The Difference in Core Temperature and Heart Rate Between Collegiate American Football Backs and Linemen During Pre-Season

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Objectives

1. Introduction
   a. Exertional heat illness (EHI)

2. Overview of Related Literature
   a. Thermoregulation – body size, aerobic fitness, acclimatization
   b. EHI and American Football

3. Purpose
4. Methods
5. Results
6. Discussion
7. Conclusions

Introduction

- Exertional heat illness (EHI) and exertional heat stroke (EHS) have been documented issues in certain occupations and sports.[1,2]

Exertional Heat Illness

- **EHI:** A condition that couples heat production and insufficient heat dissipation
  - Results in hyperthermic body core temperature (T_c) (38°C – 39.5°C)
- **EHS:** A condition associated with a T_c of 40°C or higher and central nervous system (CNS) abnormalities
  - Considered the most fatal of EHI

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Exertional Heat Illness

- EHI is more prominent during exercise in hot/humid environments
- This can result in *uncompensable heat stress*
- **Uncompensable heat stress:**
  - Occurs when evaporative sweating for cooling does not match heat production
  - Can result in decreased thermoregulation and an increased T_c → Increased EHS risk

1,6

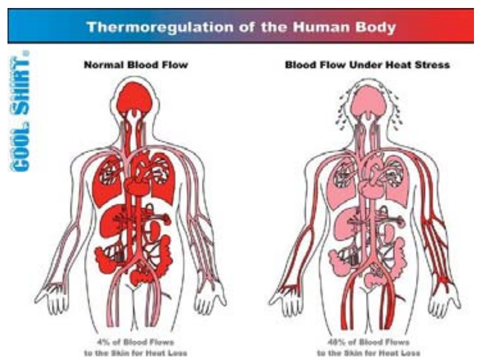
Thermoregulation

- Thermoregulation occurs when heat production and heat dissipation are balanced

- **DURING EXERCISE:**
- The body must adjust for an increase in the amount of heat generated by the muscles

- Increase in metabolic heat production

- Generated heat must move to the periphery to maintain normal T_c



Thermoregulation

- **Factors that affect thermoregulation:**
  - Hot/humid environments
  - Clothing and equipment
  - Higher Body mass
  - Lower BSA/mass
  - Lower Aerobic fitness level
  - Slower acclimatization rates
- **Each of these can contribute to one's risk for EHI**

8,9,10

Body size

- Body surface area (BSA) (m^2): the amount of skin and tissue covering the body.
- BSA/mass: the ratio of skin to mass of the body.
  - A high BSA + a high mass = a low BSA/mass ratio.
- Both of these characteristics affect heat dissipation via dry and wet methods.

11,12

Body Size

- **Those with a higher mass exercising in hot/humid environments:**
  - Rely heavily on evaporation for heat dissipation
  - Can't dissipate heat as quickly
    - Due to high humidity reducing evaporation capability
  - **Store more heat → Increased T_c**

Aerobic Fitness

During exercise:

- T_c and HR increase
  - Reach steady state – heat production and heat loss are balanced

- This steady state, known as **cardiovascular stability**, is more efficient and reached more quickly in those that have **higher aerobic fitness**

1,3,5,13,14

Aerobic Fitness

- **Those that are aerobically fit:**

- Have increased recovery from exercise

- Are able to maintain cardiovascular stability
  - Decreases risk for EHI

1,3,5,13,14

Acclimatization

- Physiological adaptations that occur due to regular exposure to an extreme environment, such hot environments
- Decrease the hindering effects of exercising in the heat
- Can take **7-14 days** of repeated exposure to acclimatize

4, 15,16,17

Acclimatization

- **Physiological changes include:**
  - Increased plasma volume
  - Increased sweat rate
  - Decreased sodium losses in sweat and urine
  - Decreased HR during exercise
  - Decreased T_c at rest
  - Decreased rate of T_c increase during exercise

- The rate of acclimatization has been associated with:
  - **Aerobic fitness**
    - Due to initial cardiovascular improvements

4, 15,16,17

EHI and American Football

- American football players are at risk for developing EHI due to the nature of the sport and the individual characteristics of each player.

EHI and American Football

- From 1995-present: **54 heat-related deaths have occurred in American football**

- **90%** of these occurred in practice

- From 2010-2014: average of **2.6 heat stroke deaths per yea**r

EHI and American Football

- **American football requires a significant level of aerobic fitness to adjust to varying exercise intensities, the addition of padding, and the potential for increased body mass**
  - However, it is common for positional players to not be aerobically fit
  - Less fit individuals can have higher heart rates and core temperatures at lower exercise intensities that will continue to rise at high intensity intervals
  - Players with a higher BMI (low BSA/mass) tend to be less conditioned and may not thermoregulate effectively

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Problem Statement

- The direct influence of BSA/mass and aerobic fitness levels on maximal T_c and HR values during athletic participation has not been widely examined.

- Specifically, not in the American Football population

Purpose

Purpose

- The purpose of this study was to evaluate the effects of HR, VO_{2peak} (aerobic fitness), and BSA/mass on T_c in American Football players during pre-season.

Hypotheses

1. Linemen (LM) will be significantly less fit and larger than backs (BKs).
2. Subjects with lower BSA/mass and VO_{2peak} values will have higher T_c values and T_c variability throughout pre-season.
3. Similarly, subjects with lower BSA/mass and VO_{2peak} values will have higher HR values and HR variability throughout pre-season.
4. All subjects will demonstrate acclimatization via reduced T_c and HR variables after 10 days of pre-season.
5. T_c and HR variables will have a direct relationship throughout pre-season.

Methods

Participants

- 20 volunteer NCAA Division III football players
- Ages 18-22
- 9 LM, 11 BKs

Experimental Design

- Field study
- Observational cohort

Independent and Dependent Variables

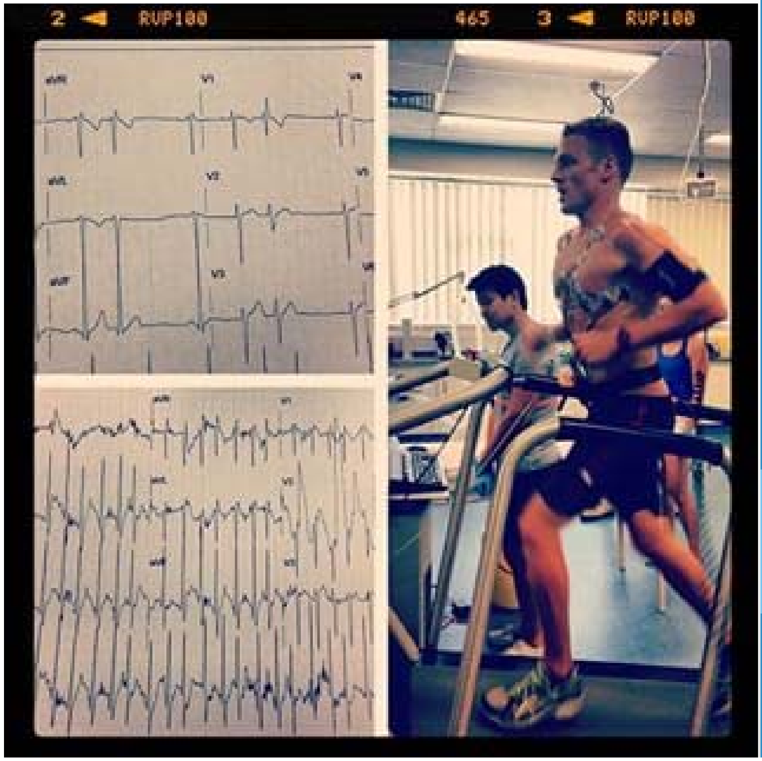
- Independent variables:
  - HR_{max}
    - (maximum HR reached that day)
  - ΔHR (max-min)
  - VO_{2peak}
  - BSA/mass
  - Group (LM vs. BKs)

Dependent Variables:

- T_{cmax}
  - (maximum T_c reached that day)
- ΔT_c (max-min)

Baseline Data Collection

- August 10-12
- Height, weight, BSA/mass, resting HR
- VO_{2peak} test (Bruce Protocol)



Data Collection Dates

- Day 2 (D1)
- Day 3 (D2)
- Day 4 (D3)
- Day 5 (D4)

- Day 10 (D5)

Core Temperature

- T_c measured via ingestible temperature pill (Ingestible CorTemp® (HQ Inc., Pametto FL).
- Subjects ingested thermistors ~5 hrs prior to practice.
- T_c was received and stored using a CorTemp® hand-held recorder (Hq Inc., Pametto FL).
- Thermistors were excreted within 12-24 hrs

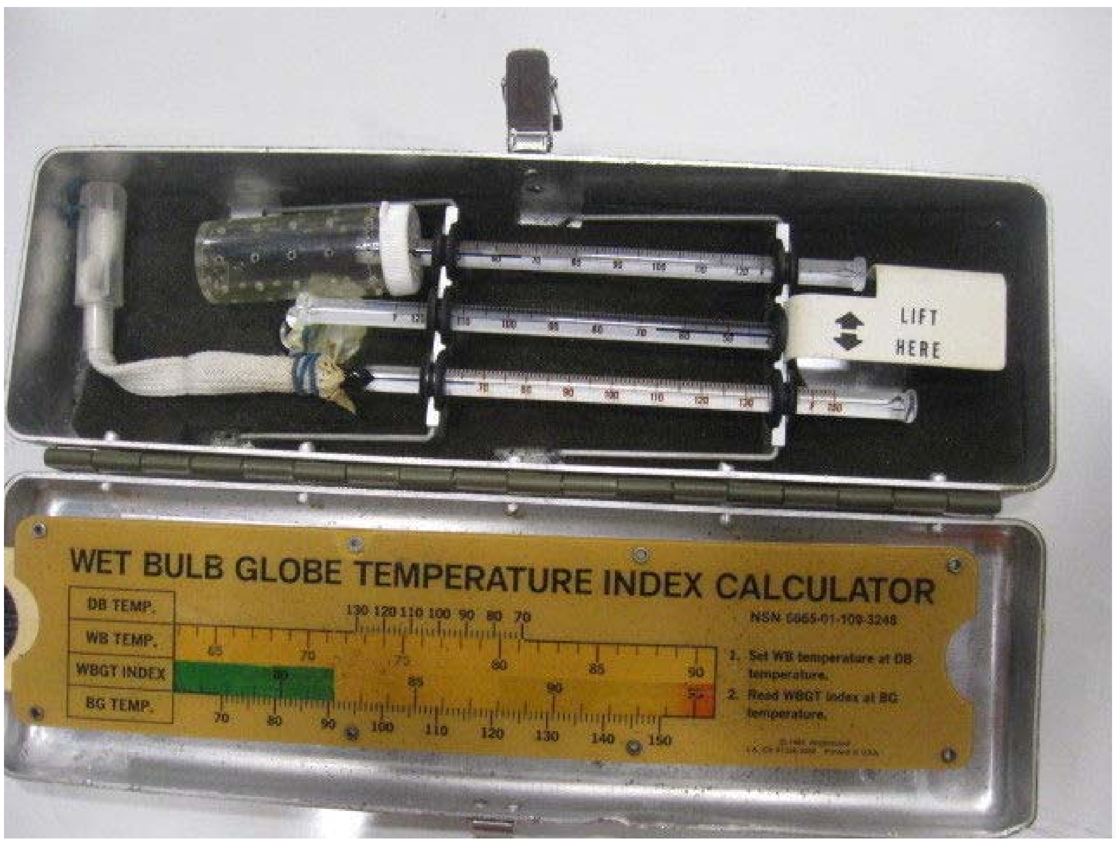
Heart Rate

- The Ingestible CorTemp® (HQ Inc., Pametto FL) sensors also measured HR in conjunction with Polar® (Polar Electro Oy., Kempele, Finland) T31 heart rate straps.

- The emitted HR for each player was received and stored using CorTemp® hand-held recorders (Hq Inc., Pametto FL).

Wet Bulb Globe Temperature

- A Wet Bulb Globe Temperature (WBGT) Index Calculator (Signma Product & MFG Inc., Fort Mill, SC) was used to measure WBGT on the designated days.



Data Collection On The Field

- Subjects swallowed The Ingestible CorTemp® sensors ~5 hrs prior to practice.
- Subjects reported to receive HR strap
- Baseline T_c and HR were recorded.
- Every 10 minutes throughout practice, T_c and HR were recorded using CorTemp® hand-held recorder.
- WBGT measurements were recorded 3-4 times during practice.

Data Collection

- **Post practice:** Subjects returned HR strap
- T_{cmax} and HR_{max}, were recorded

Statistical Analysis

- Statistical analysis was performed using the Statistical Package of Social Sciences (v.22; SPSS, Chicago, IL).

- **Unpaired t-tests:**
  - To compare between group differences

- **Separate group by day repeated measures ANOVA:**
  - To compare variables across days between groups

- **Paired t-tests:**
  - To compare variables with groups combined across days

Results

Subject	Position	Age (yr)	Height (cm)	Weight (kg)	BSA/mass (cm^2)	VO_{2peak} (ml•kg•min)
1	BK	19	190.5	86.64	248.38	49.28
2	BK	20	167.64	78.47	239.71	45.15
3	BK	21	182.88	89.81	236.17	46.73
4	BK	21	180.34	91.17	231.76	52.21
5	BK	20	180.34	91.63	231.15	42.46
6	BK	20	177.8	102.06	214.97	50.96
7	BK	20	177.8	94.8	224.37	48.36
8	BK	21	182.88	92.99	231.53	42.46
9	BK	21	180.34	97.98	222.39	47.08
10	BK	20	177.8	82.09	243.76	56.17
11	BK	19	187.96	85.05	248.56	57.02
12	LM	21	175.26	94.8	222.05	46.94
13	LM	21	185.42	97.07	228.19	53.52
14	LM	21	180.34	98.88	221.28	44.74
15	LM	19	182.88	111.13	208.94	40.34
16	LM	21	177.8	128.14	188.62	35.46
17	LM	20	180.34	105.69	212.89	39.49
18	LM	21	185.42	107.5	210.88	42.46
19	LM	20	190.5	125.64	200.57	41.11
20	LM	21	185.42	126.28	196.15	37.6
	Mean	20.35	181.48	99.39	223.12	45.98

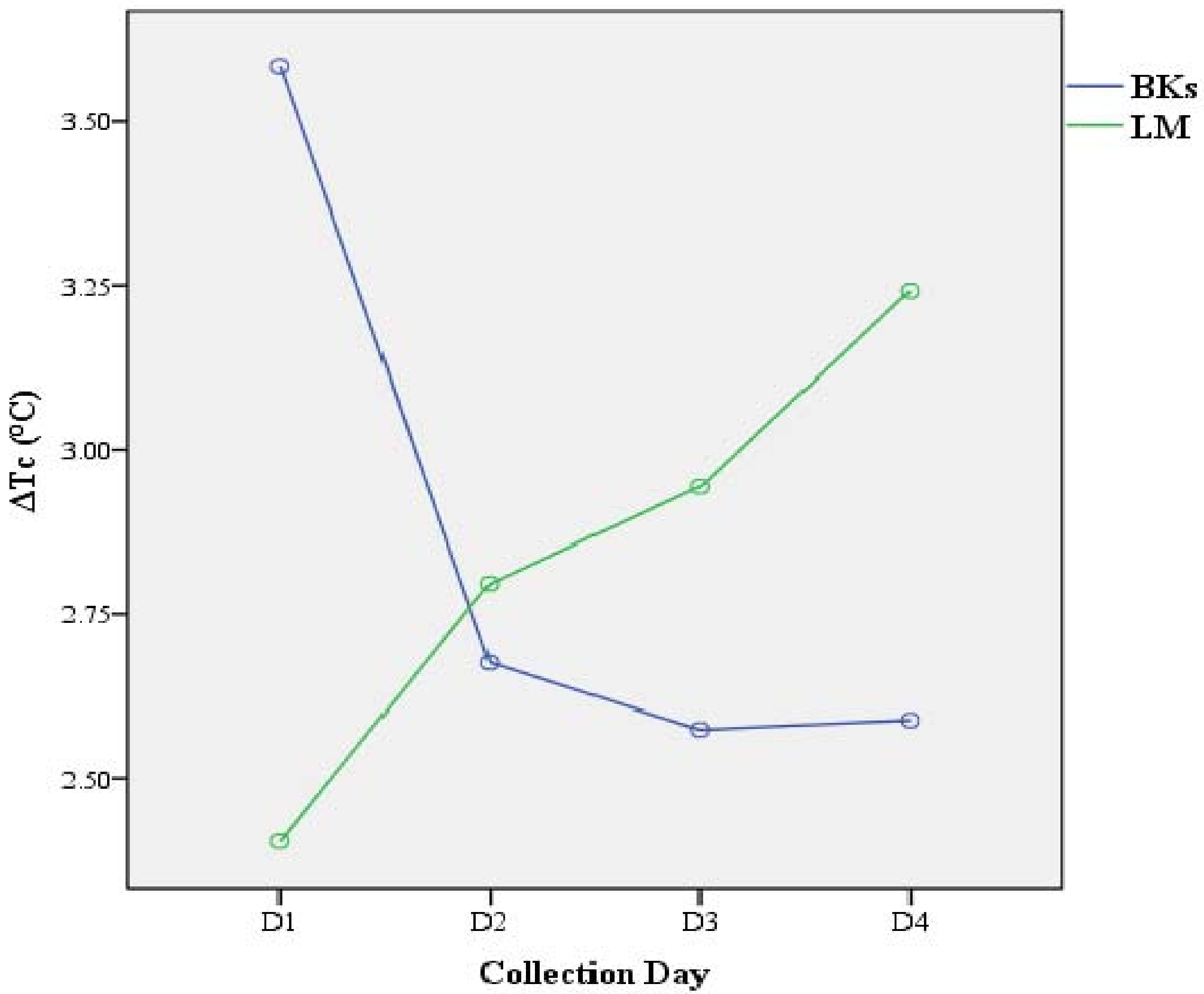
Results – Between Groups

- BSA/mass (cm^2) was higher in BKs (233.9 $\pm$ 10.8) vs. LM (209.95 $\pm$ 12.99), ($P<0.005$).
- VO_{2peak} (ml/kg•min) was higher in BKs (48.9 ± 1.5) vs. LM (42.4 ± 5.4), ($P=0.012$).

Results - Between Groups

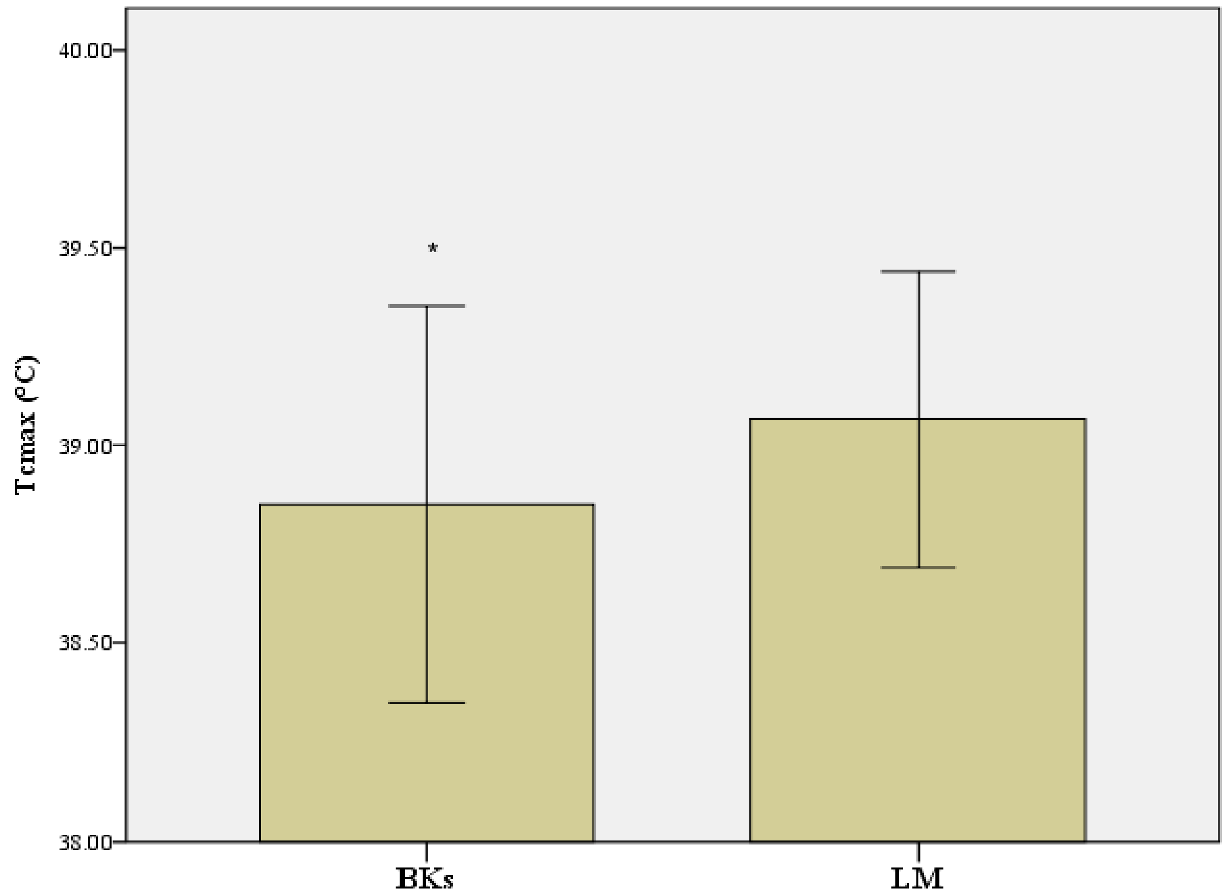
- A significant group by day (D1-5) interaction in ΔT_c $F(3.09,3.11)=3.63$, (P=0.017).
  - Post-hoc analysis revealed that BKs had significantly (P=0.02) higher ΔT_c (D1) (3.47 ± 1.23°C) vs. LM (2.34 ± 0.69°C).
  - On D4, the ΔT_c was lower in the BKs (2.59 ± 0.71°C) vs. LM (3.24 ± 0.79°C) but was not significant (P=0.11).

ΔT_c across days between BKs vs. LM



Results – Between Groups

- Overall T_{cmax} (D1-5) was significantly higher in LM (39.1 ± 0.19°C) vs. BKs (38.8 ± 0.36

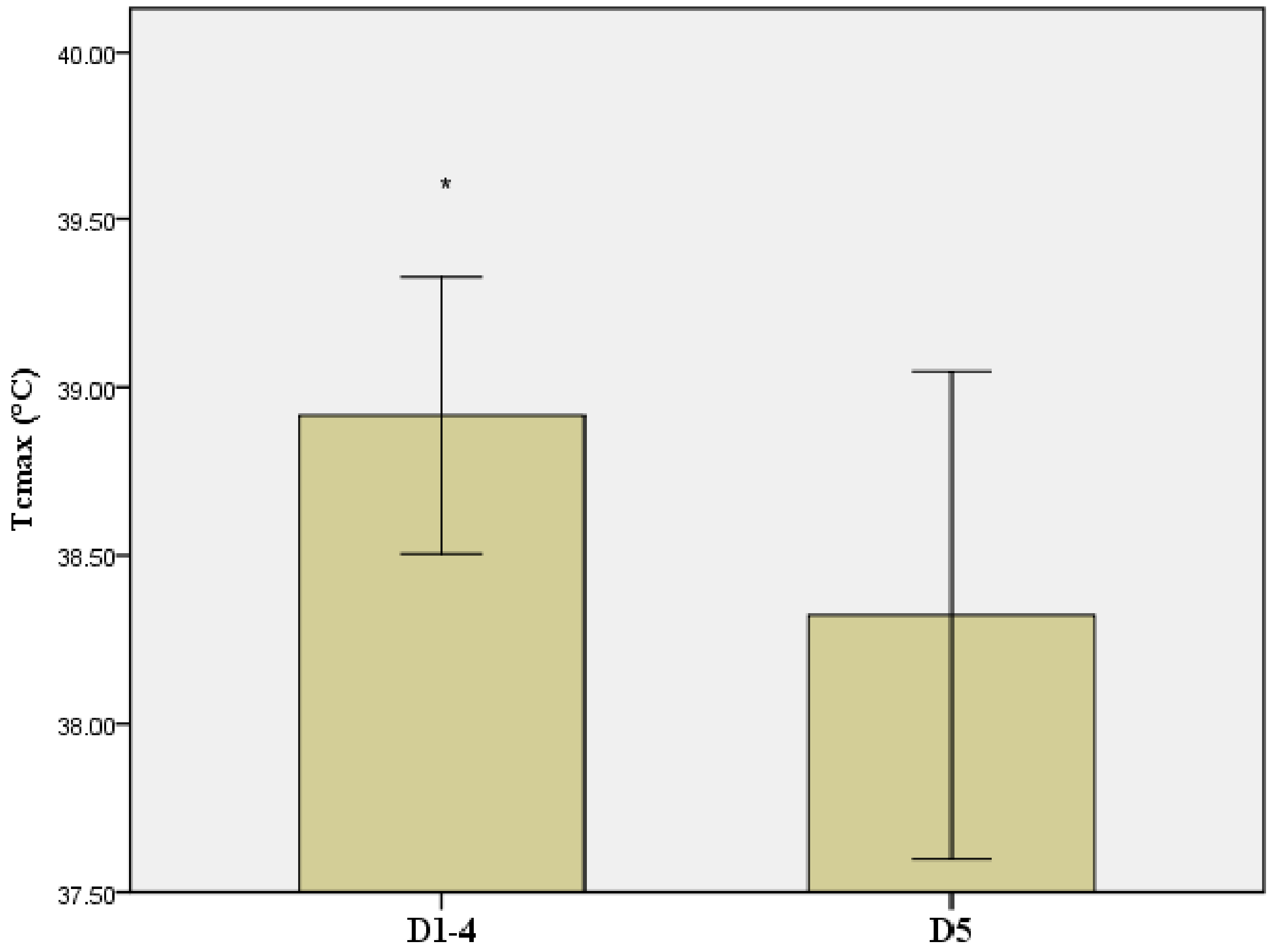


Acclimatization Results: Paired t-tests

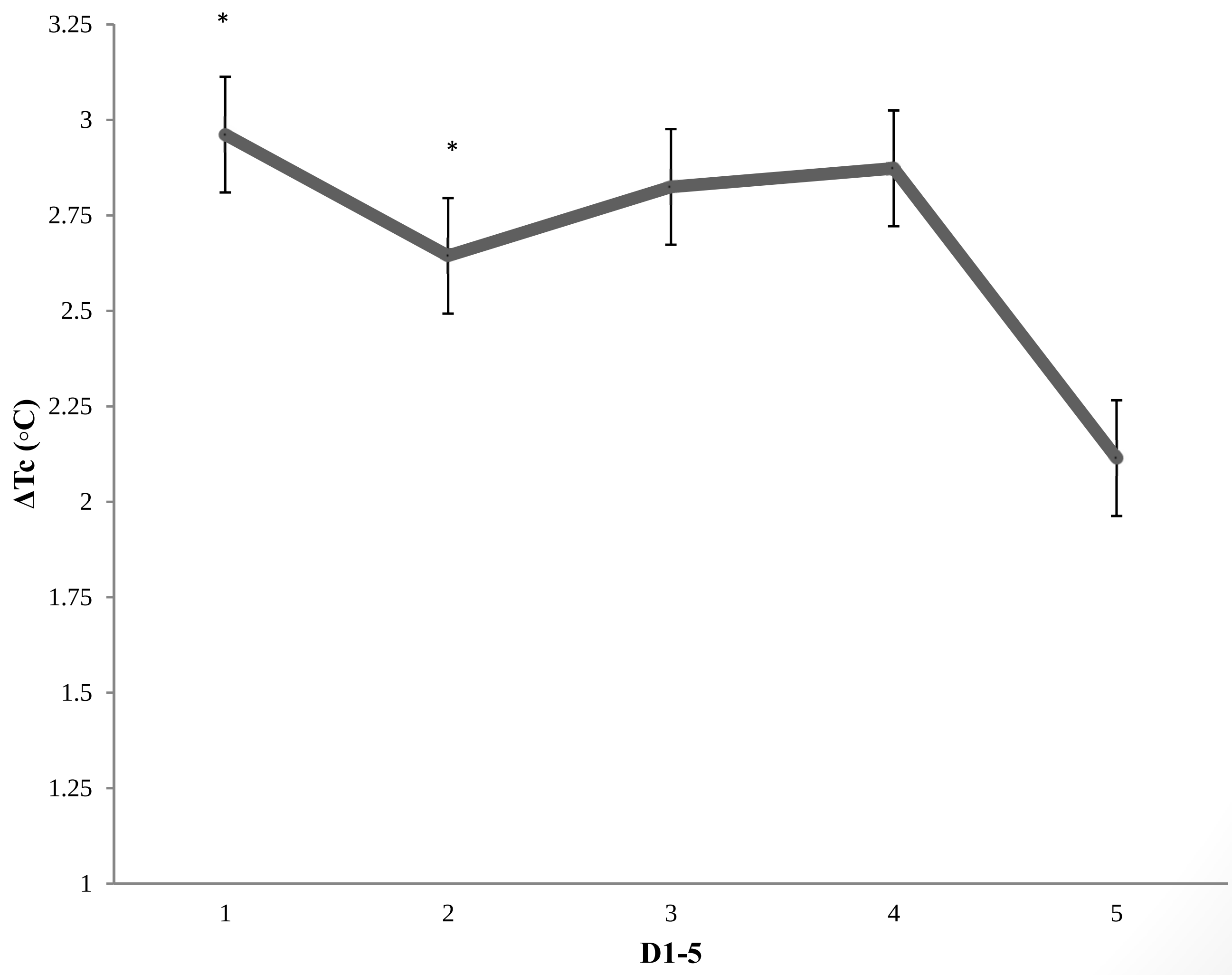
- With groups combined, T_{cmax} (D1-4) (38.92 ± 0.205°C) was significantly higher than T_{cmax} (D5) (38.32 ± 0.362°C), ($P<0.05$).

- ΔT_c (D1-4) (3.89 ± 0.78°C) was significantly higher than ΔT_c (D5) (2.11 ± 0.76°C), ($P<0.05$).

Tcmax (D1-4) vs. Tcmax (D5)



ΔT_c Across Days in All Subjects.

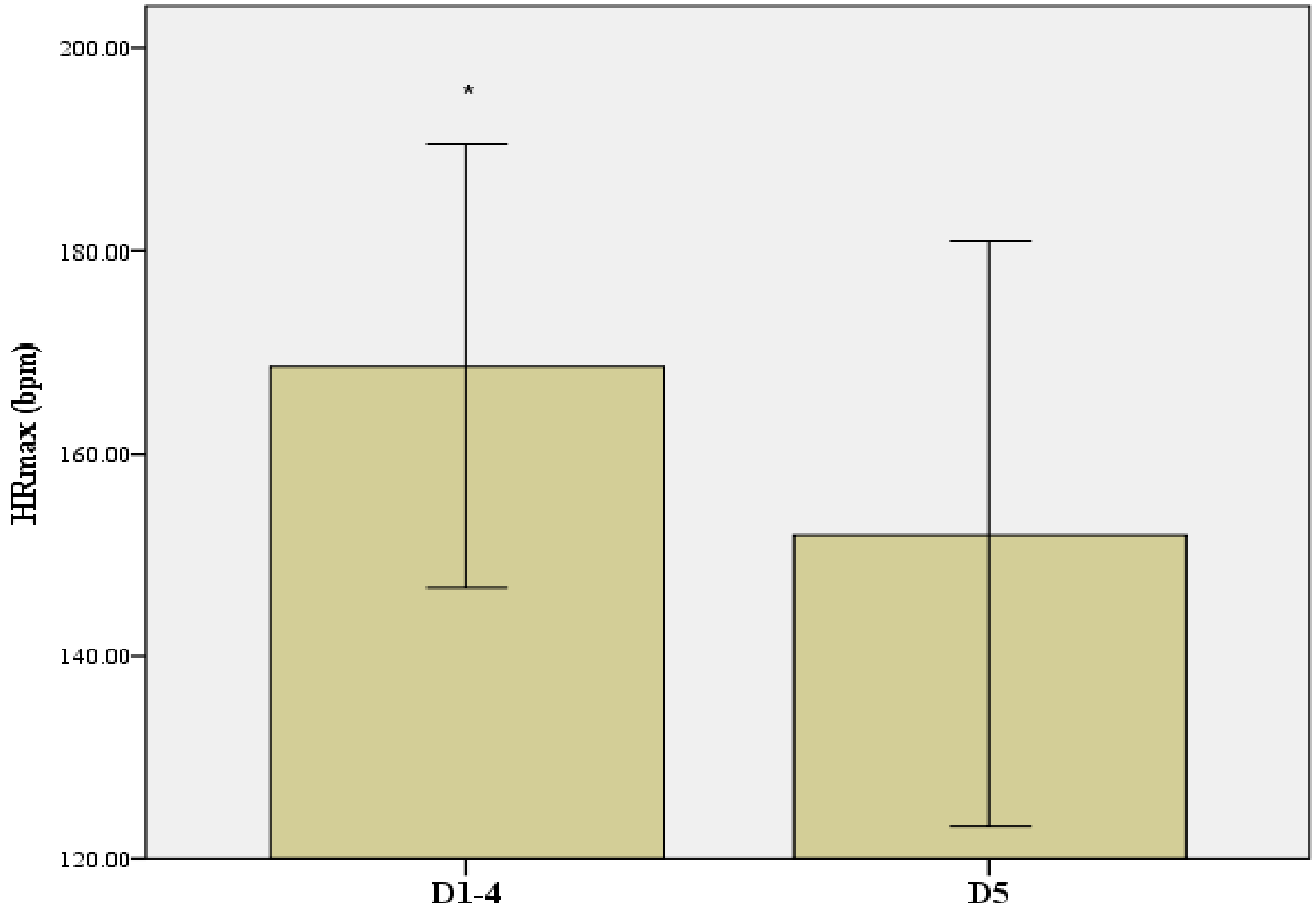


Acclimatization Results – Paired t-tests

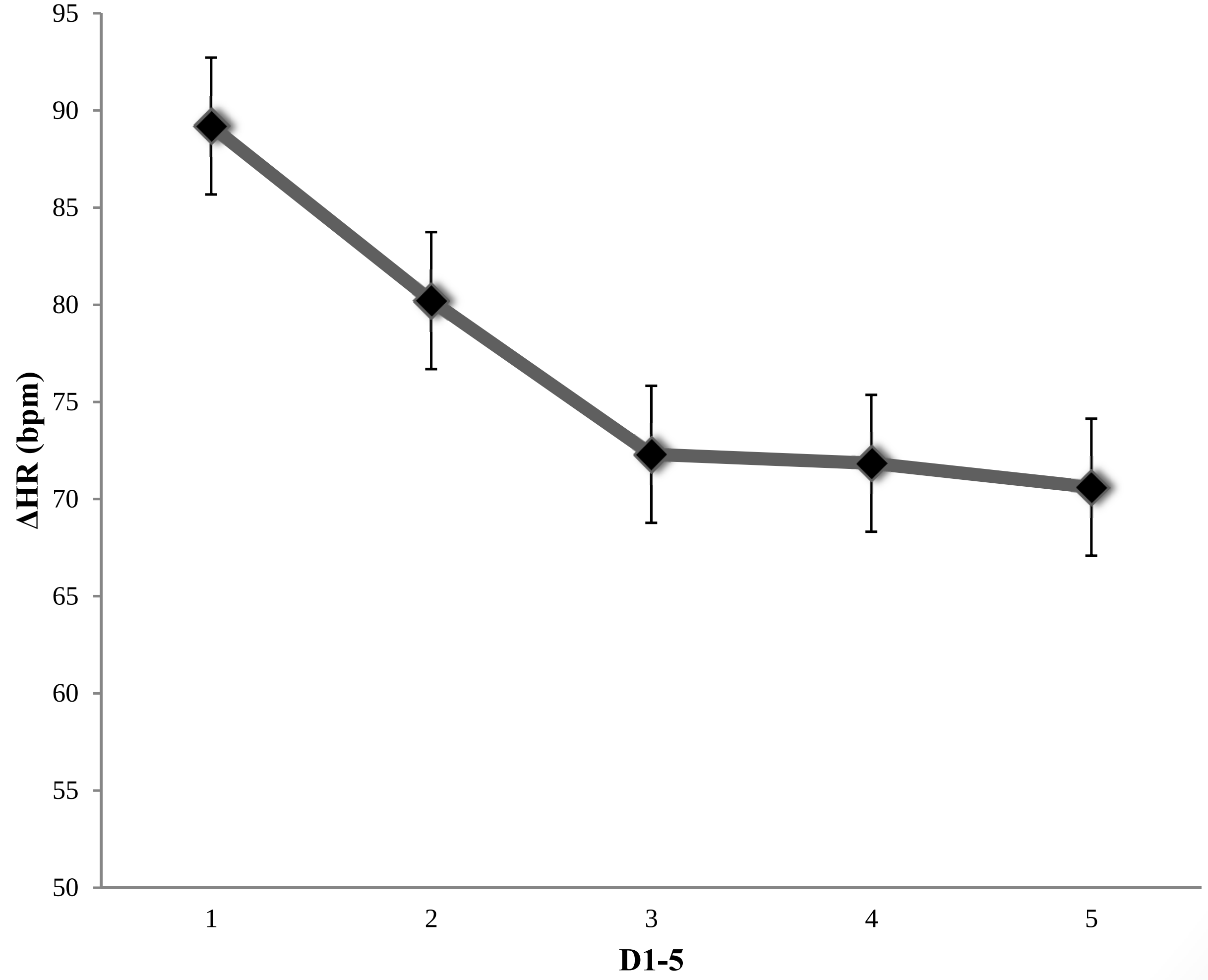
- HR_{max} (D1-4) (168.62 ± 10.94 bpm) was significantly higher than HR_{max} (D5) (152.06 ± 14.43 bpm), (*P*=0.003).

- Similarly, ΔHR (D1-4) (92.31 ± 16.4 bpm) was significantly higher than ΔHR (D5) (70.61 ± 12.98 bpm), (*P*=0.001).

HR_{max} (D1-4) vs. HR_{max} (D5)



ΔHR Across Days in All Subjects



Discussion

Discussion

- We were able to show that these groups differed in terms of body size (BSA/mass) and fitness level (VO_{2peak}).
- The LM were bigger and less fit when compared to the BKs.[19-21]
- This resulted in higher overall T_{cmax} (D1-5) values compared to BKs.[19-21]
  - The variable of T_{cmax} between LM and BKs has only been reported in 3 previous studies in the literature.[19-21]
- LM showed greater variability (ΔT_c) vs. the BKs
  - T_c variability has never been reported

Discussion

- We were able to show that all subjects showed signs of acclimatization within 10 days of pre-season
- T_{cmax} and HR_{max} values were lower on D5 of pre-season vs. D1-4
- ΔT_c and ΔHR showed less variability on D5 vs. D1-4

Conclusions

- LM can be at a higher risk of suffering from EHI longer throughout pre-season due to:
  - Lower BSA/mass vales,
  - Lower VO_{2peak} values,
  - The result of higher T_{cmax} values.
- The results of this study provide pertinent information for the identification of individuals at risk for EHI.

Conclusions

- **EHI Prevention:**
- Follow proper acclimatization guidelines (10-14 days)
  - Gradual addition of padding and equipment
  - Single day practices for the first initial days

- Identify possibly at-risk athletes
  - Larger, less aerobically fit

- Emphasize Aerobic exercise in off-season conditioning
  - Not just lifting!

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