Turning down the heat:
How heat stress affects muscle growth and limits pork production

Joshua Selsby, Ph.D.
jselsby@iastate.edu
Iowa State University
Swine Day
Heat Stress: Economics and Food Security

- Heat stress is the largest impediment to efficient animal agriculture (even in developed countries)
  - Cost: (lost productivity, mortality, product quality, health care etc.)
    - American Agriculture: > $3 billion/year
    - Global Agriculture: > $100 billion/year
  - Heat abatement is the primary strategy to mitigate heat stress
    - Most developing countries lack the resources to afford this

- Human health concern
- Threatens global food security
Therapeutic Effects of Hyperthermia

INTERMITTENT HYPERTHERMIA ENHANCES SKELETAL MUSCLE REGROWTH AND ATTENUATES OXIDATIVE DAMAGE FOLLOWING RELOADING

J. T. Sekely, S. Rother, S. Tsuda, O. Pranesh, J. Quinlivan, and S. L. Dodd
Department of Applied Physiology and Kinesiology, University of Florida, Gainesville, Florida
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A

Muscle Weight (grams)

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<tr>
<th></th>
<th>Con</th>
<th>Im</th>
<th>ImH</th>
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<td>0.00</td>
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<td>0.04</td>
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<td>0.16</td>
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B

mg muscle/g body weight

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<tr>
<th></th>
<th>Con</th>
<th>Im</th>
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The table shows the muscle weight and muscle per g body weight under different conditions (Con, Im, ImH). The asterisks (*) and hashtags (#) indicate statistical significance.
Pathological heat stress is fundamentally different

Heat Stress \rightarrow Less Muscle

Intensity? Duration? Mechanism?
Pathological heat stress is fundamentally different

Heat Stress → Less Muscle

Synthesis → Degradation
Pathological heat stress is fundamentally different

Heat Stress

Calpains
Proteasome
Oxidative Stress
Autophagy
Inflammatory Signaling
ER Stress (UPR)
Apoptosis
Mitochondrial dysfunction

Less Muscle
Increased Degradation
Decreased Synthesis
AA Repartitioning
Pig Production
Pig Production During HS
Autophagy allows removal of damaged organelles.

2-6 h of HS increases autophagy
Autophagy allows removal of damaged organelles.

2-6 h of HS increases autophagy

2-6 h of HS increases clearance of damage mitochondria through autophagy
2-6 hours of Heat Stress

After an initial injury muscle cells respond to heat stress by removing damaged mitochondria or damaged parts of mitochondria via autophagy/mitophagy.

The System Works!!!

Damaged mitochondria

Restored/protected mitochondrial pool
12-24 hours of Heat Stress

Continued HS causes increased oxidative stress

12 hrs HS

24 hrs HS
Autophagy allows removal of damaged organelles.

12 h of HS results:
Failure to sustain activation
Stalling of degradation
Autophagy allows removal of damaged organelles.

24 h of HS results:
Impaired activation
Blunted degradation
Decreased mitophagy
24 hours of Heat Stress

- **Nuclei**
  - Dapi

- **Lysosomes**
  - Lamp2

- **Autophagosomes**
  - p62

- **Composite**
  - TN
  - 1d HS
12-24 hours of Heat Stress

Continued HS causes an accumulation of mitochondria
Note: these are likely damaged, pro-oxidant mitochondria
Chronology of Heat Stress

After an initial injury muscle cells respond to heat stress by removing damaged mitochondria or damaged parts of mitochondria via autophagy/mitophagy.

2                          6                              12                                                       24
Effective response                   Collapse of response with continued heat stress

Over time this process appears to fail allowing the accumulation of oxidatively modified proteins and damaged mitochondria.
Proposed Mechanism

![Diagram of cellular processes]

- Cytosolic ROS
- Apoptosis
- Cho Lipid AA
- Ca²⁺
- ATP
- ROS
- Autophagy
Future Research Objectives

• Complete a chronology of heat stress-mediated changes in skeletal muscle.

• Determine the extent to which cytosolic sources of free radical production contribute to impaired efficiency.

• Determine the extent to which:
  Mito-protection…
  Stimulation of autophagy…
  …attenuate losses in efficiency
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Questions