MSc II year- Unit II
Thermoregulation in hot climate

Environmental Physiology

Hot Acclimatization

- **Acclimatization** is the beneficial physiological adaptations that occur during repeated exposure to a hot environment.

- **Acclimation** is the coordinated phenotypic response developed by the animal to a specific stressor **in the** environment while **acclimatization** refers to the coordinated response to several individual stressors simultaneously (e.g., temperature, humidity).

What is the main difference between adaptation and acclimatization?

- 1. **Adaptation** is a change in both physical and chemical composition of an organism brought about by habitat changes, while **acclimation** is a physical reaction made in order to adjust to said changes.
- 2. **Adaptation** is permanent, while **acclimation** is temporary.

Acclimatization to heat

Heat Acclimatization

- **Requires exercise in hot environment**
- **Adaptations occur within 7–14 days**
  - Increased plasma volume
  - Earlier onset of sweating
  - Higher sweat rate
  - Reduced sodium chloride loss in sweat
  - Reduced skin blood flow
  - Increased cellular heat shock proteins
- **Acclimatization lost within a few days of inactivity**

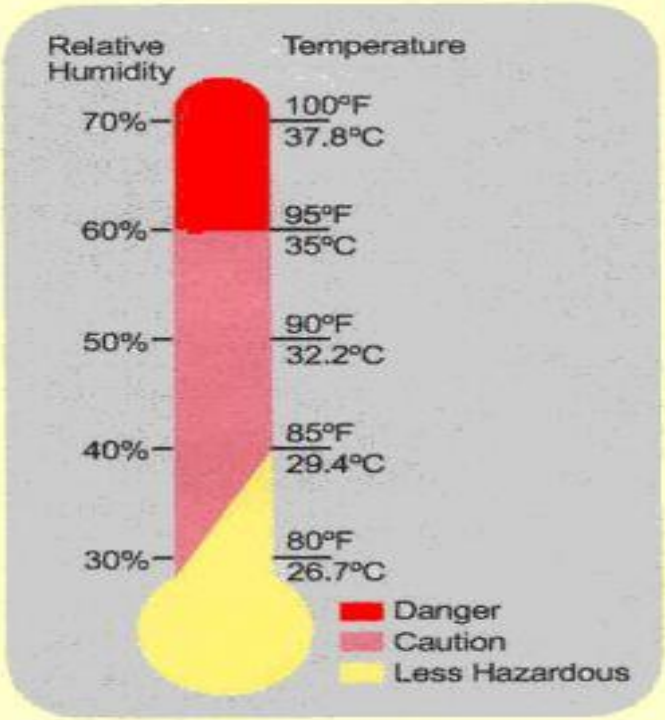
Acclimatization to Heat Exposure

- Improved metabolic efficiency (increased aerobic metabolism, decreased heat wasted in making ATP)
- Sweating promoted at lower core temperature
- Rate of sweating increases from 1.5 to 3 liters / hr
- Stroke volume increases, cardiac output increases, heart rate decreases
- Aldosterone secretion increases (Na in sweat decreases from 30 to 5 meq / liter)
- Potassium retention

The Heat Equation

HIGH TEMPERATURE + HIGH HUMIDITY + PHYSICAL WORK = HEAT ILLNESS

When the body is unable to cool itself through sweating, **serious** heat illnesses may occur. The most severe heat-induced illnesses are heat exhaustion and heat stroke. If left untreated, **heat exhaustion** could progress to **heat stroke** and possible **death**.



U.S. Department of Labor
Occupational Safety and Health Administration

OSHA 3154
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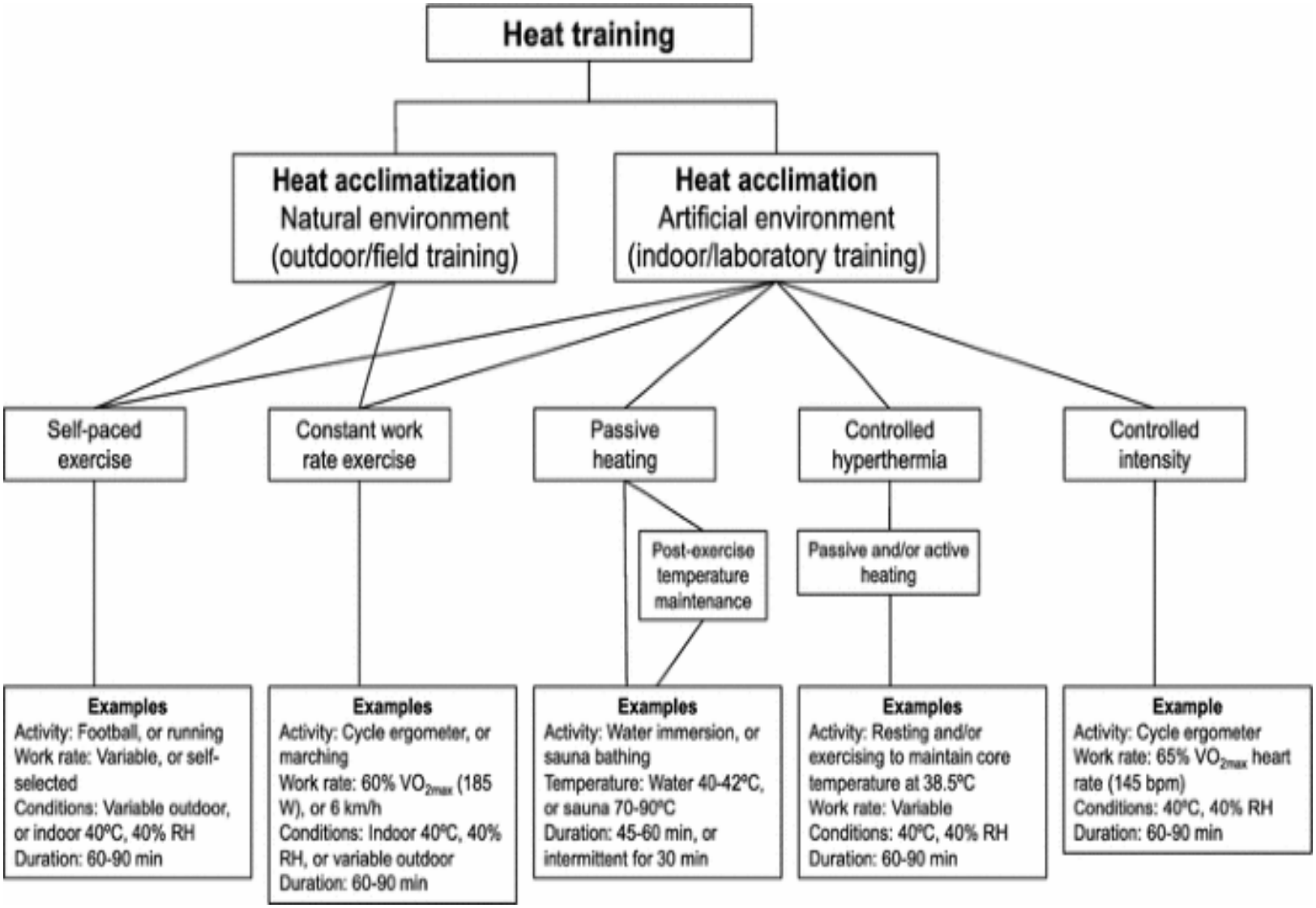
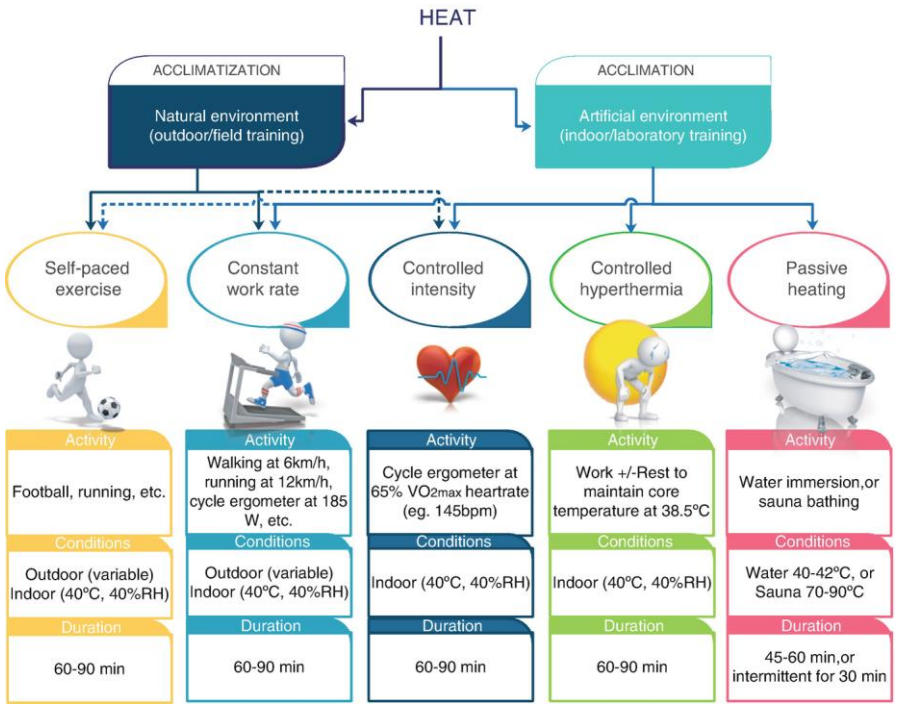

Heat training
Heat acclimatization
Natural environment
(outdoor/field training)
Heat acclimation
Artificial environment
(indoor/laboratory training)
Self-paced exercise
Constant work rate exercise
Passive heating
Controlled hyperthermia
Controlled intensity
Post-exercise temperature maintenance
Passive and/or active heating
Examples
Activity: Football, or running
Work rate: Variable, or self-selected
Conditions: Variable outdoor, or indoor 40ºC, 40% RH
Duration: 60-90 min
Examples
Activity: Cycle ergometer, or marching
Work rate: 60% VO2max (185 W), or 6 km/h
Conditions: Indoor 40ºC, 40% RH, or variable outdoor
Duration: 60-90 min
Examples
Activity: Water immersion, or sauna bathing
Temperature: Water 40-42ºC, or sauna 70-90ºC
Duration: 45-60 min, or intermittent for 30 min
Examples
Activity: Resting and/or exercising to maintain core temperature at 38.5ºC
Work rate: Variable
Conditions: 40ºC, 40% RH
Duration: 60-90 min
Example
Activity: Cycle ergometer
Work rate: 65% VO2max heart rate (145 bpm)
Conditions: 40ºC, 40% RH
Duration: 60-90 min


Heat-related Illness
High temperature & humidity
Direct sun exposure
Indoor radiant heat sources
Limited air movement
Not enough fluids
Physical exertion
PPE & clothing
Physical condition & health problems
Medications
Pregnancy
Lack of recent exposure
Advanced age
Previous heat-related illness


HEAT
ACCLIMATIZATION
Natural environment (outdoor/field training)
ACCLIMATION
Artificial environment (indoor/laboratory training)
Self-paced exercise
Constant work rate
Controlled intensity
Controlled hyperthermia
Passive heating
Activity
Football, running, etc.
Conditions
Outdoor (variable) Indoor (40°C, 40%RH)
Duration
60-90 min
Activity
Walking at 6km/h, running at 12km/h, cycle ergometer at 185 W, etc.
Conditions
Outdoor (variable) Indoor (40°C, 40%RH)
Duration
60-90 min
Activity
Cycle ergometer at 65% VO2max heartrate (eg. 145bpm)
Conditions
Indoor (40°C, 40%RH)
Duration
60-90 min
Activity
Work +/-Rest to maintain core temperature at 38.5°C
Conditions
Indoor (40°C, 40%RH)
Duration
60-90 min
Activity
Water immersion,or sauna bathing
Conditions
Water 40-42°C, or Sauna 70-90°C
Duration
45-60 min,or intermittent for 30 min

Train Cool - Bathe Hot - Perform Better in the Heat!

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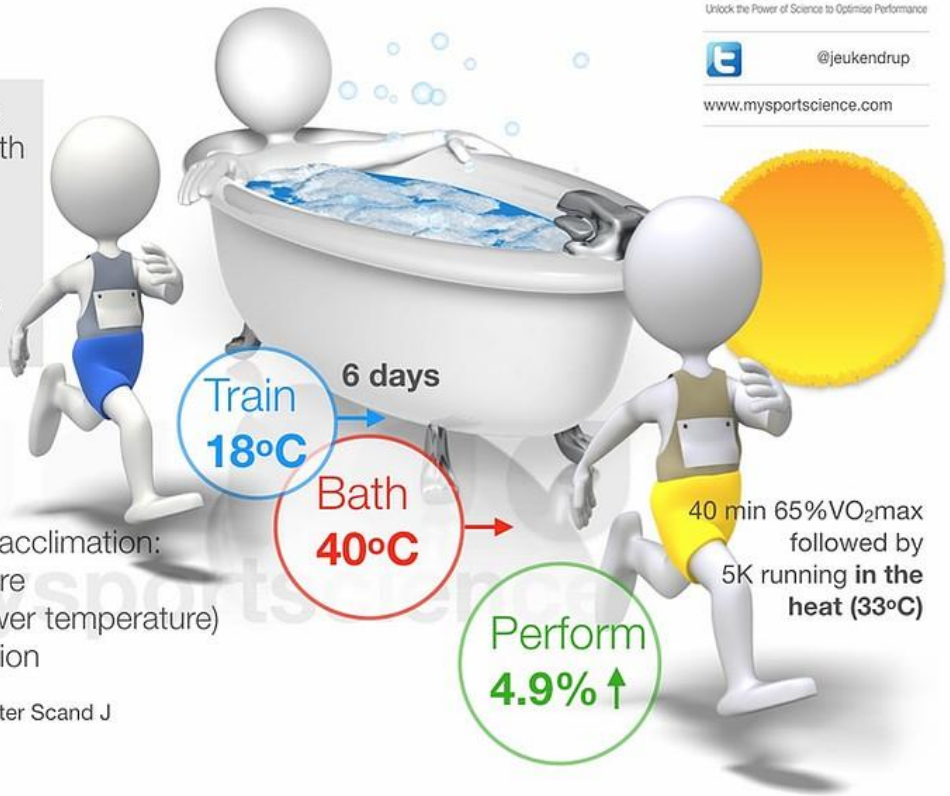
Hot bath after exercise for six days reduced both resting and exercising body temperature and **improved 5k running performance by 4.9% in the heat.**

17 males
Hot water (n=10)
Thermoneutral (n=7)



Hot bath induced heat acclimation:

- Lower core temperature
- Earlier sweating (at lower temperature)
- Lower perceived exertion

Zurawlew, Walsh, Fortes and Potter Scand J Med Sci Sports 2016

Beat the Heat

1. Acclimatization Strategy

4. Sleep and Travel Strategy

2.Hydration Strategy

3. Cooling Strategy

Korey Stringer Institute
University of Connecticut
Maximizing Safety & Performance for the Physically Active

- Changes in **skin blood flow**, comprising the initial physiological response to **increased** or decreased ambient temperatures, are regulated by sympathetic vasodilation and vasoconstriction mechanisms. An increase in core temperature causes the release of vasoconstrictor tone, resulting in **increased blood flow**.

- **Heat stress** is an illness that can be caused by exposure to extreme **heat**. It occurs when the body is unable to maintain a healthy temperature in response to a hot environment.
- ***What is Heat Stress? Occupational heat stress is the net load to which a worker is exposed from the combined contributions of metabolic heat, environmental factors, and clothing worn which results in an increase in heat storage in the body.***

Signs and symptoms of **mild or moderate heat stress** include:

- Sweaty palms
- Poor vision
- Sharp muscle cramps
- Feeling dizzy, lightheaded and/or faint
- More work errors
- Loss of concentration

Signs and symptoms of **severe heat stress** include:

- Loss of consciousness
- Heavy sweating
- Weakness
- Visual disturbances
- Intense thirst
- Nausea and/or vomiting
- Headache
- Diarrhea
- Breathlessness
- Palpitations
- Tingling and numbness of extremities

- **Contributing Factors of Heat Stress**
- Dehydration: A Risk Factor for Heat-Related Illness

- Dehydration occurs when we use or lose more fluid than we take in, and our body doesn't have enough water and other fluids to carry out its normal functions. If we don't replace lost fluids, we will get dehydrated.
- When it's hot and humid, our risk of dehydration and heat illness increases. That's because when the air is humid, sweat can't evaporate and cool , as quickly as it normally does, and this can lead to an increased body temperature and the need for more fluids.
- we can usually reverse mild to moderate dehydration by drinking more fluids, but severe dehydration needs immediate medical treatment.
- Thirst isn't always a reliable early indicator of the body's need for water. Many people, particularly older adults, don't feel thirsty until they're already dehydrated. That's why it's important to increase water intake during hot weather or when we are ill.
- **Symptoms of Dehydration**
- Extreme thirst, Less frequent urination, Dark-colored urine, Fatigue, Dizziness, Confusion, Loss of Appetite, Dry Skin, Dry Mouth, Weakness, Chills, Head Rushes.

- **Heat exhaustion** is a condition whose symptoms may include heavy sweating and a rapid pulse, a result of our body overheating. It's one of three **heat**-related syndromes, with **heat** cramps being the mildest and heatstroke being the most severe.

- **Heavy sweating**.
- Cold, pale, and clammy skin.
- Fast, weak pulse.
- Nausea or vomiting.
- **Muscle cramps**.
- Tiredness or **weakness**.
- **Dizziness**.
- Headache.

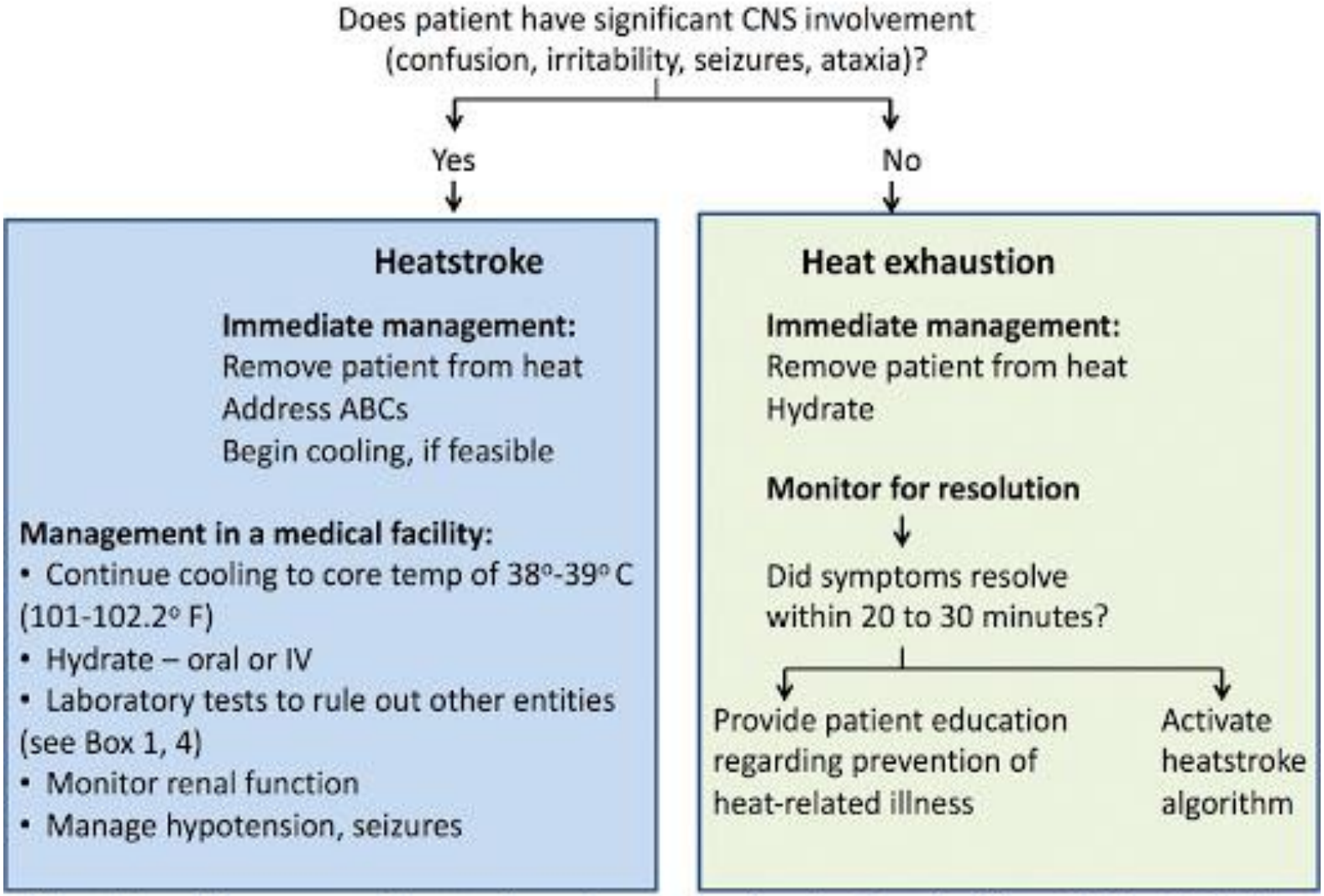
How long does it take to get over ?

- Heat exhaustion symptoms typically last **30 minutes** or less when treated promptly. Complete recovery may take anywhere from 24 to 48 hours. To shorten the duration of heat exhaustion, drink plenty of fluids and seek out a cool place to rest and recover.

What are the first signs of heat exhaustion?

- Heavy sweating.
- Cold, pale, and clammy skin.
- Fast, weak pulse.
- Nausea or vomiting.
- Muscle cramps.
- Tiredness or weakness.
- Dizziness.
- Headache.

Algorithm for management of heat stroke and heat exhaustion



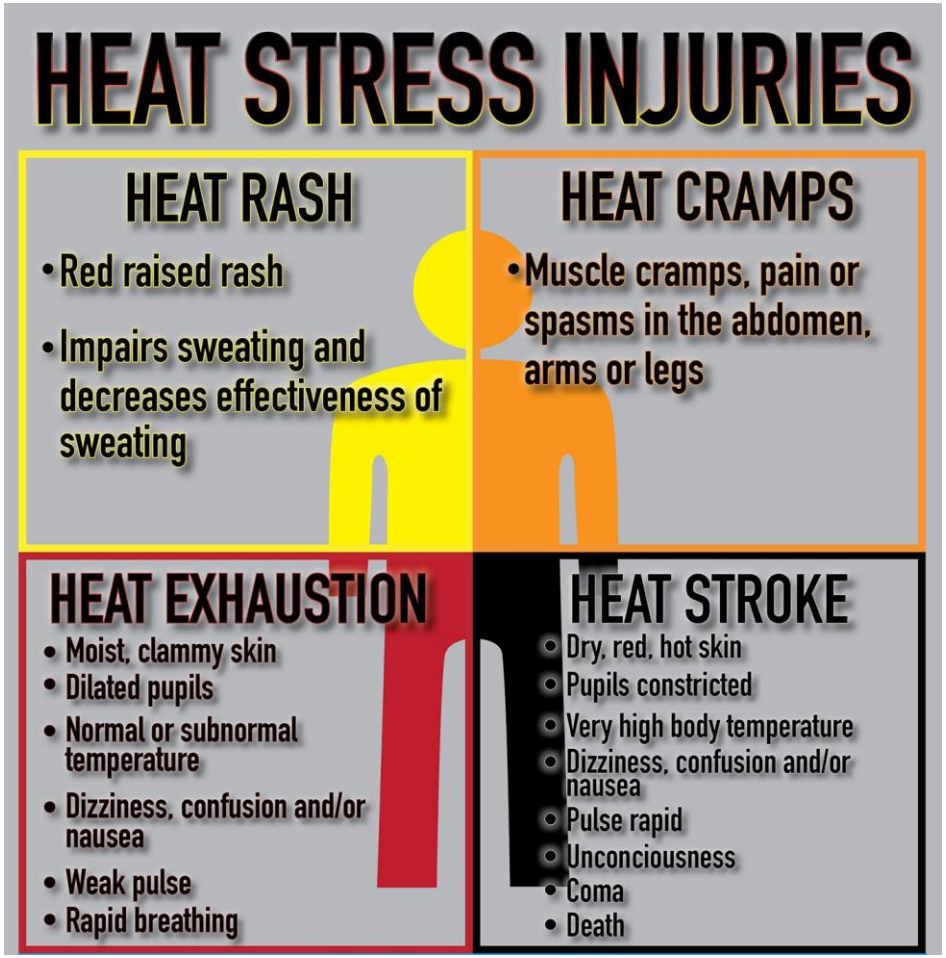
Adapted from Management of heat stroke and heat exhaustion. Am. Fam. Physician. 2005 Jun 1;71(11)

- **Heat cramps** are painful, involuntary muscle spasms that usually occur during heavy exercise in hot environments. The spasms may be more intense and more prolonged than are typical nighttime leg **cramps**. Fluid and electrolyte loss often contribute to **heat cramps**.

What causes heat cramps?

- Heat cramps are painful **muscle spasms** that occur due to dehydration and loss of nutrients from excessive **sweating**. They are associated with heavy perspiration. Heat cramps are most common in the abdomen, back, arms, or legs.

- **Heatstroke** is a condition caused by our body overheating, usually as a result of prolonged exposure to or physical exertion in high temperatures. This most serious form of **heat** injury, **heatstroke**, can occur if our body temperature rises to 104 F (40 C) or higher. The condition is most common in the summer months.


HEAT STRESS INJURIES
HEAT RASH
• Red raised rash
• Impairs sweating and decreases effectiveness of sweating
HEAT CRAMPS
• Muscle cramps, pain or spasms in the abdomen, arms or legs
HEAT EXHAUSTION
• Moist, clammy skin
• Dilated pupils
• Normal or subnormal temperature
• Dizziness, confusion and/or nausea
• Weak pulse
• Rapid breathing
HEAT STROKE
• Dry, red, hot skin
• Pupils constricted
• Very high body temperature
• Dizziness, confusion and/or nausea
• Pulse rapid
• Unconciousness
• Coma
• Death

- **Hot** weather **precautions** to reduce the risk of **heat** exhaustion and **heat** stroke. Stay indoors and in air-conditioned **environment** as much as possible unless we're sure our body has a high tolerance for **heat**. Drink plenty of fluids but avoid beverages that contain alcohol, caffeine or a lot of sugar.

precaution to be taken to avoid heat illness

- Wear loose fitting, lightweight clothing.
- **Protect** against sunburn.
- Drink plenty of fluids.
- **Take** extra **precautions** with certain medications.
- Never leave anyone in a parked car.
- **Take** it easy during the hottest parts of the day.
- Get acclimated.
- Be cautious if you're at increased risk.

What safety considerations can be taken to prevent heat stress injuries?

- Drink plenty of **water** or other cool, non-alcoholic **fluids** even if we're not thirsty (check with the doctor if we are on limited **fluids** or fluid pills.) Avoid drinking extremely cold liquids as they can cause stomach cramps. Plan ahead. Reduce activity ,avoid **exercise** in hot weather.

- To avoid heat-related illnesses, wear light-weight, light-colored **clothing** made of breathable material, like cotton.
- Stay hydrated by drinking **water** throughout the day.
- Avoid strenuous outdoor activity on hot days.
- If we're outside, take frequent breaks in a cool place.

Athlete to prevent heat injury

- Pre-hydrate. Begin hydrating several hours before practicing or performing any sports outdoors and continue to hydrate during the activity.
- Wear sunscreen.
- Consider the clock.
- Get acclimated.
- Wear light-colored clothing.
- Manage medications.

- **Protecting our body from the heat or how to prevent overheating**
- Use proper gear for warm-weather running.
- **Protect** our head and eyes.
- **Protect** our skin with waterproof sunscreen.
- Regularly moisten our clothing, head, arms and legs.
- Running in warm weather: A special kind of protection for a special kind of pleasure!