THERMOREGULATION IN EXERCISE

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Introduction

- What is thermoregulation?
  - Process that allows the human body to maintain its internal temperature

- The cardiovascular system and heat exchange between internal body tissues is not well understood

- Maximizing exercise efficiency
Key Points

Heat production and pathways
  ATP Production
  Intercellular conductive heat transfer vs. vascular convective heat transfer

Haemodynamic responses to exercise
  Environment
  Types and intensity of exercise
  Dehydration

Muscle blood flow
  Resting conditions
  Changes in blood flow
  Leg exercise
Heat Production

- Heat is produced in all body cells from the conversion of metabolic energy into mechanical energy
- This process is very inefficient!
- 30-70% of the energy liberated during muscle contraction appears as thermal energy
ATP Production in exercise

- The elevation of total heat production over time in contracting skeletal muscle is tightly related with changes in heat liberation during metabolic ATP production early in exercise.

- Heat production during ATP utilization varies depending upon what provides the energy for ATP resynthesis:
  - Creatine phosphate (PCr), glycolysis, or oxidative phosphorylation.
Heat Exchange Pathways

• The local and central mechanisms regulating tissue temperature in the exercising limbs, body trunk and head are essential to avoid deleterious consequences on human performance

• 2 Pathways:
• Intercellular conductive heat transfer
• Vascular convective heat transfer
Differences in Pathways

- **Intercellular conductive heat transfer:** dependent on temperature gradient between muscle and skin and the thermal conductivity of the muscle

- **Vascular convective heat transfer:** transfer of heat via mass flow, depends on tissue blood flow and blood temperature difference
Haemodynamic Responses to Exercise

• Haemodynamic response (n): rapid delivery of blood to active neuronal tissues

• Adjust blood flow to and from stressed tissues depending on:
  1. Environment
  2. Type and Intensity of Exercise
  3. Hydration Level
Hot vs. Cold Environments

• Hot and cold stress alters blood flow to both skin and skeletal muscles.

• Temperature-mediated release of arterial plasma ATP results in an enhanced muscle blood flow at high temperatures.

• Cold temperatures reduce the blood flow from the heart to the skeletal muscles.
Type and Intensity of Exercise

1. Small muscle mass
2. Large muscle mass

Small muscles are more greatly affected by environmental stress.

Hardest for body to regulate temperature during intense, large muscle mass exercise in heat.
Haemodynamic Responses to Dehydration

- Minimal effect on cardiac output, skin blood flow, and arterial blood pressure in cold environments.
- Cardiac output decreases under heat stress.
- Heart rate increases significantly.
Muscle Blood Flow and Limb Heat Liberation

- Heat inside the body is transported through blood flow in relation to blood temperature and flow rate
- Heat transfer in the major arteries that supply and drain the limbs is bidirectional
Blood Temperatures in Resting Conditions

- Limb muscle and venous blood temperatures are lower than arterial and core temperatures

- Negative arteriovenous temperature gradient

- More heat is transferred from the upper body core to the extremities
  - Helps maintain limb tissue temperature when metabolic heat production is low

- Limb tissue temperature drops when the circulation is arrested and heat dissipation to surrounding limbs is kept constant
Changes in Blood Flow

• Manipulating blood flow in the resting rat hindlimb revealed…
  • Increasing blood flow = reduced temperature difference
    • Net limb heat influx was the same
  • Reducing blood flow = reduced heat influx into the hindlimb
    • Unchanged arteriovenous temperature gradient
  • Increase in limb blood flow in resting limbs does not necessarily cause the net amount of heat being transferred from the core to the limbs to increase
  • Reducing blood flow might have an impact on limb heat transfer
Heat Production in Leg Exercise

• During exercise, limb tissue perfusion, connective heat exchange, and heat production increase

1. Temperatures of contracting muscle and outflowing femoral venous blood increase at faster rate than temperatures of inflowing femoral arterial blood and upper body core

2. After a few minutes of exercise, muscle and venous blood temperature becomes higher than arterial blood and upper body core temperatures
Thermoregulation in Review

1. Heat Production in skeletal muscle

2. Cardiovascular responses to exercise and environmental stress

3. Muscle Blood flow and limb heat regulation
Reason #101 why the Plex needs AC...

On average the plex is 98°F regardless of the temperature outside...

- Heat leads to a higher rate of dehydration
- Heat compromises the functioning of cellular and organ systems
- Heat encourages greater tachycardia and skin and core hypothermia

I exercised once, but found I was allergic to it. My skin flushed and my heart raced. I got sweaty and short of breath. Very dangerous.
And during exercise heat production increases…

- Dynamic exercise increases abruptly
- Steady-state exercise increases at a lower rate and eventually levels off
- In intense exercise, increases abruptly and does not level off
But you should still exercise...

Lack of exercise causes...

- Circulatory system Problems
- Weight gain
- Diabetes
- Joint and bone fragility
- Depression
Final Thoughts

Exercising to your fullest potential… which days are best to skip the gym?

What to keep in mind while working out

- Dehydration
- Heat
- Cold