

MARCHING TO THE BEAT OF SAFETY: UNDERSTANDING HEAT STRESS IN MARCHING BAND

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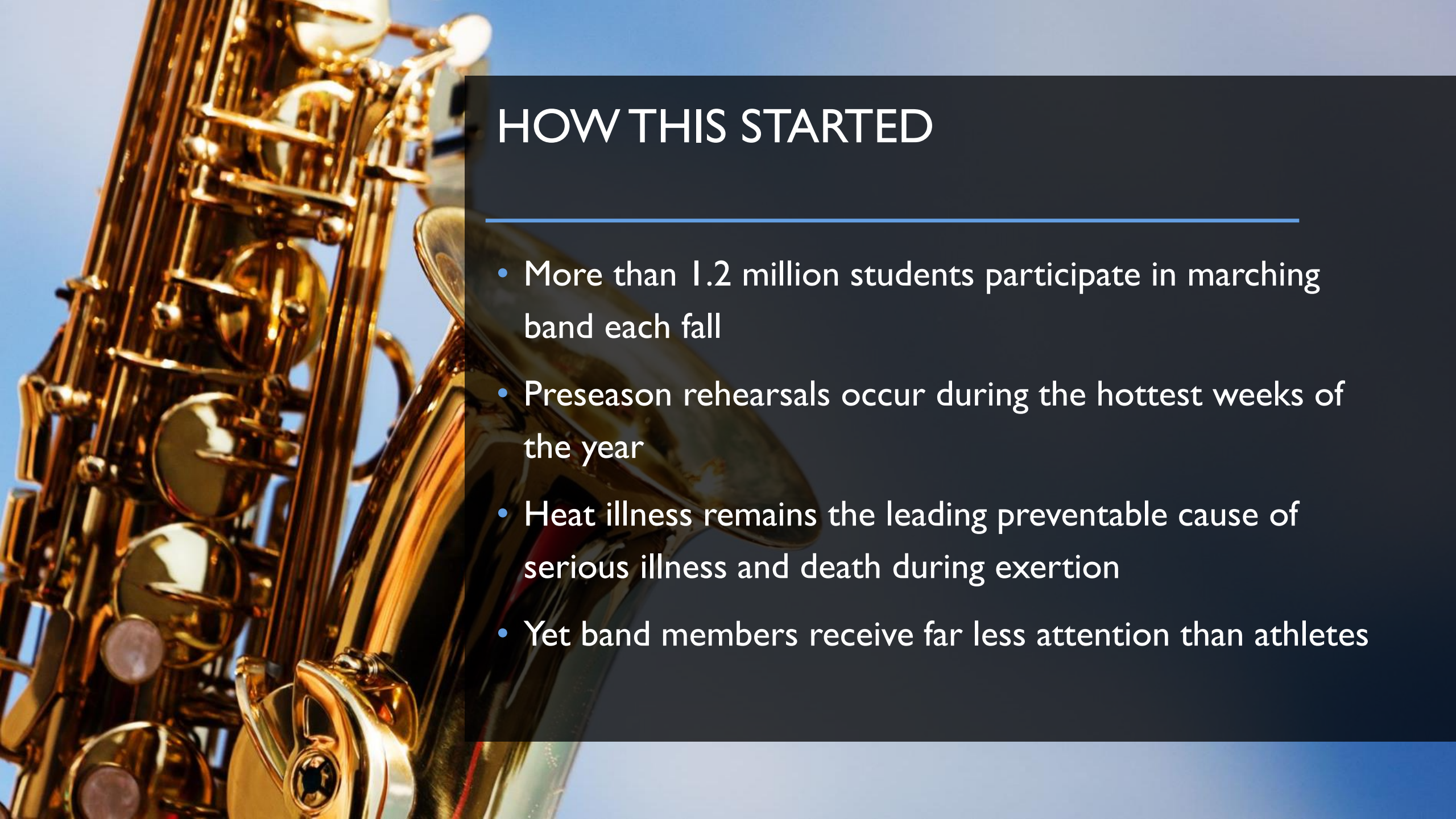
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HOW THIS STARTED

- More than 1.2 million students participate in marching band each fall
- Preseason rehearsals occur during the hottest weeks of the year
- Heat illness remains the leading preventable cause of serious illness and death during exertion
- Yet band members receive far less attention than athletes

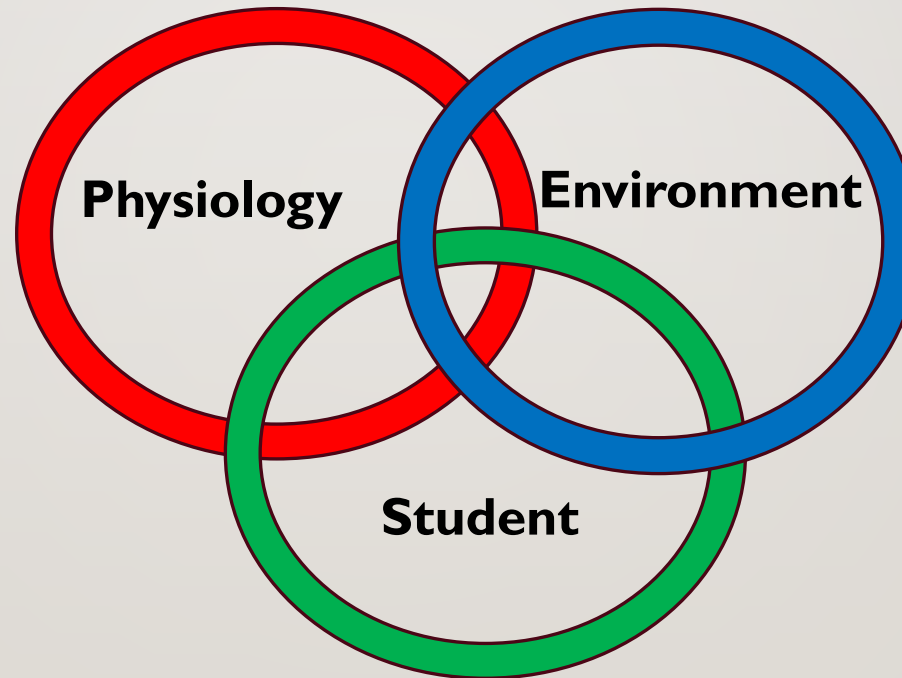
MARCHING BAND IS AN ATHLETIC ACTIVITY

- Sustained exertion (hours at a time)
- Heavy equipment + uniforms
- Precision + performance under stress

This is sustained athletic performance—not just music



THREE PARTS TO THE STUDY



WHAT DATA WE COLLECT



HEART



TEMPERATURE



WEATHER



SURVEY

We're combining objective and subjective data.

HEAT DRIVES SYMPTOMS IN OUR DATASET

- Higher heat → more symptoms
- **WBGT $\geq 70^{\circ}\text{F} \approx 2\times$ likelihood of symptoms**

THE BODY SIGNALS STRESS EARLY

- Heart rate rises before temperature
- Happens before symptoms
- Early warning opportunity



WHAT HAPPENS DURING A HOT PRACTICE



HR RISES → HRV FALLS → CORE TEMP RISES → SYMPTOMS APPEAR

WHAT IS HEART VARIABILITY?

Higher = adaptable

Lower = physiologic stress

Useful early warning signal

Think of this as how responsive the body is.



CAN WE PREDICT HEAT STRAIN BEFORE IT HAPPENS?

Moving from
describing →
predicting

Goal: identify
early warning
signs

Prevent serious
heat illness
before it happens

BUILDING A PREDICTIVE MODEL

INPUT

WBGT	
Heart rate	
HRV	
Core temp	
Symptoms	

OUTPUT

- Risk of physiologic strain



Detected 33 of 38 strain events

Predict risk before collapse

BASELINE FACTORS MATTER

- >60% report a mental health condition or use related medications
- This is higher than the general population (25–30%)
- Students with these conditions:
 - More likely to report fatigue, headache, nausea, lightheadedness
 - More likely to sit out of practice

Students with these conditions may be more vulnerable to heat-related stress



HYDRATION AND NUTRITION MATTER



Water → fewer symptoms



Energy drinks/soda → more symptoms



Skipping meals → lightheadedness

These are modifiable risks.

HEAT EXHAUSTION/STROKE

HEAT EXHAUSTION

- Temp < 104
- Collapse, fatigue, high heart rate
- Gradual rise in temp – 101.3 – 104
- Moderately reduced Heart Rate Variation

HEAT STROKE

- Temp > 104
- Collapse, confusion
- Rapid rise or sustained over 104
- Markedly reduced heart rate variation

HEART RATE

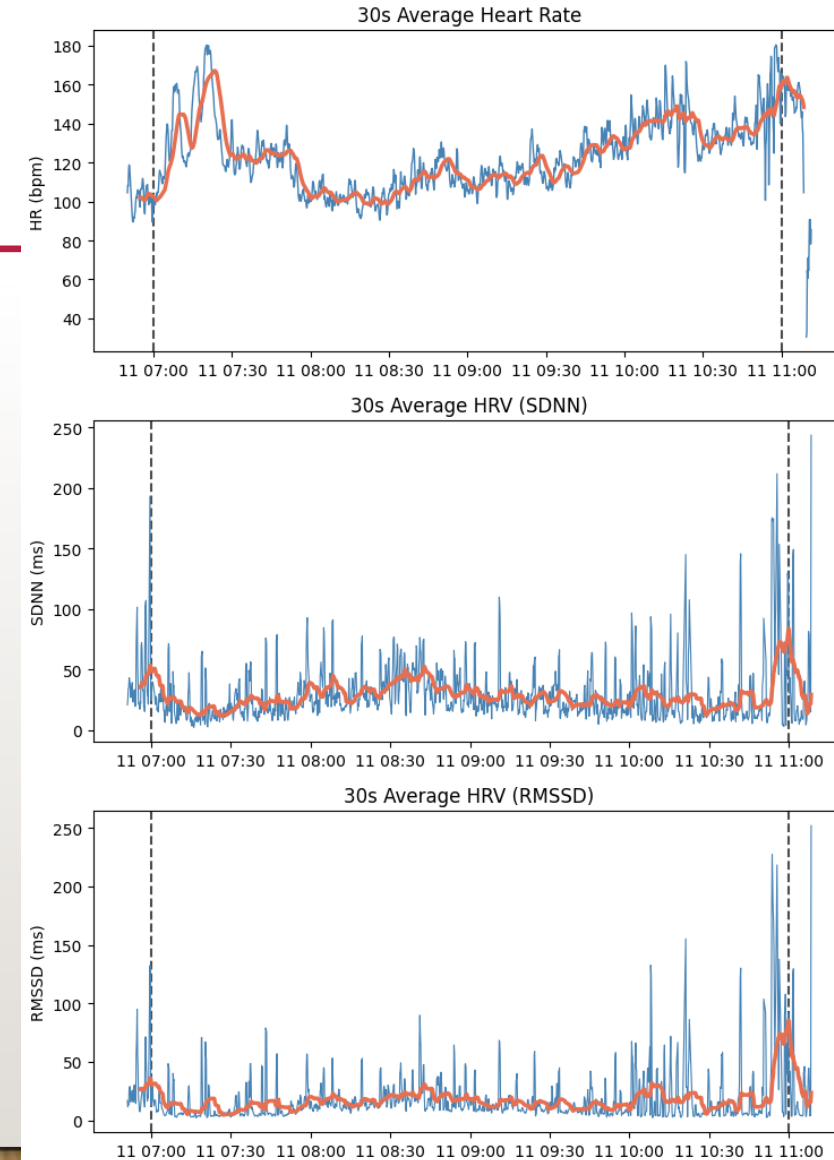
- HR correlates with temperature, core temp has a 5-15 min delay
- HR rises earlier than temperature
 - Early warning signal

RED FLAGS

- Concerning if HR is sustained > 180-age
- Heart rate recovery – failure to drop after rest
- HR/Temp dissociation

HR AND HRV

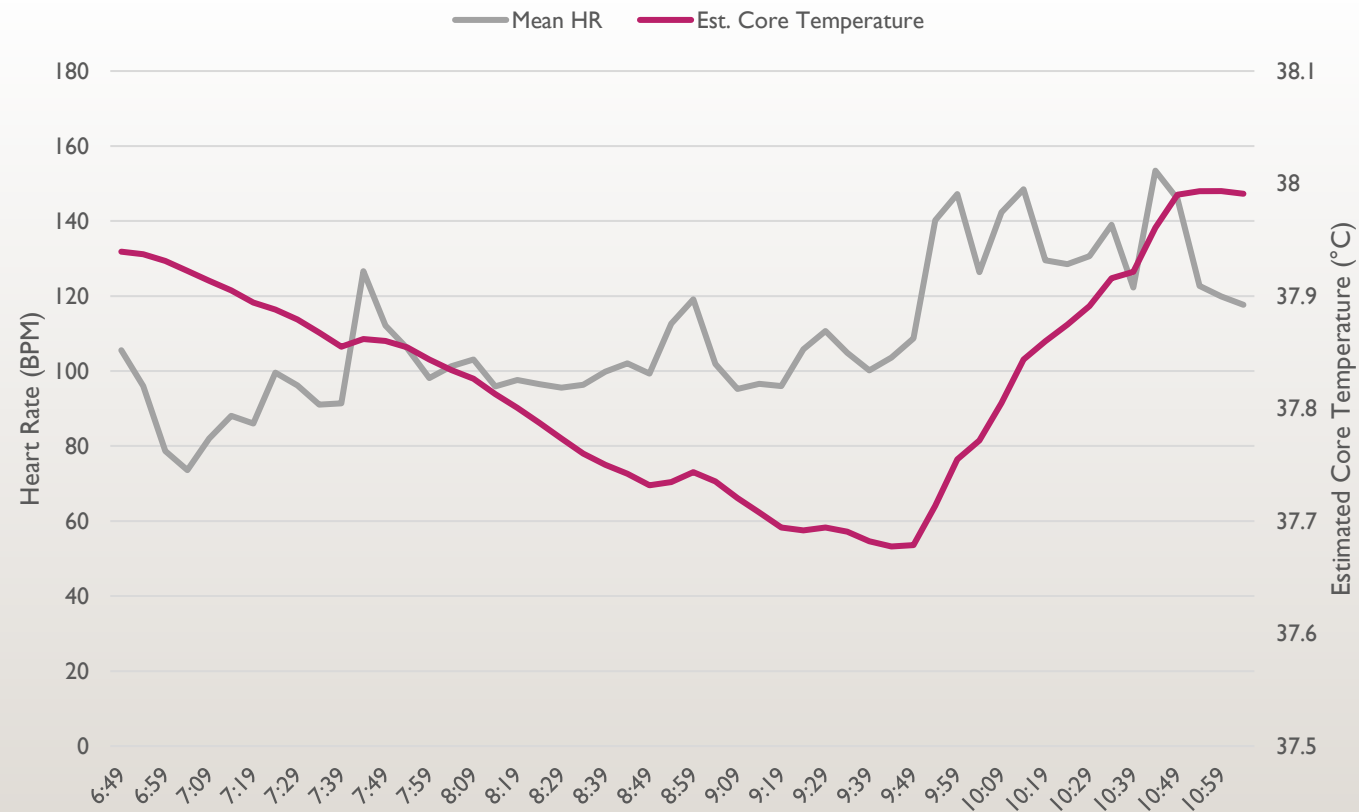
- HR = workload
- HRV = stress
- Blue: HR collected every 10 seconds for last 30 seconds
- Red: 5 minute average HR



HR rises while HRV falls = increasing strain

HEART RATE AND CORE TEMP

HR increases first.
Temperature lags.



CAN WE PREDICT HEAT STRAIN BEFORE IT HAPPENS?

- **Goal:** Predict **physiologic strain 10 minutes before it occurs**
- **Outcome Definition:** Students were considered to have physiologic strain when they developed:
 - **Estimated core temperature $\geq 39^{\circ}\text{C}$**
 - **Heart rate ≥ 160 bpm sustained for ≥ 2 minutes**
- **Preliminary Results**
 -  **Detected 33 of 38 physiologic strain events**
(Sensitivity $\approx 87\%$)
 -  **False positive rate $\approx 12\%$**

FALSE POSITIVES ARE THE EARLY WARNING SIGNS

- Many students flagged by the model had:
 - Heart rate **>155 bpm**
 - Estimated core temperature **>38.5°C**
- Significant physiologic stress **without meeting the strict research definition**
- These may represent **clinically meaningful early warning signs**, rather than simply incorrect predictions.

TAKE-HOME MESSAGE

- Our goal is not to diagnose heat illness.
- Our goal is to identify physiologic strain early enough to intervene before heat illness develops.

PREVENTION OF HEAT ILLNESS

Before Practice

Heat acclimatization

Hydration and nutrition

Emergency Action Plan

During Practice

Monitor WBGT and environmental conditions

Schedule regular hydration/rest breaks

Modify workload, rehearsal duration, or attire based on conditions

When Risk Is Detected

Recognize early physiologic strain

Remove from activity and evaluate

Rapid cooling when indicated

The future of heat illness prevention is moving from reacting to symptoms to identifying physiologic strain before collapse occurs.



THANK YOU

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