Daily sweat losses
    - 12.2L Necessary daily fluid consumption (130%)
      - Godek SF, Bartolozzi AR, Godek JJ, Sweat Rate and Fluid Turnover in American Football Players Compared with Runners in a Hot and Humid Environment, British Journal of Sports Mediciine, Vol. 39, 205-211, 2005.

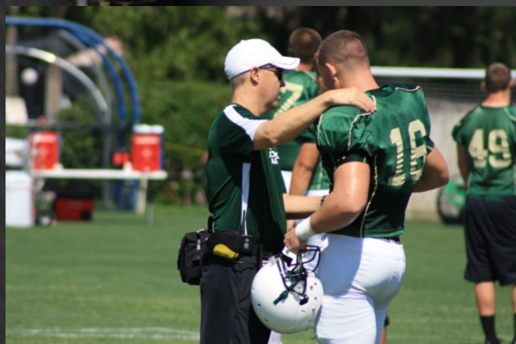
Pathophysiology - Hypohydration

- Vasodilation, shunting of blood to periphery, sweat gland activation
- Sweat rate increases with work intensity
- Increases with environmental heat
- Sweat rates 1-3 L / hr, variable
- Eliminate 2.7 kJ heat/ml sweat
- Efficiency of heat loss through evaporation decreases with increases in ambient temperature and humidity, and with dehydration (>3%)

Pathophysiology - Hypohydration

- Osmolality of blood increases
- Hypothalamus triggers vasopressin release via pituitary, renin release via kidneys
- Increase water and sodium retention in kidneys, increased thirst drive
- Thirst drive ~ 5% dehydration
- Fluid absorption .8-1L/hr optimal
- Maximal fluid intake 300-500 ml/hr runners (600-800 ml/hr cyclists) in reality

Electrolyte Losses



	Sweat	Absorption %	Drink (max value)
Sodium	413–1,091	100	1,100
Chloride	533–1,495	100	1,500
Potassium	121–225	100	225
Calcium	13–67	30	225
Magnesium	4–34	35	100

- Sweat is hypotonic, but does contain Na, K, Cl, Mg
- Increased electrolyte loss with increased sweat rate
- Also burn carbohydrate with muscle activity, leading to hypoglycemia and fatigue
- Average sweat sodium loss for 2.5 hr collegiate football practice 5.1 g +/- 2.3g
  - Stofan JR, Zachwieja JJ, Horswill CA, Murray R, Anderson SA, Eichner ER, *Sweat and Sodium Losses in NCAA Football Players: A Precursor to Heat Cramps?,* International Journal of Sport Nutrition & Exercise Metabolism. Vol. 15(6): 641-652, Dec 2005.

Electrolyte Losses

- **Sweat rate** **2.5 L /hr**
- **Sweat sodium concentration** **83meq/L**
- **Total sweat loss (2.5L/hr x 4 hours)** **10L sweat loss**
- **Total meq sodium in sweat (10L x 83meq/L)** **830meq/L**
- **Total NaCl in sweat needing replacement**
  - **830meq/L x 23 mg Na/1meq Na x 1 g NaCl/393mg Na =**

- **<u>48.6 g NaCl</u>**
  - **8-10 cans soup**
  - **12.6 servings of tomato juice**
  - **40-128 L of sports drink**
- **Average daily intake = 8-13 g NaCl**

- **Bergeron MF, *Exertional Heat Cramps*, in Heat Illness, Armstrong LE ed., Human Kinetics Publishers Inc, 2003 pp.91-102**

Pathophysiology - Team Sports

- Work rate difficult to predict
- Multiple work bouts at near maximal effort
- Intervals of rest/low intensity exercise
- High degree of individual variability
  - position, size, style of play
- Sport variability
  - protective gear, uniforms, season, i outdoor
- Significant loss of body water
- Psychomotor demands

So What?

Metabolic Consequences

- Decreased blood volume
- Impaired heat dissipation
- Reduced oxygen carrying capacity to muscle
- Decreased stroke volume, cutaneous blood flow
- Impaired gastric emptying, splanchnic and renal blood flow
- Performance

Metabolic Consequences

- Increased HR, Temp, Perceived effort
- Increased osmolality
- Increased catecholamines
- Increased core temperature at given intensity
- Enhanced muscle glycogen breakdown
- Hyperthermia, death

Cumulative Heat Stress

- Wallace 2004,Medicine and Science in Sports and Exercise
  - WBGT not only from day of disease increased risk of EHI
  - 11% per degree F
  - (OR = 1.1 °F, 95% CI, 1.10-1.30)
  - WBGT of day prior to disease increased risk
  - (OR = 1.03 °F, 95% CI, 1.02-1.05)

Performance Consequences

Performance consequences of hypohydration

- 2% dehydration led to increased times and decreased running velocity in 1500-10000m distances. Armstrong, Medicine and Science in Sports and Exercise, 1985.
- > 2% fluid deficits associated with significantly decreased performance on psychomotor tests, progressive with degree of dehydration. Gopinathan PM, Archives of Environmental Medicine, 1988.
- Cyclists exercising in heat, inc HR, perceived exertion, and core body temp, as well as dec. stroke volume, decreased cardiac output directly proportional to degree of dehydration. Coyle et. al., Medicine and Science in Sports and Exercise, 1992.

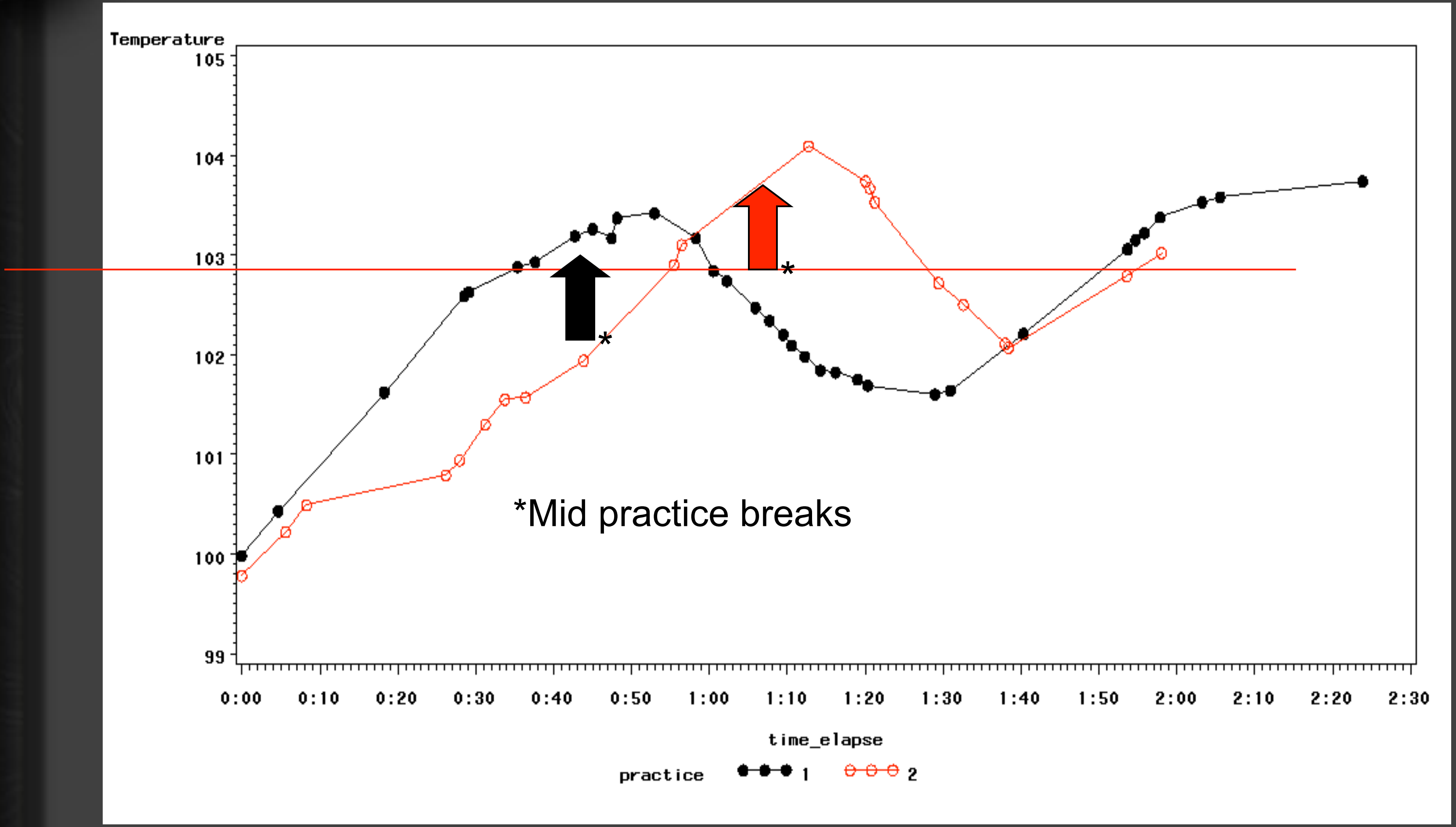
Performance consequences of hypohydration

- 1.8% BM fluid deficits significantly impair performance of high intensity exercise, Walsh et el., Int J Sports Med, 1994.
- 2% fluid deficits *trend* towards decrease in 30 second jump test, inaccuracy with free throw shooting, inc. HR. Hoffman et al., International Journal of Sports Medicine, 1995.

Clinical Syndromes

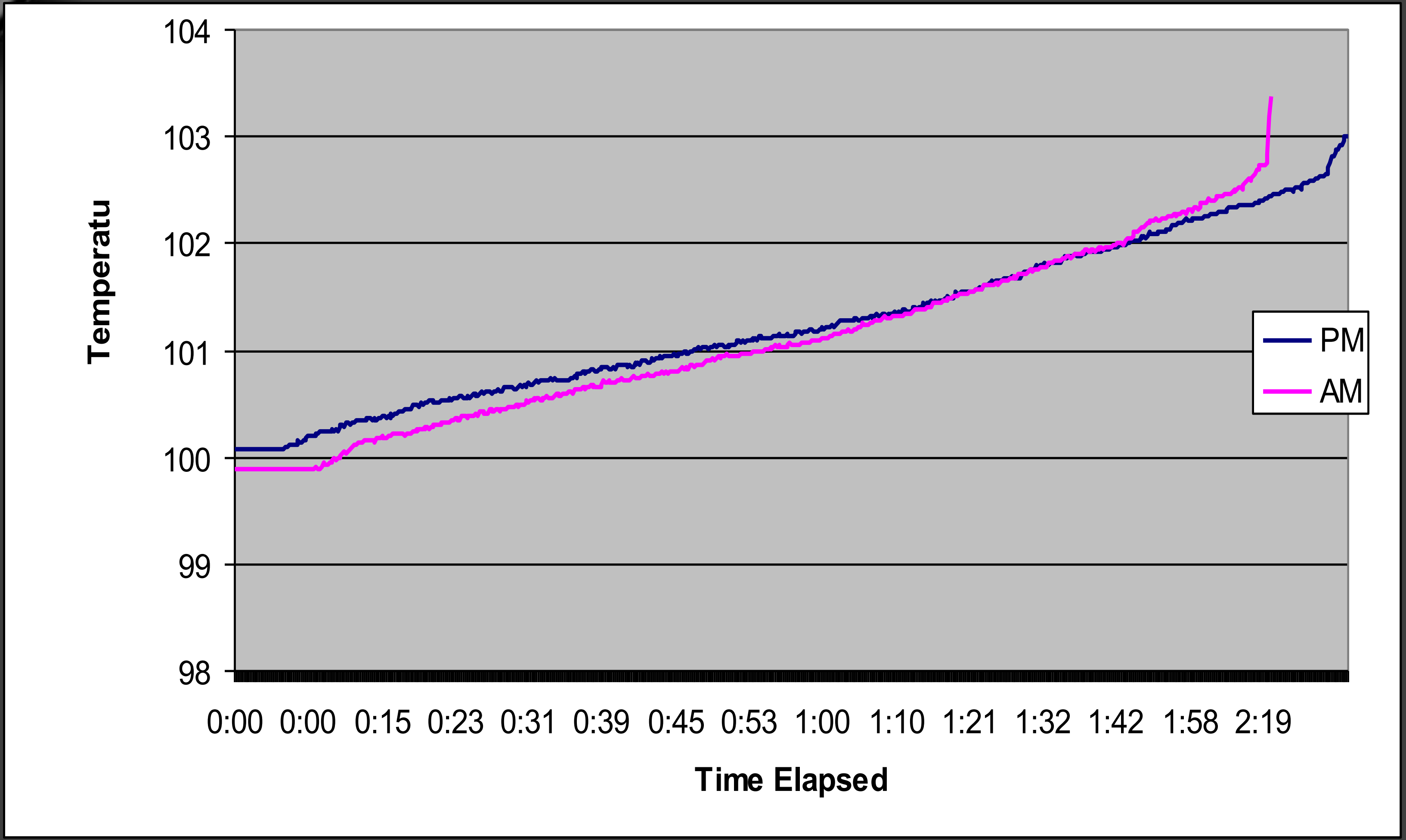
- Heat Cramps
- Heat Syncope
- Heat Exhaustion
- Exertional Heat Stroke
- Hyponatremia

Core temperature Offensive lineman



Coris EE, Mehra S, Jennings J, Walz S, Duncanson R, Pescasio M, *Core Temperature Changes in Collegiate Football Linemen*, Southern Medical Journal, May 7, 2009

Core temp over time two a day practice



Coris EE, Mehra S, Jennings J, Walz S, Duncanson R, Pescasio M, Core Temperature Changes in Collegiate Football Linemen, Southern Medical Journal, May 7, 2009

Work Output Variance Among Athletes

- **Examining Work Output in NCAA Division I Football Players During Pre-season Training in the Heat**
- Julie K. DeMartini, Jessica L. Marchschinske, Douglas J. Casa, Eric E. Coris, Ollie Jay, Rebecca M. Lopez, Brendon P. McDermott, Dawn M. Minton, Kelly D. Pagnotta, Rebecca L. Stearns, Steve M. Walz
- University of Connecticut, Storrs, CT; University of South Florida, Tampa, FL; University of Tennessee Chattanooga, Chattanooga, TN; University of South Carolina, Columbia, SC; University of Ottawa, Ontario, Canada
- **Purpose:** To evaluate the work output that occurs during a preseason football practice in the heat. Furthermore, to compare how these data differ between positions and skill level. **Methods:** Observational field study in hot conditions in the Southeast United States (WBGT: 28.75 ± 2.11°C) involving 49 male NCAA Division 1 football players (21±2 yrs, 187±7 cm, 110.3 ± 23.4 kg). Subjects exercised for 9 practice sessions (142 ± 16 min) over 8 days. Body mass was recorded pre and post-practice to determine percent body mass loss (% DHY), while heart rate and GPS data were recorded throughout the entirety of each practice session to determine intensity (HR), distance covered (DC), and velocity (V). The 49 subjects were divided into 2 groups: linemen (L) (N=25; 22 + 1 yrs, 126 + 16 kg, 190 + 4 cm,) vs. non-linemen (NL) (N=24; 21 + 1 yrs, 91 + 11 kg, 183 + 8cm); and starters (S) (N=17; 21 + 1 yrs, 118 + 21 kg, 190 + 7 cm) vs. non-starters (NS) (N=32; 20 + 1 yrs, 105 + 22 kg, 185 + 7 cm) for statistical analysis. Comparisons of intensity, distance covered, percentage of total distance covered spent at a velocity greater than 2 m·s, and % body mass loss were made using an independent samples t-test. **Results:** DC was significantly greater (p=0.001) in NL compared to L (3532 ± 943 m vs. 2573 ± 489 m). HR (135 ± 12 bpm vs. 136 ± 8 bpm; p=0.617), V (29.5 ± 5.75% vs. 26.08 ± 6.42%; p=0.504), and %DHY (-1.76 ± 0.95% vs. -1.63 ± 0.82%; p=0.609) were similar between NL and L, respectively. No significant differences were observed between S and NS for DC (3072 ± 761 m vs. 3027 ± 953 m; p=0.867), V (28.29 ± 6.28% vs. 27.16 ± 6.27%; p=0.763), HR (136 ± 10 bpm vs. 135 ± 10 bmp; 0.750), or %DHY (-1.56 ± 0.98% vs. -1.82 ± 0.78%; p=0.316). **Conclusions:** Non-linemen are subjected to covering a greater absolute distance during a preseason practice session, while maintaining a similar intensity, velocity, and hydration status (when permitted to drink *ad libitum)* as linemen. In addition, players exposed to similar practice demands provide similar work output during a preseason practice session regardless of their skill level.

- Julie K. DeMartini1, Jessica L. Martschinske1, Douglas J. Casa1, Ollie Jay2, Rebecca M. Lopez3, Matthew S. Ganio4, Steve M. Walz3, Eric E. Coris3,, EXAMINING PHYSICAL DEMANDS IN NCAA DIVISION I FOOTBALL PLAYERS DURING PRE-SEASON TRAINING IN THE HEAT, Running Head: Physical Demands of American Football Players, MSSE, supplement, May 2011. Presented, ACSM 2011

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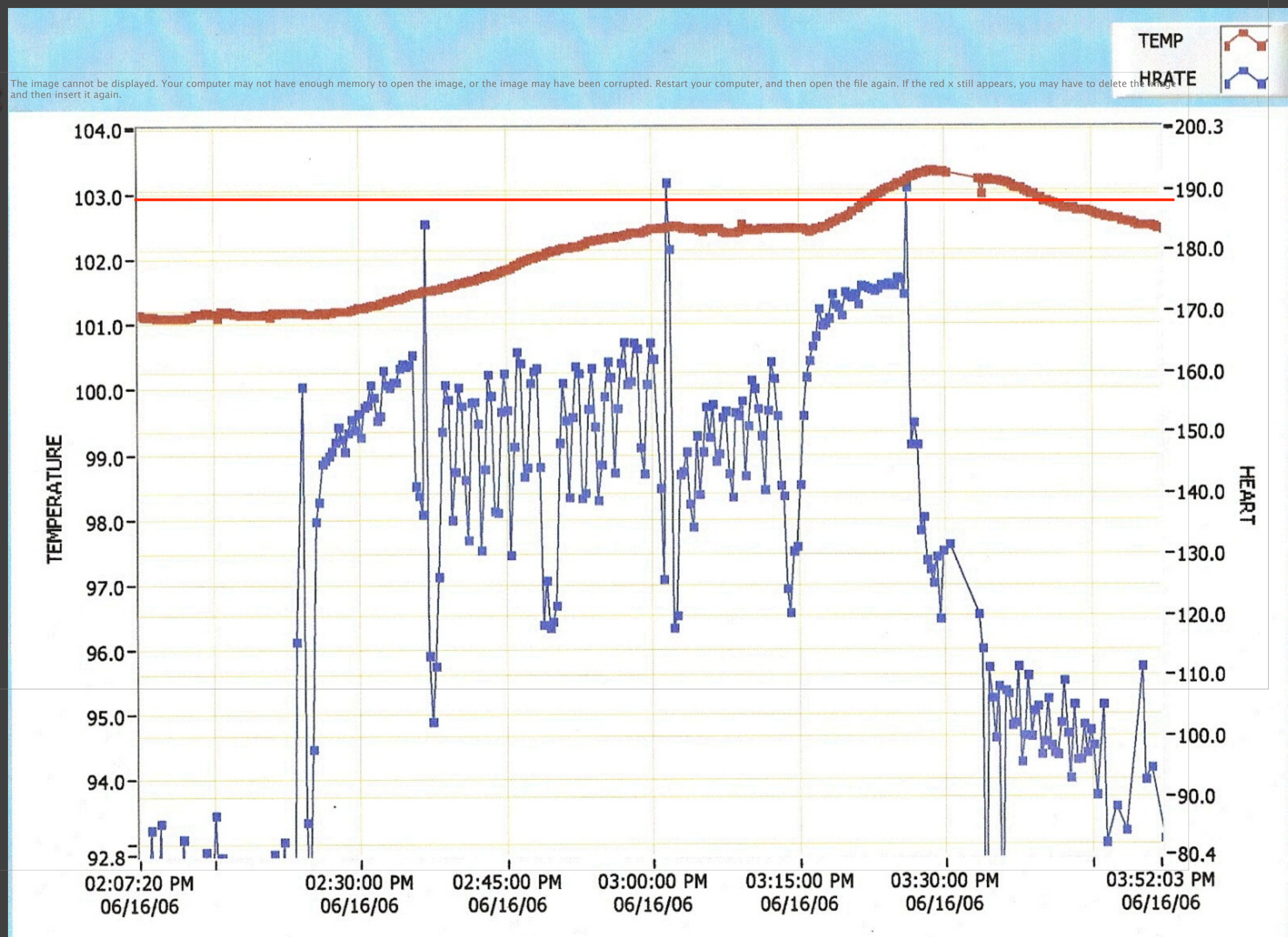
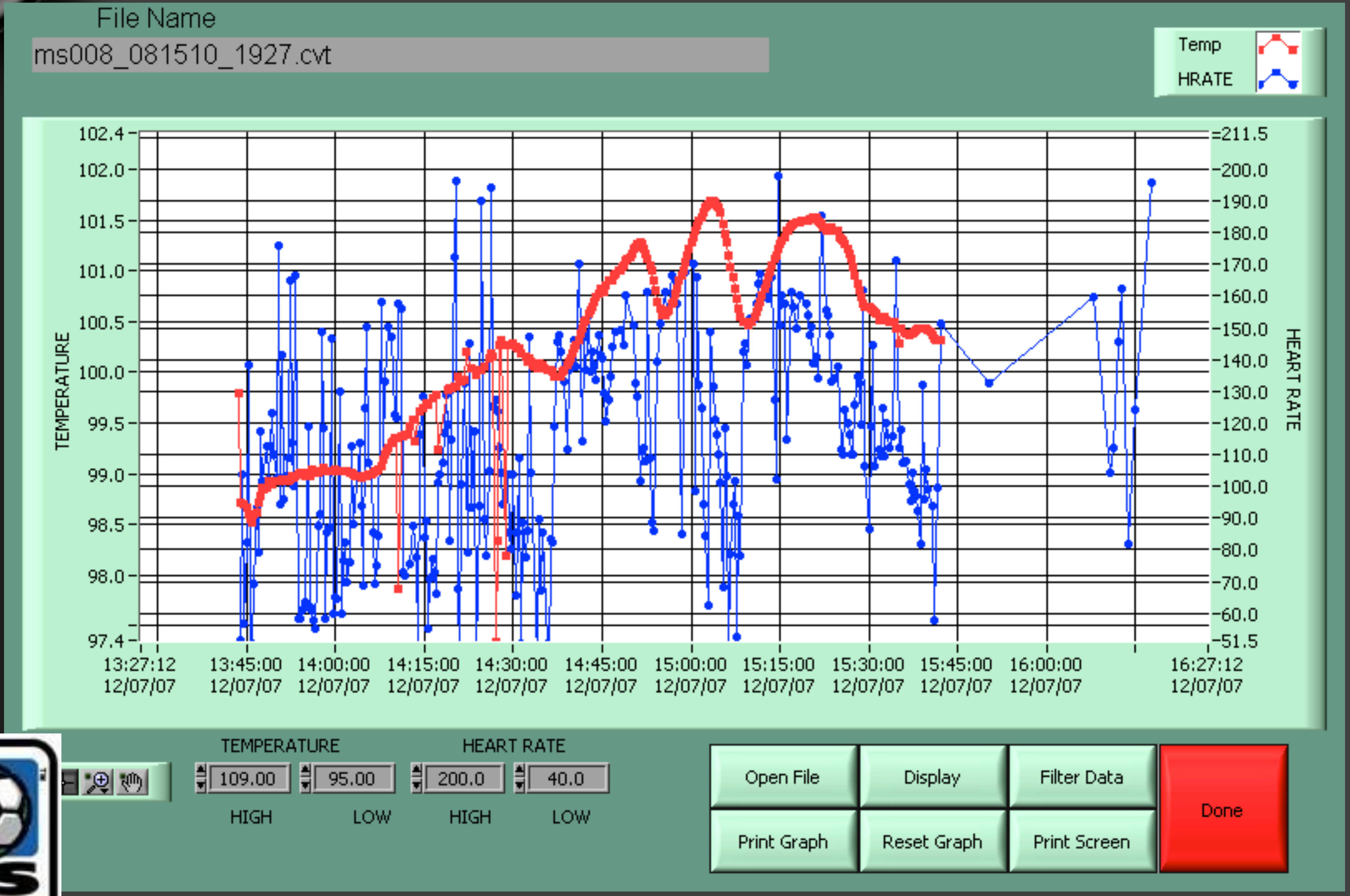
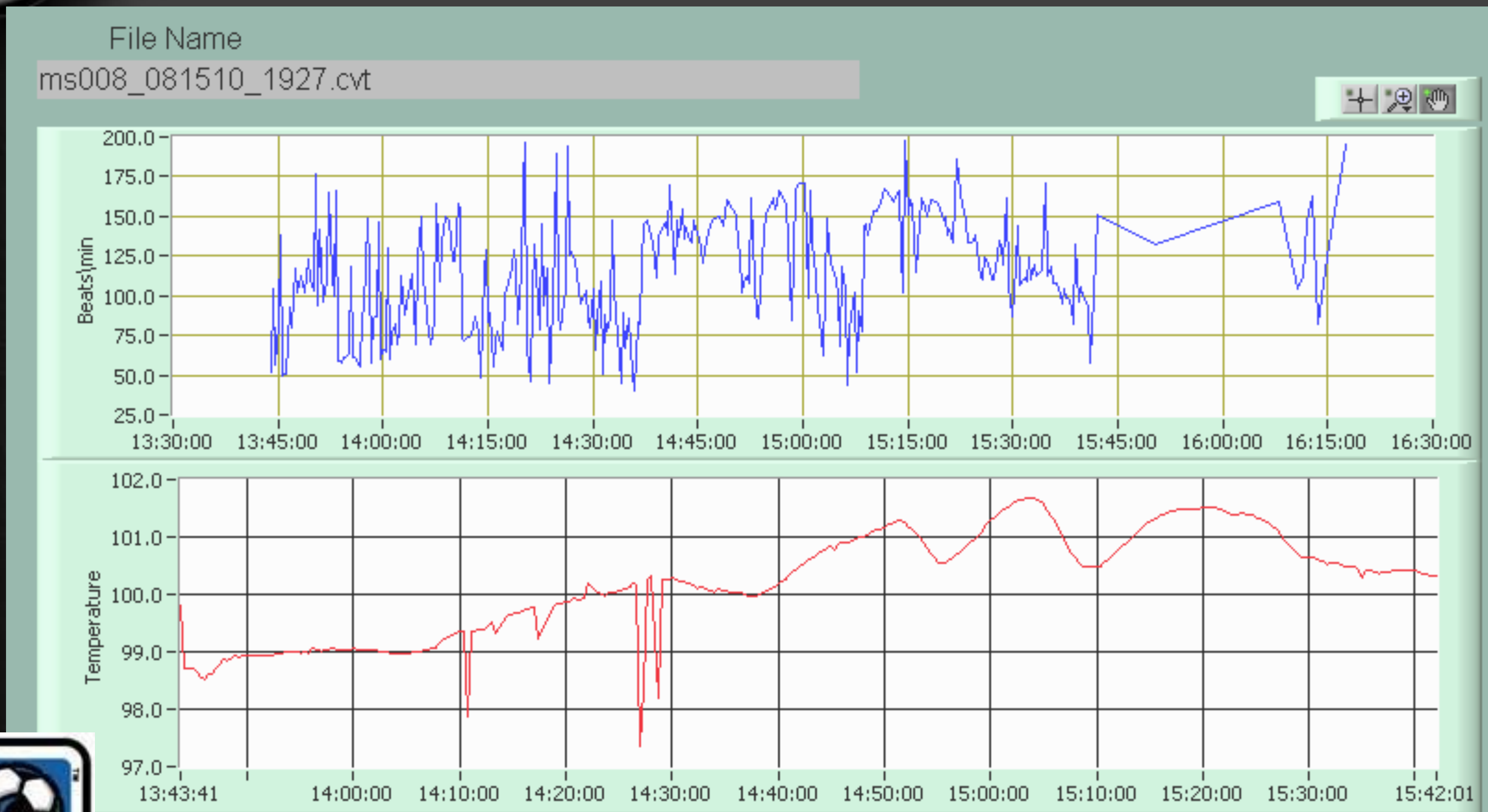


Soccer Core Temperature Elevations



Soccer Core Temperature Elevations



AM Practices	P = < 0.05 Significant	PM Practices	P = < 0.05 Significant
OL vs. OB	P = <0.01*	OL vs. OB	P = <0.01*
OL vs. DL	P = <0.01*	OL vs. DL	P = <0.01*
DL vs. DB + WR	P = <0.01*	OB vs. DB + WR	P = <0.01*
DB + WR vs. OB	P = 0.012	DB + WR vs. OB	P = 0.02

N=66

Control Variables	DF	F Value	Pr > F
Time Elapse	1	63.24	<.0001*
Group	3	6.33	0.0003*
BMI	1	31.84	<.0001*
Previous Practice Heat Stress	3	8.60	<.0001*
Heat Stress	3	13.88	<.0001*
Overall	3	11.47	<.0001*

Self Generated Air velocity affects cooling

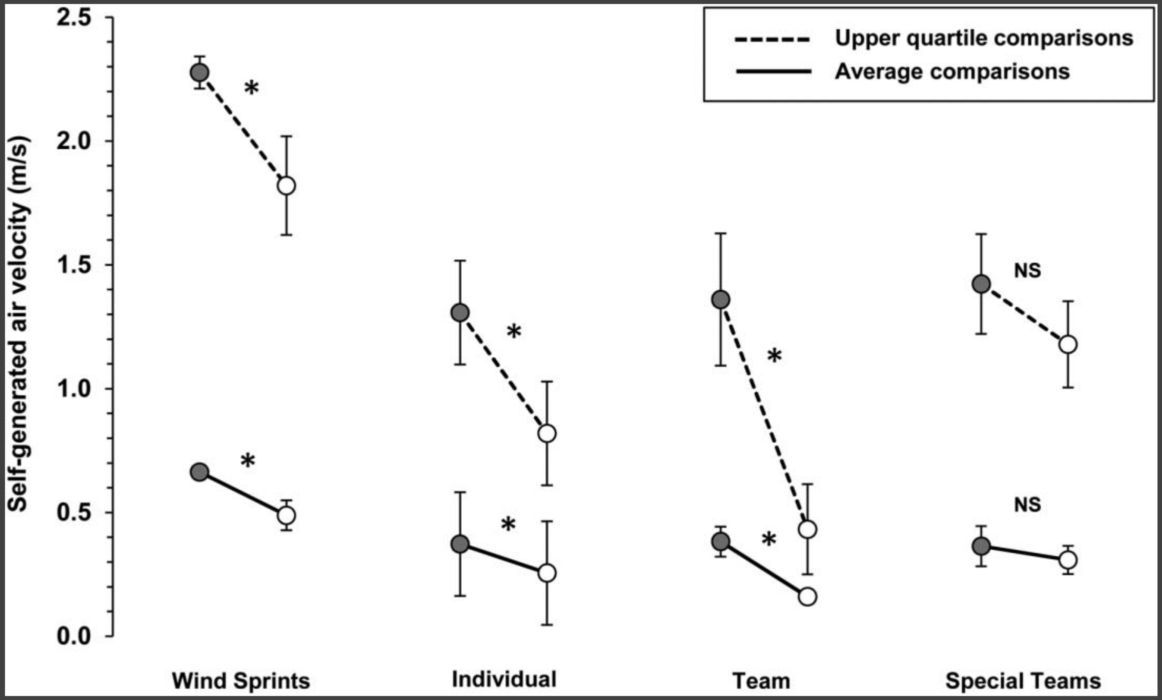


Figure 2. A comparison of self-generated air velocities (vself) between non-linemen (gray) and linemen (white)
during the 4 key drill classifications. Comparisons between linemen and non-linemen are given for average vself
values (solid line) and the average vself values within the upper quartile of movement (dotted line). *Significant
difference between non-linemen and linemen (p # 0.05). NS indicates no significant difference. Error bars indicate
standard error.

Deren TM, Coris EE, Casa DJ, et al. Maximum Heat Loss Potential Is Lower In Football Linemen During An NCAA Summer Training Camp Because Of Lower Self-Generated Air Flow, Journal of Strength and Conditioning Research, pp. 1656-1663, June 2014

What do we do about it?

Preventative Cooling?

- 21 D-I football offensive lineman
- Core temp monitoring via ingestible thermistors
- Traditional break vs “Polar Pod” break during normal practice breaks
- Temps recorded throughout practice and before/after breaks
- Environmental conditions via WBGTo
- Heat Illness Symptom Questionnaire to assess subjective symptoms (3)

More than willing participants…

Ambient: WBGTo 94.2, Heat Index 103, Humidity 65%

Polar Pod: WBGTi 52.3, Humidity 50%

Results

- Cooling rate
  - Polar pod: 0.035 +/- 0.55 deg F/min
  - Traditional: 0.016 +/- 0.52 deg F/min
  - P = 0.308 (no significant difference)
- Max temperatures
  - Polar Pod: 101.73 +/- 0.61 deg F
  - Traditional: 101.76 +/- 0.67 deg F
  - P= 0.905 (no significant difference)

Results

- Subjective symptoms assessment via HISI
  - Polar pod: 2.4
  - Traditional: 2.6
- Subjective feedback:
  - “Refreshed”
  - “Improved energy”
  - “I died and the polar pod brought me back to life”

USF Sports Medicine Soccer Heat Physiology Study

USF Sports Medicine Soccer Heat Physiology Study : Field Study

- Twelve Division-I female soccer players volunteered for this randomized, crossover study.
- Participants were assigned to either their traditional shade break (CON) or a cold trailer (POD) cooled to 4-10 °C.
- Environmental conditions were recorded for both conditions.
- Core temperature (T_{gi}) was monitored via ingestible thermistors.
- Heart rates (HR) were monitored using wearable sensors.
- Percent loss of body weight (% BML) and urine specific gravity (U_{sg}) were measured to determine hydration status.
- Repeated measures ANOVA were used to assess differences between conditions.

USF Sports Medicine Soccer Heat Physiology Study : Field Study Results

- Mean wet bulb globe temperature was similar across days (31.3±2.1°C; $P=.095$)

- Percent of time in various aerobic intensity zones was similar ($P>0.05$)

USF Sports Medicine Soccer Heat Physiology Study : Field Study Results

- There were no differences in overall practice T_{gi} between POD (38.2±0.4°C) and CON (38.2±0.3°F; P>0.05)
- No differences realized in T_{gi} over time, condition, pre to post-break T_{gi} or cooling rates (P>0.05)
- Both conditions saw decreased HR over time (P=0.000) but post-break POD HR (98.6±11.6 bpm) was significantly lower than CON HR (123.8±19 bpm; P=0.005)
- Mean % BML was similar for POD (-0.76±.48%) and CON (-0.53±.56%; P=.218)
- There was an overall time effect for U_{SG} (P=0.001) and pre-to-post differences between conditions in U_{SG} (POD: -0.010±0.007, CON: -0.005±0.006; P=0.035).

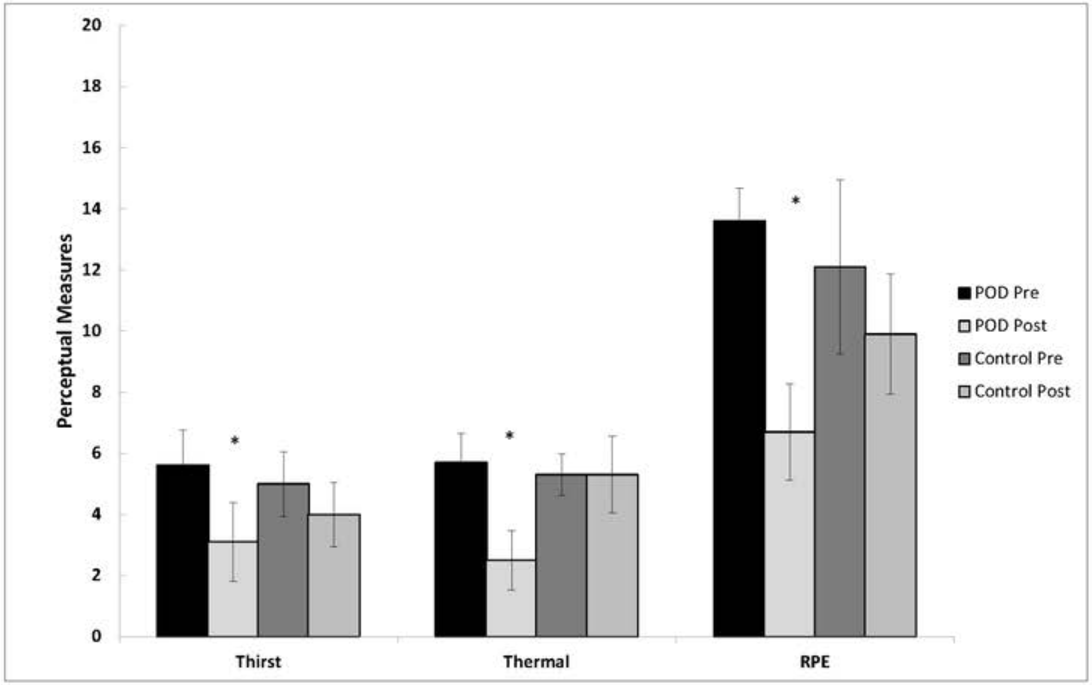
Tgi and HR Pre and Post Polar Pod

Table 1. Temperature and heart rate responses during practice breaks

	TGI			HR		
	Pre	**Post**	**Difference**	**Pre**	**Post**	**Difference**
POD	38.4 ± 0.40	38.25 ± 0.44	-0.09 ± 0.38	125.2 ± 24.1	98.6 ± 11.6	-26.7 ± 22.0
Control	38.51 ± 0.41	38.45 ± 0.46	-0.06 ± 0.12	139.9 ± 19.0	123.8 ± 19.1	-16.1 ± 21.0

TGI=gastrointestinal temperature; HR=heart rate

Polar Pod Perceptuals



* Indicates post break POD < CON ($p \leq 0.05$)

Core Temperature and Intensity vs. Hydration

- Twenty-nine male football players (age = 21 ± 1 year, height = 187 ± 9 cm, mass = 110.1 ± 23.5 kg, body mass index [BMI] = 31.3 ± 5.0, and body surface area [BSA] = 2.34 ± 0.27 m^2)
- 8 days of practice in a warm environment (wet bulb globe temperature: 29.6 ± 1.6° C).
- Starters (S; n = 12), nonstarters (n = 17) and linemen (L; n = 14) or nonlinemen (NL; n = 15).
- Core body temperature (T), hydration status, physical performance characteristics (GPS)

DeMartini-Nolan JK, Martschinske, JL, Casa, DJ, Lopez, RM, Stearns, RL, Ganio, MS, and Coris, E. Examining the influence of exercise intensity and hydration on gastrointestinal temperature in collegiate football players. *J Strength Cond Res* 32(10): 2888–2896, 2018

Core Temperature, Intensity and Hydration

- Low-velocity movement, high-velocity movement, average velocity, BMI, and BSA were significantly different ($p = 0.002$, $p < 0.001$, $p = 0.02$, $p < 0.001$, $p < 0.001$, respectively) between L vs. NL.
- Intensity measures of average heart rate (138 ± 9 bpm), low-velocity movement (4.2 ± 1.7%), high-velocity movement (0.6 ± 0.6%), and average velocity (0.36 ± 0.10 $m \cdot s^{-1}$) accounted for 42% of the variability observed in T (38.32 ± 0.34° C, $r = 0.65$, $p = 0.01$).

Core Temperature, Intensity and Hydration

- Hydration measures (percent body mass loss = −1.56 ± 0.80%, urine specific gravity [U_{sg}] = 1.025 ± 0.006, and urine color [U_{col}] = 6 ± 1) did not add to the prediction of T ($p = 0.83$). Metrics of exercise intensity accounted for 39% of the variability observed in maximum T (38.83 ± 0.42° C, $r = 0.62$, $p = 0.02$). Hydration measures did not add to this prediction ($p = 0.40$).
- Heart rate and T were not different between L and NL ($p > 0.05$). Exercise intensity primarily accounted for the rise in core body temperature. Although L spent less time at higher velocities, T was similar to NL, suggesting that differences in BMI and BSA added to thermoregulatory strain.

Prediction of Tgi

Model factors	Temperature	Variability in temperature explained by model	Pearson product-moment correlation (r)	*p*
Intensity*	T_{avg}	42%	0.65	0.01†
	T_{max}	43%	0.66	0.02†
Intensity, hydration‡	T_{avg}	44%	0.66	0.40
	T_{max}	39%	0.62	0.83
Intensity, hydration, individual characteristics§	T_{avg}	60%	0.78	0.09
	T_{max}	53%	0.73	0.33

*Intensity variables are the following: heart rate, V_{2-4}, V_{4-6}, V_{avg}.
†$p \leq 0.05$.
‡Hydration variables are the following: % body mass loss and posturine specific gravity.
§Individual Characteristics variables are the following: position, body mass index, and body surface area.

Field studies	Percent dehydration	Correlation with body temperature?	Intensity monitored?	Controlled for intensity?
Godek et al. (15)	−1.11 ± 0.70%	No	No	No
Yeargin et al. (29)	−1.2%	No	Yes	No
Byrne et al. (7)	−1.78 ± 0.74%	No	Yes	No
Laursen et al. (18)	−3.00 ± 1.5%	No	Yes	No
Lopez et al. (19)	−3.64 ± 1.33%	Yes	Yes	Yes
Casa et al. (9)	−4.30 ± 1.25%	Yes	Yes	Yes
Current Study	−1.56 ± 0.80%	No	Yes	No

Variance in Temperature and Local Sweat Rates

Regional sweating differs between elite American football linemen and backs independently of metabolic heat production

Tomasz M. Deren[1], Anthony R. Bain[1], Eric E. Coris[2], Steve M. Walz[2] and Ollie Jay[1]

[1]University of Ottawa, Ottawa, ON, Canada; [2]University of South Florida, Tampa, FL, USA

Evaporative heat loss via sweating is the primary heat dissipation avenue during exercise, particularly in the heat. In typical summer football training camps, linemen have significantly greater elevations in core temperature than backs. However it is unclear if differences in sweating are responsible for these higher core temperatures. **PURPOSE**: To investigate whether differences in local and whole-body sweat rates between football linemen and backs exist independently of differences in metabolic heat production. **METHODS:** 12 NCAA Division 1 American football players (6 linemen [mass: 141.6±6.5 kg; BSA: 2.67±0.08 m^2] and 6 backs [mass: 88.1±13.4 kg; BSA: 2.11±0.19 m^2]) at a fixed metabolic heat production of 350 W/m^2 for 60-min in a climatic chamber (T_{db}: 32.4±1.0ºC; T_{wb}: 26.3±0.6ºC; V_{air}: 0.9±0.1 m/s). Core temperature (T_{core}) and mean skin temperature (T_{sk}) were measured throughout exercise. Local sweat rates (LSR) on the head, arm, upper back, lower back and chest were measured after 10, 30 and 50 min of exercise using a technical absorbent method, and whole-body sweat loss was measured using changes in pre and postexercise body weight. **RESULTS:** Whole-body sweat rate was identical in linemen (8.6±1.8 g/m^2/min) and backs (8.6±1.4 g/m^2/min); however LSR was significantly greater ($P<0.05$) in linemen at 4 of 5 sites (head, arm, upper back and chest) after 10-min; at 2 of 5 sites (arm and chest) after 30-min; but no differences were observed for LSR between linemen and backs after 50-min. Core temperature at the end of the trial was significantly greater ($P=0.025$) in linemen (38.48±0.39ºC) relative to backs (38.01±0.24ºC). Mean T_{sk} was similar in linemen (35.34±0.48ºC) compared to backs (35.21±0.25ºC); however when accounting for differences in starting T_{sk}, linemen (1.71±0.23ºC) had a greater change ($P<0.001$) in T_{sk} than backs (0.82±0.26ºC).

CONCLUSION: Despite identical whole-body sweating at a fixed heat production per unit surface area, upper body LSR in linemen is greater during the early stages of exercise and presumably lower elsewhere. More profuse upper body sweating in linemen is attributed to a greater change in skin temperature. This potentially leads to a greater amount of non-evaporated sweat dripping off the body, a lower whole-body evaporative efficiency and greater elevations in core temperature.

Tomasz M. Deren1, Eric E. Coris2, Anthony R. Bain1, Steve M. Walz2 and Ollie Jay1, *Sweating is greater in NCAA football linemen independently of heat production*, Medicine and Science in Sports and Exercise, Med Sci Sports Exerc. 2011. Jul 11.

Monitoring

- Predisposing illness/medication?
- Environmental conditions
- Athletic trainers critical
- Be conscious of excessive reps at any given position
- Watchful eye for mild and more severe heat illness
- Core temp, heart rate monitoring
- Heat illness symptom index
- Weight changes post practice
- Replacing fluid/electrolyte losses – oral or I.V. ??
- Immediate cooling for even mild heat illness

Emergency Treatment

- Mental confusion – Heat stroke until proven otherwise
- ABCs – rectal temperature
- Activate emergency plan
- Immediate cooling – Ice water immersion
- IVF?
- Cool to 101, avoid shivering
- Watch for cardiac arrythmia, seizure, multiorgan failure, DIC,

Prehosp Emerg Care. 2018 May-Jun;22(3):392-397. doi: 10.1080/10903127.2017.1392666. Epub 2018 Jan 16.
Consensus Statement- Prehospital Care of Exertional Heat Stroke.
Belval LN, Casa DJ, Adams WM, Chiampas GT, Holschen JC, Hosokawa Y, Jardine J, Kane SF, Labotz M, Lemieux RS, McClaine KB, Nye NS, O'Connor FG, Prine B, Raukar NP, Smith MS, Stearns RL.

Summary

- Get conditioned and acclimatized
- Pre season risk assessment
- Drink fluids – sports drink
  - At least 20 ounces (2 to 3 cups) before practice
  - 10 ounces (one cup) every 10-15 min
  - One liter per hour
  - Weigh in and out - Don't lose weight during practice
  - 24 ounces (3 cups) per pound of body weight lost
- Let us know if having trouble
- Symptom questionairres
- Heat pills

Thank you!

References

- [illegible] combination of heat, humidity and exercise. Sports Med. 2004;34(1):9-16.
- Coris EE, Walz SM, Duncanson R, Ramirez AM, Roetzheim RG, Heat illness symptom index (HISI): a novel instrument for the assessment of heat illness in athletes. South Med J. 2006 Apr;99(4):340-
- Shukla K, Lopez RM, Moran B, Ashley C, Tristch AJ, Fanelli A, Batia N, Coris EE, Evaluating the Effectiveness of Cooling Units on Collegiate Female Athletes, Clinical Journal of Sport Medicine: March 2016 - Volume 26 - Issue 2 - p e58–e68
- DeMartini-Nolan, JK, Martschinske, JL, Casa, DJ, Lopez, RM, Stearns, RL, Ganio, MS, and Coris, E. Examining the influence of exercise intensity and hydration on gastrointestinal temperature in collegiate football players. J Strength Cond Res 32(10): 2888–2896, 2018
- Deren,T, Coris E, Bain A, Walz S, Ollie J. (2011). Sweating Is Greater in NCAA Football Linemen Independently of Heat Production. Medicine and science in sports and exercise. 44. 244-52.
- Deren, Tomasz M.[1]; Coris, Eric E.[2]; Casa, Douglas J.[3]; DeMartini, Julie K.[3]; Bain, Anthony R.[1]; Walz, Steve M.[2]; Jay, Ollie[1,4] **Maximum Heat Loss Potential Is Lower in Football Linemen During an NCAA Summer Training Camp Because of Lower Self-Generated Air Flow,** Journal of Strength and Conditioning Research: June 2014 - Volume 28 - Issue 6 - p 1656–1663

References

- Coris E, Mehra S, et. al., Gastrointestinal Temperature Trends in Football Linemen During Physical Exertion Under Heat Stress, Southern Medical Journal, 102(6), June 2009, 569-574.
- Speedy DB, Rogers IR, Diagnosis and Prevention of Hyponatremia at an Ultradistance triatholon, Clinical Journal of Sports Medicine, vol. 10, no. 1, 2000, pp. 52-58.
- Coyle EF, Montain SJ, *Benefits of Fluid Replacement with Carbohydrate during exercise,* Medicine and Science in Sports and Exercise, Vol. 24, No. 9, 1992, pp. S324-s330.
- Murray R, *Rehydration Strategies-Balancing Substrate, Fluid, and Electrolyte Provision,* International Journal of Sports Medicine, 1998, s133-s135.
- MMWR: *Hyperthermia and Dehydration-Related Deaths Associated With Intentional Rapid Weight Loss in Three Collegiate Wrestlers-North Carolina, Wisconsin, and Michigan, November-December 1997*, JAMA, March 1998, Vol. 279, No. 11, pp. 824-825.
- Holtzhausen LM, Noakes TD, *Collapsed Ultraendurance Athlete: Proposed Mechanisms and an Approach to Management*, Clinical Journal of Sport Medicine, Vol. 7, 1997, pp. 292-301.
- Walsh RM, Noakes TD, et al., *Impaired High Intensity Cycling Performance Time at Low Levels of Dehydration,* International Journal of Sports Medicine, Vol. 15, 1994, pp. 392-398.ercise

References

- Alonso G, Rodriguez RM, et al., *Dehydration Markedly Impairs Cardiovascular Function in Hyperthermic Endurance Athletes During Exercise*, Journal of Applied Physiology, Vol. 82, no. 4, 1997, pp. 1229-1236.
- ACSM Position Stand: *Heat and Cold Illnesses During Distance Running*, Medicine and Science in Sports and Exercise, pp. I-X.
- Cheung SC, McLellan TM, *The Thermophysiology of Uncompensable Heat Stress*, Sports Medicine, May 2000, vol.5, pp. 329-359.
- Noakes TD, *Dehydration During Exercise: What are the real Dangers?* Clinical Journal of Sports Medicine, vol.5, 1995, pp. 123-128.
- Belval LN, Casa DJ, et.al., **Consensus Statement- Prehospital Care of Exertional Heat Stroke.** Prehosp Emerg Care. 2018 May-Jun;22(3): 392-397. doi: 10.1080/10903127.2017.1392666. Epub 2018 Jan 16.
- Sawka MN[1], Montain SJ. **Fluid and electrolyte supplementation for exercise heat stress.** Am J Clin Nutr. 2000 Aug;72(2 Suppl):564S-72S.

References

- Burke LM, Hawley JA, *Fluid Balance in Team Sports, Guidelines for Optimal Practices*, Sports Medicine, July 1997, Vol. 24, no. 1, pp. 38- 54.
- Brouns F, *Aspects of Dehydration and Rehydration in Sport, Nutrition and Fitness:* Metabolic and Behavioral Aspects in Health and Disease. World Review of Nutritional Dietetics, vol. 82, pp. 63-80, 1997.
- Gisolfi CV, Duchman SM, *Guidelines for Optimal Replacement Beverages for Different Athletic Events,* Medicine and Science in Sports and Exercise, vol. 24, no. 6, 1992, pp. 679-687.
- Godek SF, Bartolozzi AR, Godek JJ, Sweat Rate and Fluid Turnover in American Football Players Compared with Runners in a Hot and Humid Environment, British Journal of Sports Mediciine, Vol. 39, 205-211, 2005.
- Stofan JR, Zachwieja JJ, Horswill CA, Murray R, Anderson SA, Eichner ER, *Sweat and Sodium Losses in NCAA Football Players: A Precursor to Heat Cramps?,* International Journal of Sport Nutrition & Exercise Metabolism. Vol. 15(6): 641-652, Dec 2005.
- Bergeron MF, *Exertional Heat Cramps*, in Heat Illness, Armstrong LE ed., Human Kinetics Publishers Inc, 2003 pp.91-102