ONE SIZE DOESN’T FIT ALL IN REGARDS TO MEASURING CORE BODY TEMPERATURE

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OBJECTIVES

• Foster an Open Discussion

• Enhance Research Interest
BOC DISCLOSURE

- The *NATA Position Statement: Preventing Sudden Death in Sports* clinical recommendations are current best practice for the profession of Athletic Training at this time.
- Clinical Bottom Line: Review best practice for other possible alternatives as it relies to CBT measures.
- I have no actual or financial relationship with products discussed or agencies reviewed nor can I warrantee their product.
- My views may not be the same as the views of my colleagues (Other AT’s).
- Participants must use discretion when using the information contained in this presentation.
• (EBP) Identify potential methods to enhance practice (modalities, concussion, etc)
• Identify the components of and create a PICO question
• Review the Strength of Recommendation Taxonomy (SORT) levels
• NATA Position Statement
  – Address as best current standard
  – Consider social and legal implications
• Identify methods to assess Core Body Temp (CBT)
  – Article Review
  – Clinical Bottom Line (Definitions)
  – Including strengths and weaknesses of each
  – Side by side literature review
• Introduce current research outcomes and plans
• Generate a self lead critical review of your own practice guidelines related to Exertional Heat Stroke (EHS)
Define EBP

- EBP is "the conscientious, explicit and judicious use of current best evidence in making decisions about the care of the individual patient. It means integrating individual clinical expertise with the best available external clinical evidence from systematic research." (Sackett D, 1996)
  - Focused and clinically relevant (PICO)
  - Search arising from a clinical question (Search terms)
  - Critical appraisal of relevant literature (SORT)
  - Clinical application of evidence and appraisal of the outcome (Pilot Study)
The best evidence is usually found in clinically relevant research that has been conducted using sound methodology. (Sackett D, 2002)
PICO COMPONENTS

- **PICO**
  - **Patient / Population / Problem**
    - Who are your patients?
    - What age group, what sex, what population do they belong to (athletics, etc)?
    - What is the health concern?
    - Example: For persons entering a health care facility…
  - **Intervention, prognostic factor, exposure**
    - What therapeutic, diagnostic, or preventative intervention are you interested in (does LLLT work?)
    - What have patients been exposed to?
    - Example: For persons entering a health care facility, is hand rubbing with waterless alcohol solution…..
PICO COMPONENTS

- **PICO**
  - **Comparison**
    - Alternative, nothing, different test, placebo
    - Compare to current standard
    - Example: For persons entering a health care facility, is hand rubbing with waterless alcohol solution, as effective as standard hand washing with antibacterial soap…..
  - **Outcomes**
    - What's accomplished, measured, improved, relief…
    - How is population affected
    - How is desired outcome evaluated
    - Example: For persons entering a health care facility, is hand rubbing with waterless alcohol solution, as effective as standard hand washing with antibacterial soap for reducing hand contamination?

Effectiveness Education Cincinnati Children's Hospital
PICO Model

Create one in regard to today's presentation

- **Patient / Population / Problem** (among _____)
- **Intervention / Exposure** (does _____)
- **Comparison** (versus ______)
- **Outcome** (affect ______)

Effectiveness Education Cincinnati Children's Hospital
# Strength of Recommendation Taxonomy (SORT)

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<th>Strength of Rec</th>
<th>Definition</th>
<th>Interpretation</th>
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<td>A</td>
<td>Recommendation based on consistent and good-quality patient orientated evidence</td>
<td>High quality RCTs, consistent findings</td>
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<tr>
<td>B</td>
<td>Recommendation based on inconsistent or limited-quality patient orientated evidence</td>
<td>Lower quality clinical trials with inconsistent findings</td>
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<tr>
<td>C</td>
<td>Recommendation based on consensus, usual practice, opinion, or screenings</td>
<td>Consensus guidelines, extrapolations</td>
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EXERTIONAL HEAT STROKE

Recommendations

Prevention

1. In conjunction with preseason screening, athletes should be questioned about risk factors for heat illness or a history of heat illness. Evidence Category: C
2. Special considerations and modifications are needed for those wearing protective equipment during periods of high environmental stress. Evidence Category: B
3. Athletes should be acclimatized to the heat gradually over a period of 7 to 14 days. Evidence Category: B
4. Athletes should maintain a consistent level of euhydration and replace fluids lost through sweat during games and practices. Athletes should have free access to readily available fluids at all times, not only during designated breaks. Evidence Category: B
5. The sports medicine staff must educate relevant personnel (e.g., coaches, administrators, security guards, EMS staff, athletes) about preventing exertional heat stroke (EHS) and the policies and procedures that are to be followed in the event of an incident. Signs and symptoms of
Recognition

6. The 2 main criteria for diagnosis of EHS are (1) core body temperature of greater than 104°F to 105°F (40.0° to 40.5°C) taken via a rectal thermometer soon after collapse and (2) CNS dysfunction (including disorientation, confusion, dizziness, vomiting, diarrhea, loss of balance, staggering, irritability, irrational or unusual behavior, apathy, aggressiveness, hysteria, delirium, collapse, loss of consciousness, and coma). Evidence Category: B

7. Rectal temperature and gastrointestinal temperature (if available) are the only methods proven valid for accurate temperature measurement in a patient with EHS. Inferior temperature assessment devices should not be relied on in the absence of a valid device. Evidence Category: B

Treatment

8. Core body temperature must be reduced to less than 102°F (38.9°C) as soon as possible to limit morbidity and mortality. Cold-water immersion is the fastest cooling modality. If that is not available, cold-water dousing or wet ice towel rotation may be used to assist with cooling, but these methods have not been shown to be as effective as cold-water immersion. Athletes should be cooled first and then transported to a hospital unless cooling and proper medical care are unavailable onsite. Evidence Category: B
Heat Stroke Treatment Authorization Form

The National Athletic Trainers’ Association Preventing Sudden Death in Sports Position Statement is a research-based, peer-reviewed document that specifies model practices for treating conditions in athletes such as exertional heat stroke.

The position statement calls for taking a rectal temperature of those suspected of having exertional heat stroke. “The only accurate measurements of core body temperature are via rectal thermometry or ingestible thermistors. Other devices, such as oral, axillary, aural canal and temporal artery thermometers, are inaccurate methods of assessing body temperature in an exercising person.”

“The evidence strongly indicates that in patients with suspected exertional heat stroke, prompt determination of rectal temperature, followed by aggressive, whole-body cold-water immersion maximizes the chances for survival. Practitioners in settings in which taking rectal temperature is a concern should consult with their administrators in advance.”

This form facilitates that opportunity for consultation.

Authorization

I am the duly appointed representative of ____________________________ (school or employer). By circling a choice and signing below, I am directing the athletic trainer(s) at ____________________________ (school or employer) to determine core temperature via rectal thermometer

or

not to determine core temperature via rectal thermometer

in cases of suspected exertional heat stroke.

When rectal temperature is not utilized, I understand the position statement makes the following recommendation. “Because immediate treatment is critical in exertional heat stroke, it is important to not waste time by substituting an invalid method of temperature assessment. Instead, the practitioner should rely on other key diagnostic indicators (e.g., CNS dysfunction, circumstances of the collapse). If exertional heat stroke is suspected, cold-water immersion should be initiated at once.”

____________________ Administrator/Date  ________________ Team Physician/Date  ________________ Head Athletic Trainer/Date
SOCIAL AND PROFESSIONAL ISSUE

- Legal risk for not following current NATA Position Statement.
- Legal risk of not having a plan in place prior to an EHS event.
  - May have consent for your athletes, what if you host a XC meet, etc
- Local jurisdictions can supersede (States set scope of practice, not NATA, not BOC)
  - Jurors
  - Athletic Directors
  - Team Physician
  - School Board
  - Etc.
VALIDITY OF DEVICES THAT ASSESS BODY TEMPERATURE DURING OUTDOOR EXERCISE IN THE HEAT

• Well done study by Casa, et al.
• Revisit the devices
  – Oral digital (2 types based on cost)
  – Axillary digital (2 types based on cost)
  – Aural/Tympanic (Braun IRT)
  – Forehead sticker
  – Temporal
  – Rectal (Thermistor)
  – Compared to Rectal, declared unreliable if deviated from rectal beyond ± 0.27 degrees C.
  – Maybe each area is actually different and not unreliable (blood flow)
The purpose of this presentation is to review the various existing methods to assess CBT in order to focus on the breakthrough needed for a simple, non-invasive, universally accepted device for CBT measurement which is essential for preventing EHS.

- **Universally accepted**
  - Reliable
  - No need for disclaimer due to possible social unacceptability (patient or clinician discomfort) or fear of legal implications
  - Less labor intensive

EHS S&S

• Heat Exhaustion:
  – Alert, CBT<40 C (104 F)
  – Cool environment, oral hydration

• Heat Stroke:
  – Classic (hot environment)
  – Exertional Heat Stroke (EHS) (Exercise)
    • Altered mental status, CBT >40 C
    • Rapid cooling, spray with cold water (evaporative), ice bags (convective), and fanning
      – Debate over immersion and shunting of blood to core secondary to vasoconstriction
        » Hard to study and also compare between 35 – 50 degree F water.

METHODS TO ASSESS CBT

- Bladder (catheter)
- Esophagus (catheter/thermistor, sedated)
- Intestinal (ingested, time delay)
- Nasopharynx
- Pulmonary artery (invasive/risk)
- Rectal (invasive/safe)
- Tympanic (infrared/thermistor)
- Temporal
**PROS AND CONS OF EACH METHOD**

- **Bladder**
  - Catheter, slow to respond, used during surgery (Pompei)

- **Esophagus (catheter/thermistor, sedated)**
  - Agree well with temporal and are not significantly different than rectal (Al-Mukhaizeem)
  - Placement about the level of the heart is important

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• Intestinal (Telemetry)
  – Ingested, time delay, not for emergency, expensive!
  – (Contra) Intestinal disease, MRI
  – Mixed results: Lower than rectal, consistent with esophageal (Kolka. Sparling)

• Nasopharynx
  – Measured at a position closest to brain reflects epidural brain temp more closely than rectal (Hae-Kyung)

Kolka, Margaret A.; Levine, Leslie; Stephenson, Lou A. Accuracy of a Commercially Available Telemetry System to Measure Core Temperature during Exercise when Wearing Chemical Protective Clothing. Army Research.
PROS AND CONS OF EACH METHOD

- Pulmonary artery
  - Invasive/risk
- Rectal
  - Invasive/safe
  - \( p = .000 \)
  - \( r = 0.98 \)

Kolka, Margaret A.; Levine, Leslie; Stephenson, Lou A. Accuracy of a Commercially Available Telemetry System to Measure Core Temperature during Exercise when Wearing Chemical Protective Clothing. Army Research.
PROS AND CONS OF EACH METHOD

• Pulmonary artery
  – Invasive/risk

• Tympanic (heat balance)
  – Thermistor
  – \( p = 0.000 \)
  – \( r = 0.98 \)

• Tympanic
  – Infrared
  – Inconsistent!

• Kolka, Margaret A.; Levine, Leslie; Stephenson, Lou A. Accuracy of a Commercially Available Telemetry System to Measure Core Temperature during Exercise when Wearing Chemical Protective Clothing. Army Research.
**Pros and Cons of Each Method**

- **Pulmonary artery**
  - Invasive/risk
- **Temporal**
  - Consistent with PAC (Kolka)
  - Not sufficiently Accurate to replace Rectal (Hebbar)

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- Kolka, Margaret A.; Levine, Leslie; Stephenson, Lou A. *Accuracy of a Commercially Available Telemetry System to Measure Core Temperature during Exercise when Wearing Chemical Protective Clothing*. Army Research.
**Blood Flow During Exercise**

- Splanchnic blood flow (liver, entire GI tract) is inversely proportional to intensity of exercise. May drop 20-50% and remain lower for 30 minutes of rest.

- Cerebral Blood Flow increases during exercise. Several factors impact but reported is from 5-30%. Specific in several animal models to the vestibular and visual regions of the brain.

LITERATURE STATEMENTS TO CONSIDER

- Intestinal and esophageal not different, greater than rectal (lags)
- Ear phone type IR thermometer can be used reliably during surgery (measure hypothermia)
- Brain temp can be higher than core during hyperthermia, some athletes can tolerate rectal temps above recommended (concern)
- Rectal should be used in EHS (ACSM, NATA)
- Infrared tympanic doesn’t accurately predict CBT
- Tympanic thermistors are one of the best indicators of CBT
LITERATURE STATEMENTS TO CONSIDER

- Rectal measurements are invasive and positioning in non-compliant patients can be difficult
- The core thermal compartment can be evaluated using pulmonary, esophagus, tympanic, and nasopharynx even though there may be transient real differences between them. Rectal lags behind and is considered an intermediate site.

* Engels, HJ., Yarandi, HN., Davis, JE., Utility of an ingestible capsule fore core temperature measurements during body warming. JEP. 2009; Feb 12(1).
LITERATURE STATEMENTS TO CONSIDER

• Tympanic temperature accurately reflects pulmonary artery temperature when body temperature is rapidly changing.

• Systematic review states rectal temp to be 36.7-37.5 and tympanic to be 35.5-37.5 in for adult males. More studies needed.

• Esophageal temperature is a good measure of CBT and tympanic membrane temperature is a good indicator of cerebral blood temperature.

• Evidence supports using oral even if it takes longer than IR tympanic, its also more acceptable to users than rectal. Ingestible sensors are acceptable surrogate.

• Lim, CL., Byrne, C., Lee, JKW. Human thermoregulation and measurement of body temperature in exercise and clinical settings, 2008; 37(4)
Literature Statements to Consider

• Given the proximity to the internal carotid artery, the tympanic membrane temperature, when measured by thermocouple is considered to represent true CBT.

• In 2447 subjects age 12 hrs to 103 years, normal body temp was 36.51±0.46°C in adults using IR Temporal thermometry.

• Tympanic thermometry is a reliable method to measure temperature with a change of 0.6°C being significant with M = 36.65°C.

• Tympanic temperature when measured accurately is a good index of CBT and its variations may reflect variations in brain temperature.


LITERATURE STATEMENTS TO CONSIDER

• Accuracy of noninvasive core temperature measurement in acutely ill adults: The state of the science. (Meta-Analysis)
  – Compared tympanic, temporal, and oral to esophageal or pulmonary
  – Difference between devices and accuracy (IE: thermistor and IR)
  – Pull vs no-pull to straighten out ear canal when using IR tympanic
  – Supported oral held in the sublingual pocket over tympanic

Literature Statements to Consider

- Several State EMS and ERs are not taking rectal
  - Exception is in hypothermic cases
- No one measure completely characterizes CBT
  - Varies by 2-4 Centigrade
  - Best practice might be 2 or 3 sites (tympanic, temporal, oral, rectal, etc)

- It's worthy of further research
Purpose:
- Assess the relationship between rectal temperature measures of core body temperature and earplug measures of core body temperature at rest and then during heat stress events

Events:
- Bike (various intensities), Water baths (various temperatures)

Objective:
- Determine reliability between measures or disparities depending on the physiological stress and the bodies response
CURRENT RESEARCH

• Methods:
  – Earplug Temperature Measurement
    • Soft foam ear plug (hair size)
  – Rectal
    • Flexible, size of # 2 lead
• **Methods:**
  - BMI, HR, Exercise and Health History
  - Estimate VO$_2$ (George Non-Ex Test) and Watts
  - Establish 40 and 65% max, each for 20 minutes
  - 10 minutes rest before and after
• **Descriptives:**
  - Room 24.4±1.1 degrees Centigrade (73-77 F)
  - 9 Fit Healthy Participants
    - Tympanic measures (n = 3240): 37.06 ± .56
    - Rectal (n = 3240): 37.60 ± .42
      - Statistically different ($t_{3239} = -51.371, p = .000$)
      - Significantly related ($p = .000$) relationship is a weak positive ($r = .269$).
      - If predicting $r^2 = .072$ (7.2% of the variability)
RESULTS (PILOT!)

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RESULTS (PILOT!)
At the moment can predict rectal from tympanic but can only account for 7% of the variance. Not meaningful if you consider blood shunting and low participant numbers (not capturing between subjects variability).

- Tympanic ($F_{1,3239} = 252.070, p = .000$) ($r^2 = .072$)

Had 3 participants excluded with major flaws (equipment failure, placement failure)

Need more research, may consider oral.

Encourage others to explore the questions raised.
• 2 way RM ANOVA
  – Within factor of time (4 levels: 8 minutes, 28 minutes, 48 minutes and 58 minutes)
  – Within factor of temperature type (2 levels: tympanic and rectal)
• There was no interaction present ($F_{3,24} = 1.231, p = .320$)
• Temperature was significantly different ($F_{1,8} = 6.761, p = .032$)
  – Tympanic = 37.105
  – Rectal = 37.697
RESULTS (PILOT!)
CONCLUSIONS

• Pre-mature to make recommendations. This is a limited study that needs to be expanded.
• Need to ensure proper fitted and placed ear plug
• Need to ensure proper placement of thermocouple in ear plug
• Need to stress 8-10 cm rectal thermocouple placement
• Further data collection required
  – Varied exercise intensities
  – Varied temps of water submersion
  – Variable controlled environment
  – High quality studies with validated equipment
  – Maybe look at oral, etc
• Follow NATA PS. Consider Practice Act.
• Get involved in research!