



Factors that impact the stress and immune responses of beef cattle and swine

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Natural Variations

Breed Effects
Sexual Dimorphism
Animal Temperament

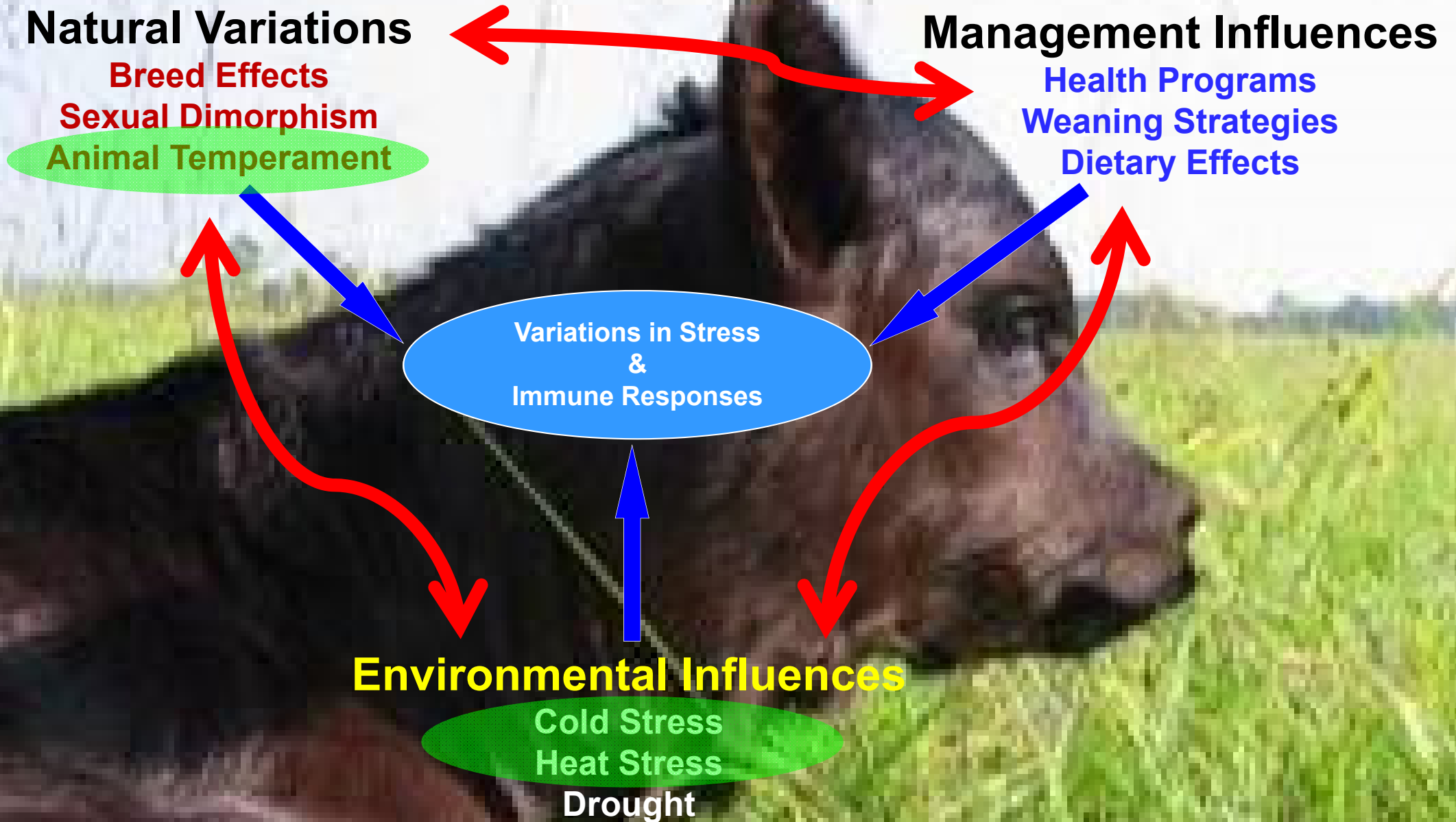
Management Influences

Health Programs
Weaning Strategies
Dietary Effects

Variations in Stress
&
Immune Responses

Environmental Influences

Cold Stress
Heat Stress
Drought





Seminar Outline

- **Effect of cold stress on the innate immune response of neonatal pigs**
- **Effect of heat stress on the innate immune response in beef cattle**
- **Cattle Temperament: Effect on the stress, immune and metabolic responses to an immune challenge**





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What role, if any, does environmental temperature play in the neonatal pig's pro-inflammatory response to an immunological challenge?





Materials and Methods

Male pigs (n = 36) were taken from their dams at **24 hr of age**.

Body weights (1.52 ± 0.053 kg) and rectal temperatures were recorded before moving the pigs to environmentally controlled chambers that were maintained at 50% relative humidity and at either **18°C (64.4°F; n=18 pigs) or 34°C (93.2°F; n=18 pigs)**.

Immediately upon entering their respective chamber, pigs received an i.p. injection of either **saline** (n = 7 pigs/temperature group) **or LPS** (150 ug/kg; n = 11 pigs/temperature group).

Rectal temperatures were recorded **every 15 min for a 3-hr period** after which time all pigs were humanely sacrificed for blood and tissue collection.





Results

Physiological parameters:

Rectal temperatures

Body weight loss

Activation of the stress axis:

Serum cortisol

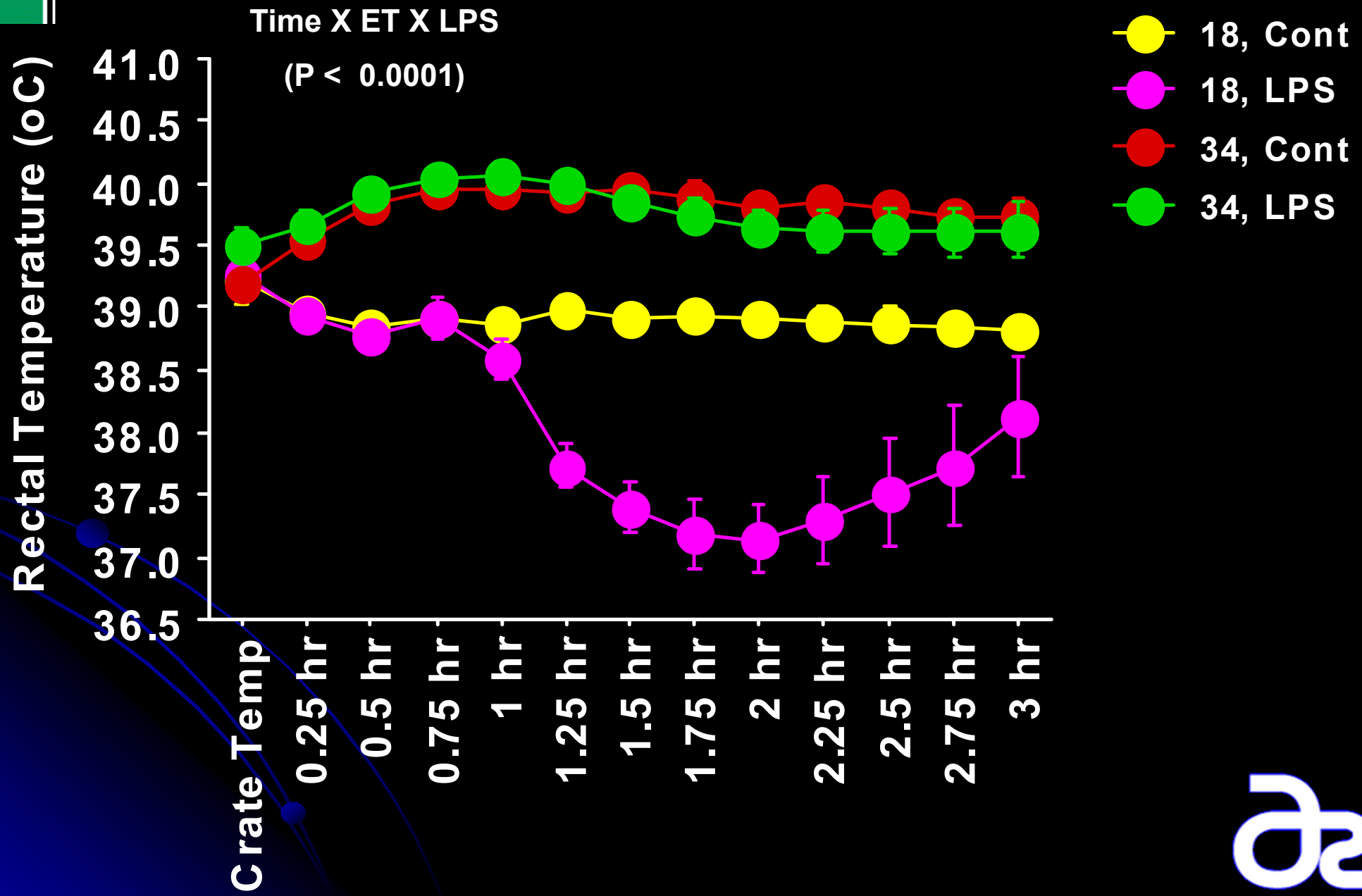
Activation of the immune system:

Serum TNF- α





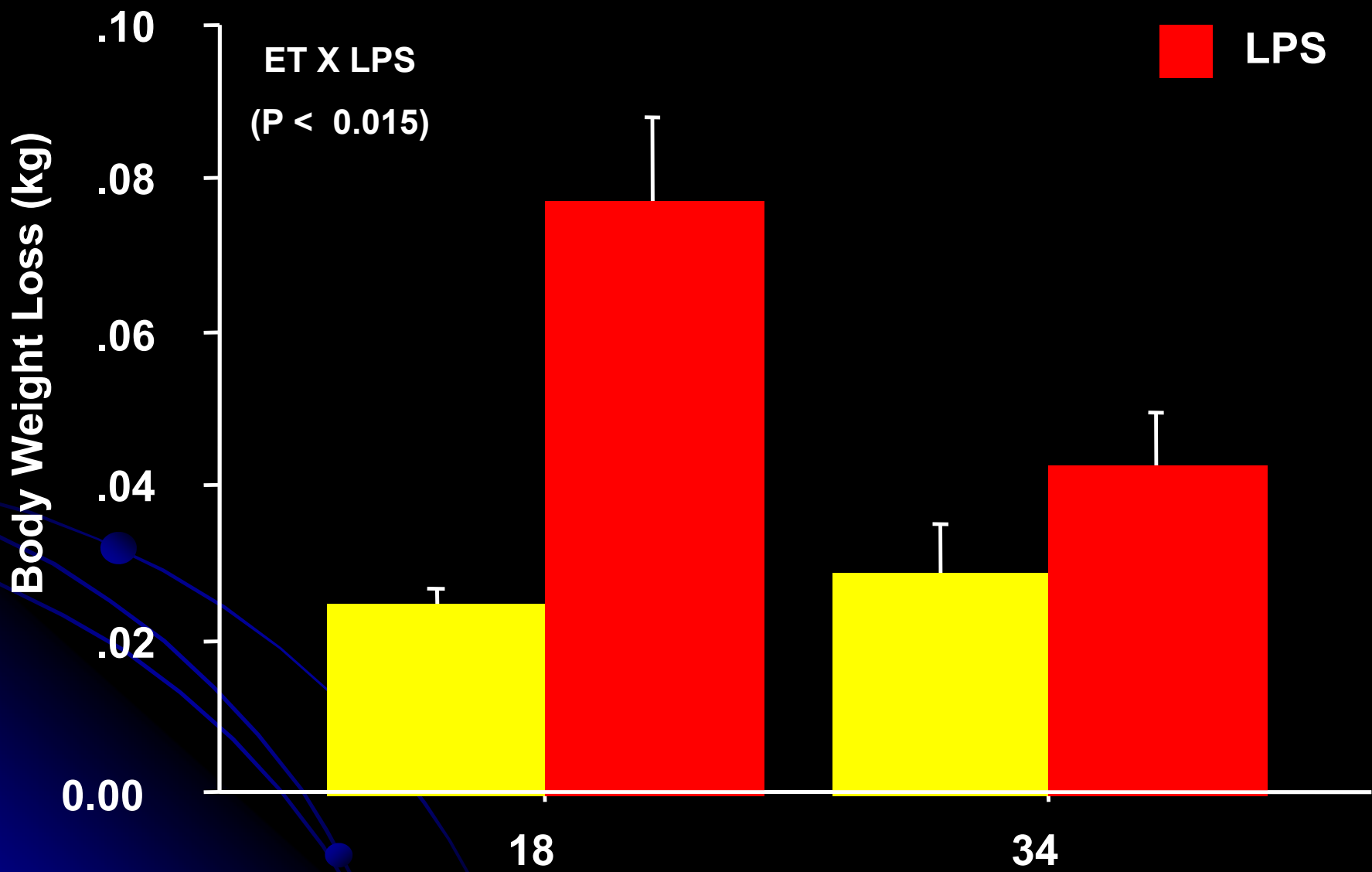
Rectal Temperatures





Body Weight Loss

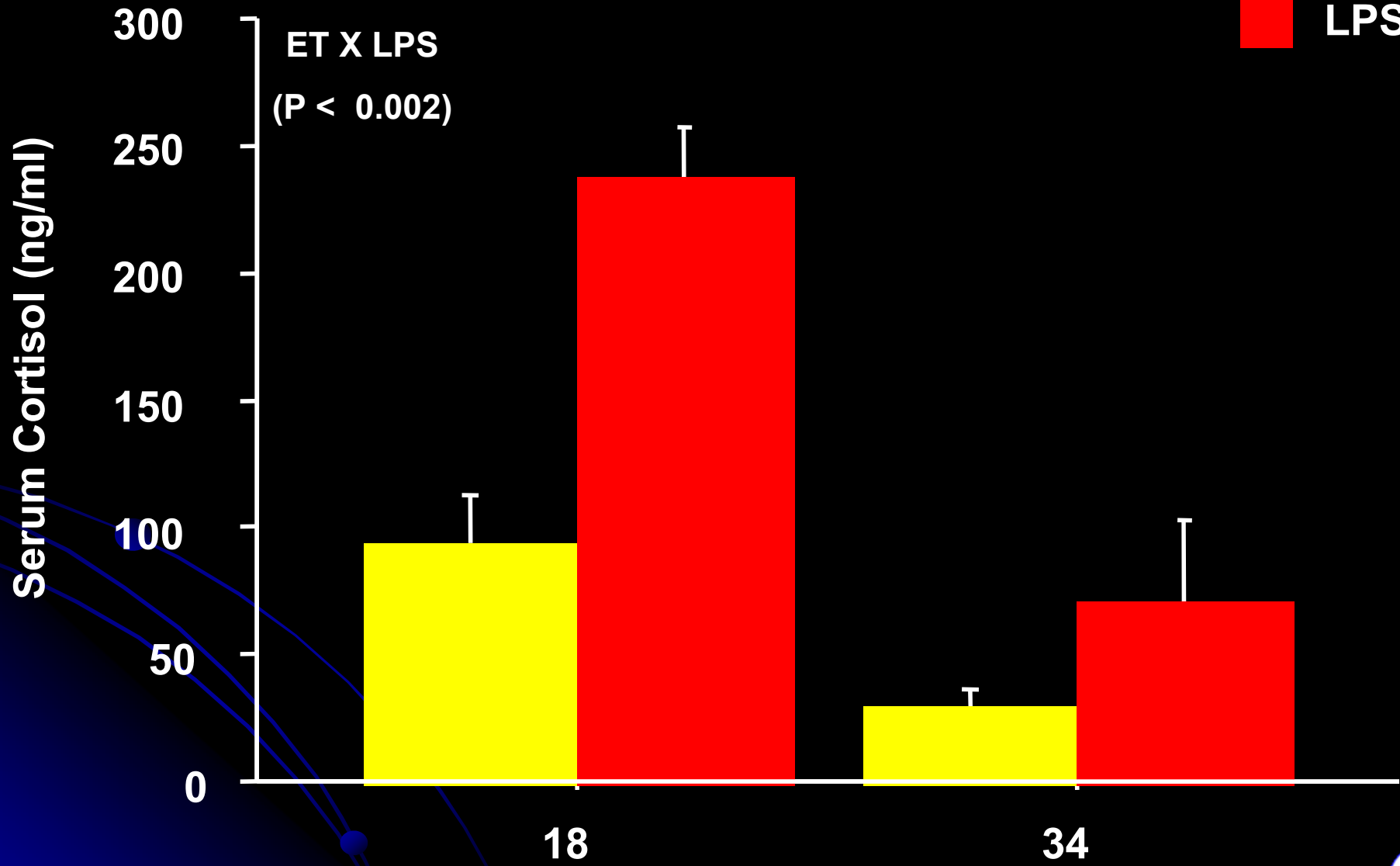
Cont
LPS





Serum Concentration of Cortisol

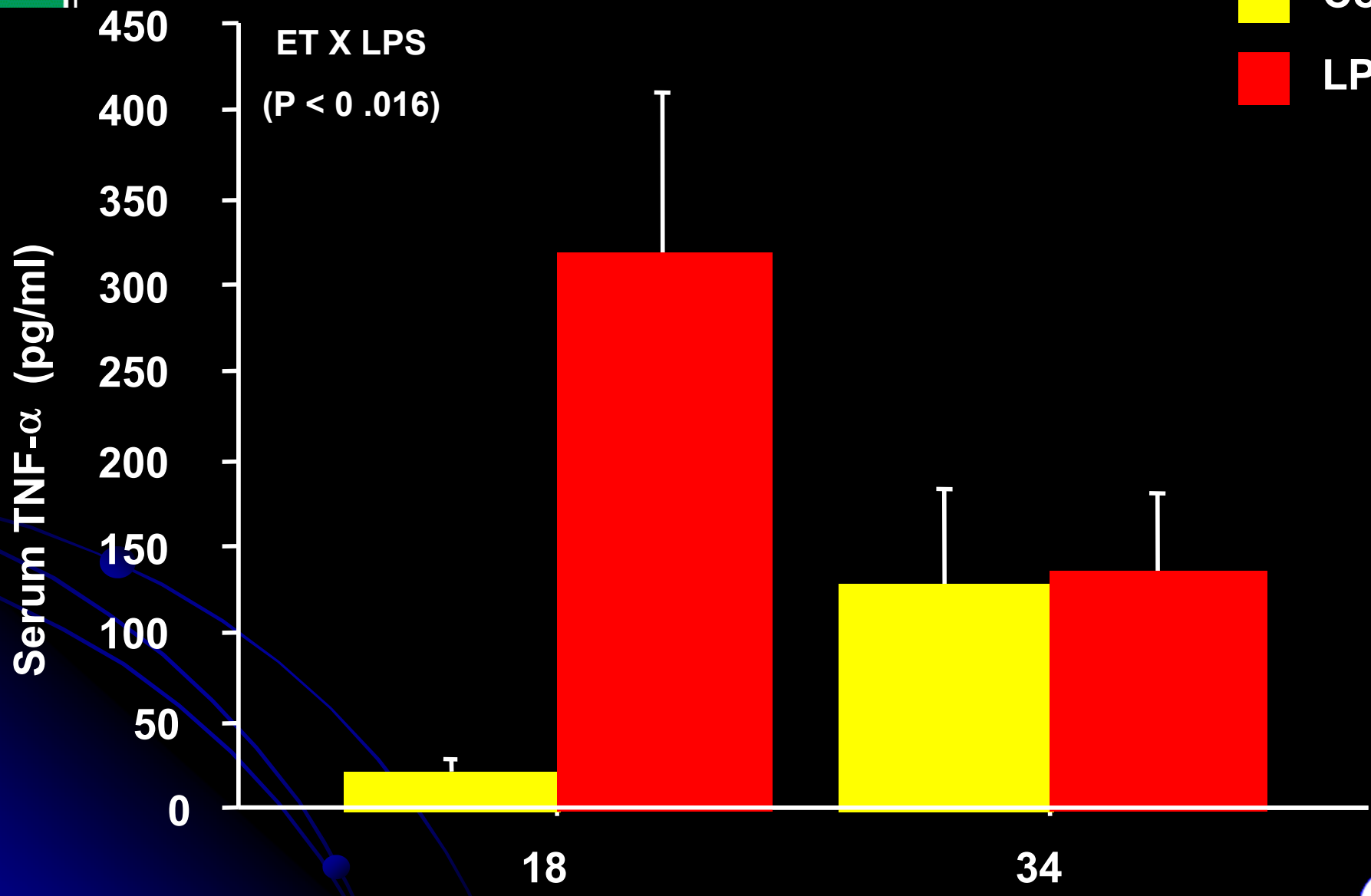
Cont
LPS





Serum Concentration of TNF- α

Cont
LPS





Cold Stress in Neonatal Swine: Summary

Exposure to a cold (18°C) environmental temperature resulted in a more severe response to the LPS challenge.

Pigs maintained in a warm (34°C) environment **exhibited no visual signs** and only minimal endocrinological or immunological activation associated with the LPS challenge.

- The significant impact of the cold environment alone was evident by the **elevation in basal cortisol and the reduction in rectal temperatures** in saline treated pigs.





Cold Stress in Neonatal Swine: Implications

These results indicate that, when combined, **cold stress and exposure to endotoxin induce a rapid and potentially dangerous loss of body heat** in the neonatal pig.

Though routine management practice includes supplying a supplemental heat source (e.g., heat lamps and/or heat pads) to newborn pigs, the overall advantage of this practice may not be fully appreciated.

It's possible that providing the additional heat source may reduce the severity and or duration of illness.





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Does environmental temperature play a role in the beef calf's pro-inflammatory response to an immunological challenge?





Materials and Methods

Angus (ANG; n=11; 306.7 ± 25.9 Kg BW) heifers were housed in the Brody Environmental Chambers for 21 days.

Heifers were split between 2 chambers, maintained in cycling heat stress (**HS; 24-38°C; n = 6**), or at thermoneutral (**TN; 18.5-23.5°C; n = 5**) ambient temperature conditions.

One day prior to the endotoxin challenge (Day 19), all heifers were fitted with **indwelling jugular catheters and rectal temperature probes** that recorded rectal temperatures at 1-min intervals.

On the day of the challenge (Day 20), blood samples were collected at **30-min intervals from -2 to 8 hours**, and then at 24 hours. At 0 hour a blood sample was collected and then all heifers immediately received an i.v. injection of LPS (0.5 ug/Kg BW).



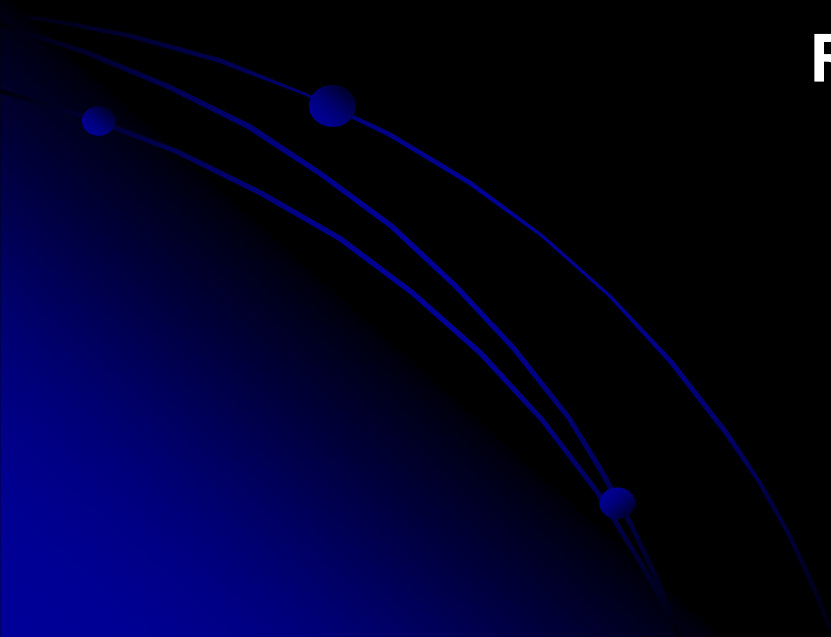


Results

Physiological Responses

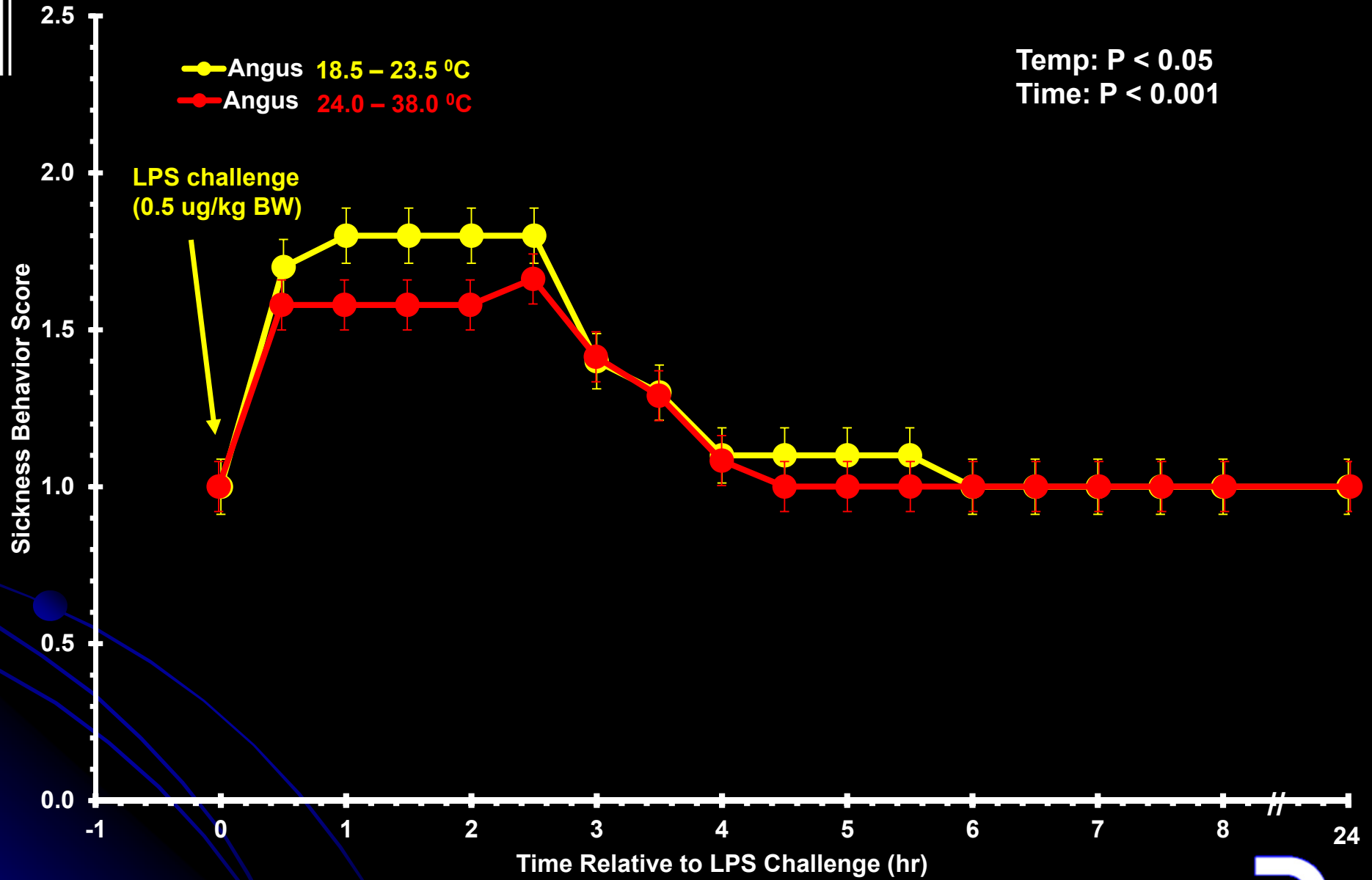
Sickness Scores

Rectal Temperatures



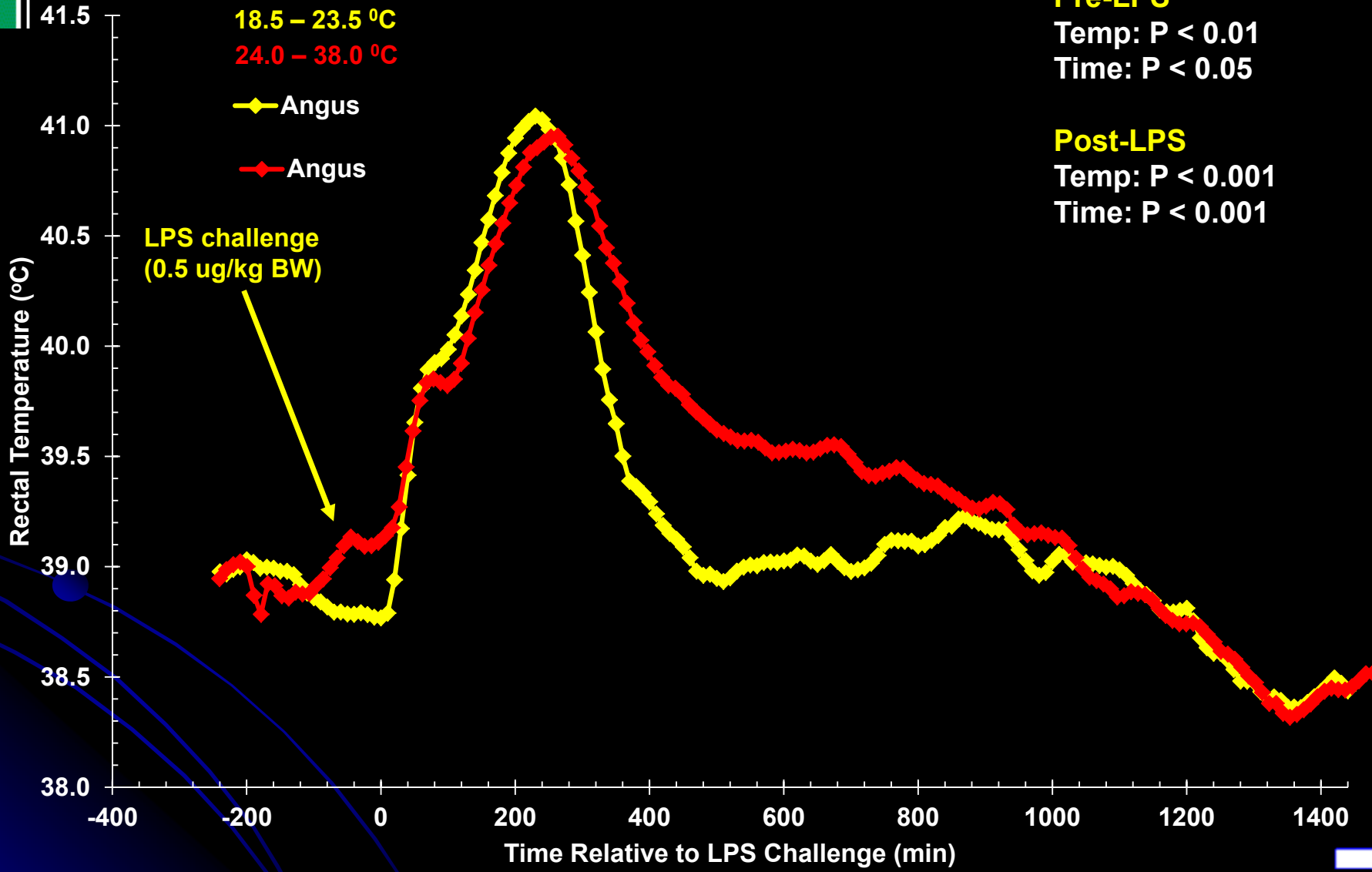


Sickness Scores: Thermoneutral vs Heat Stress





Rectal Temperature: Thermoneutral vs Heat Stress

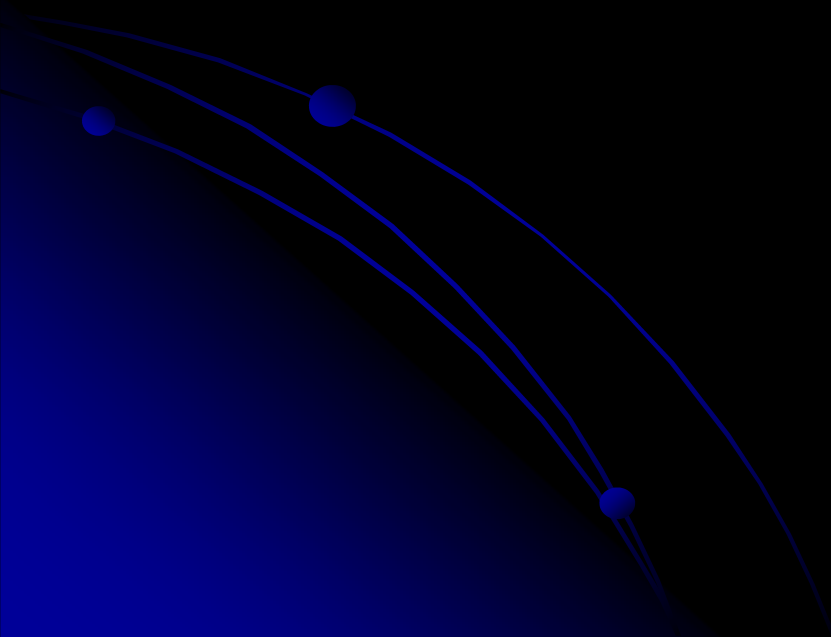




Results

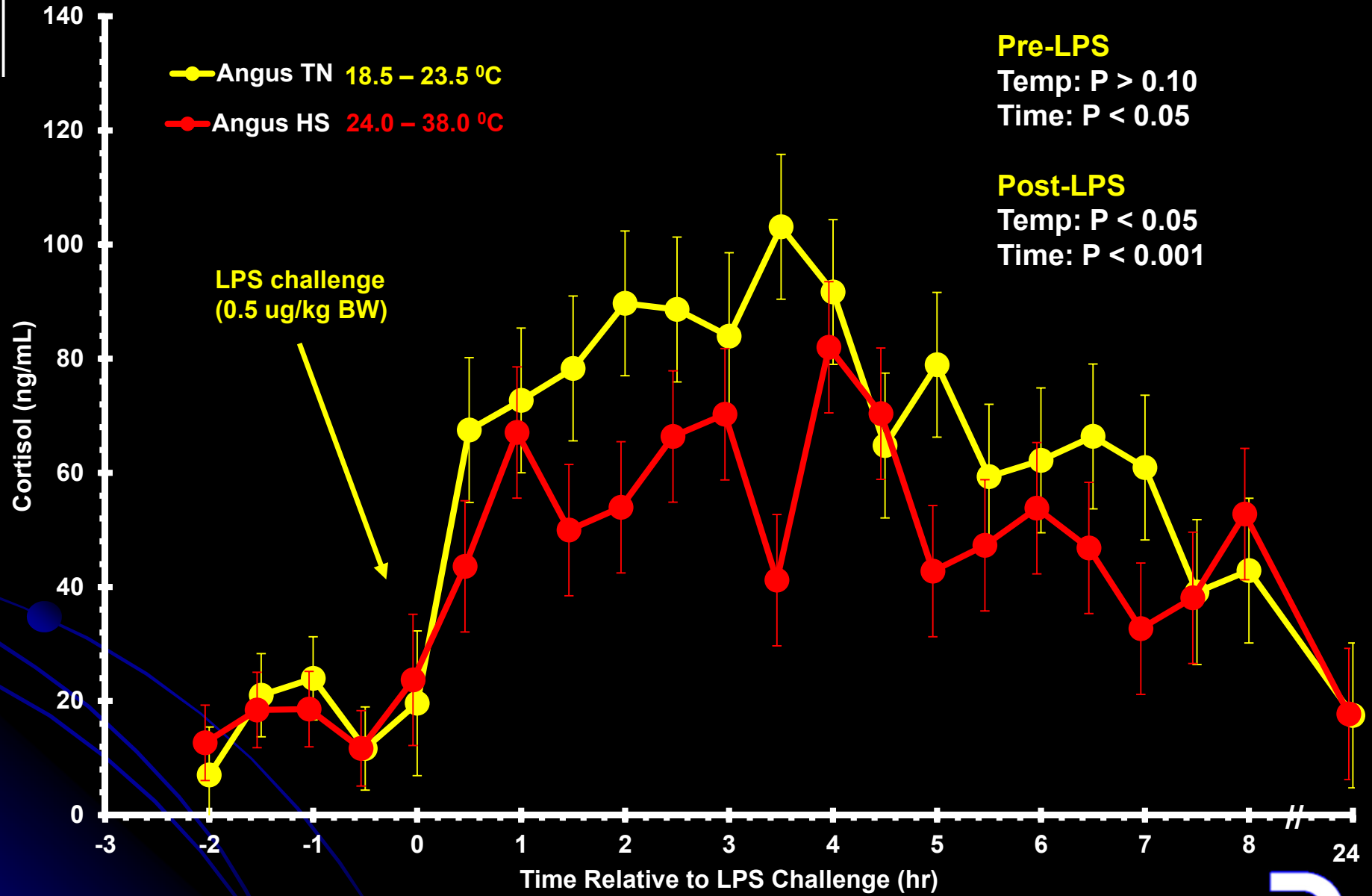
Stress Response

Serum Cortisol





Serum Cortisol: Thermoneutral vs Heat Stress





Results

Pro-inflammatory Cytokine Response

Tumor Necrosis Factor-alpha

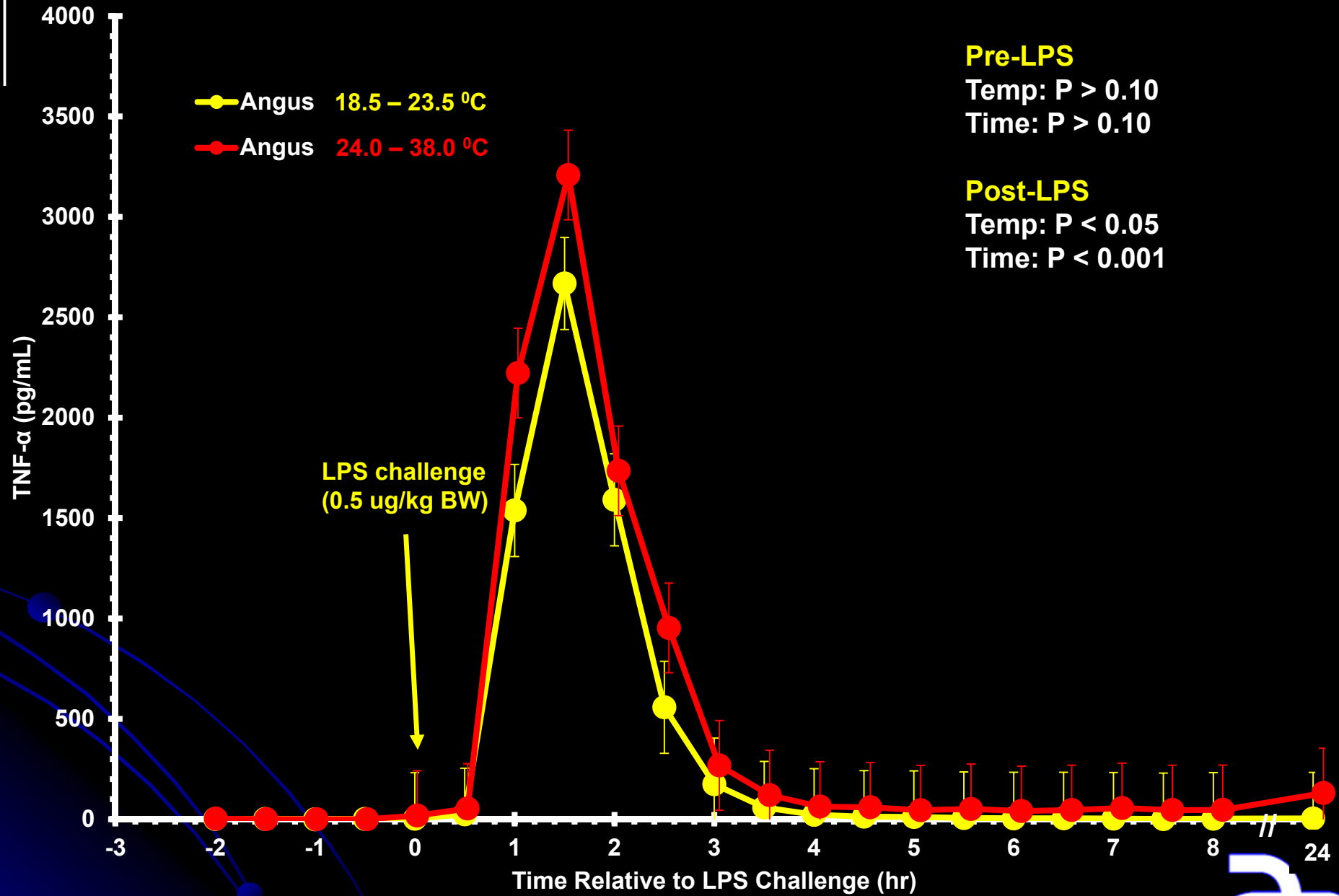
Interleukin 6

Interferon-gamma



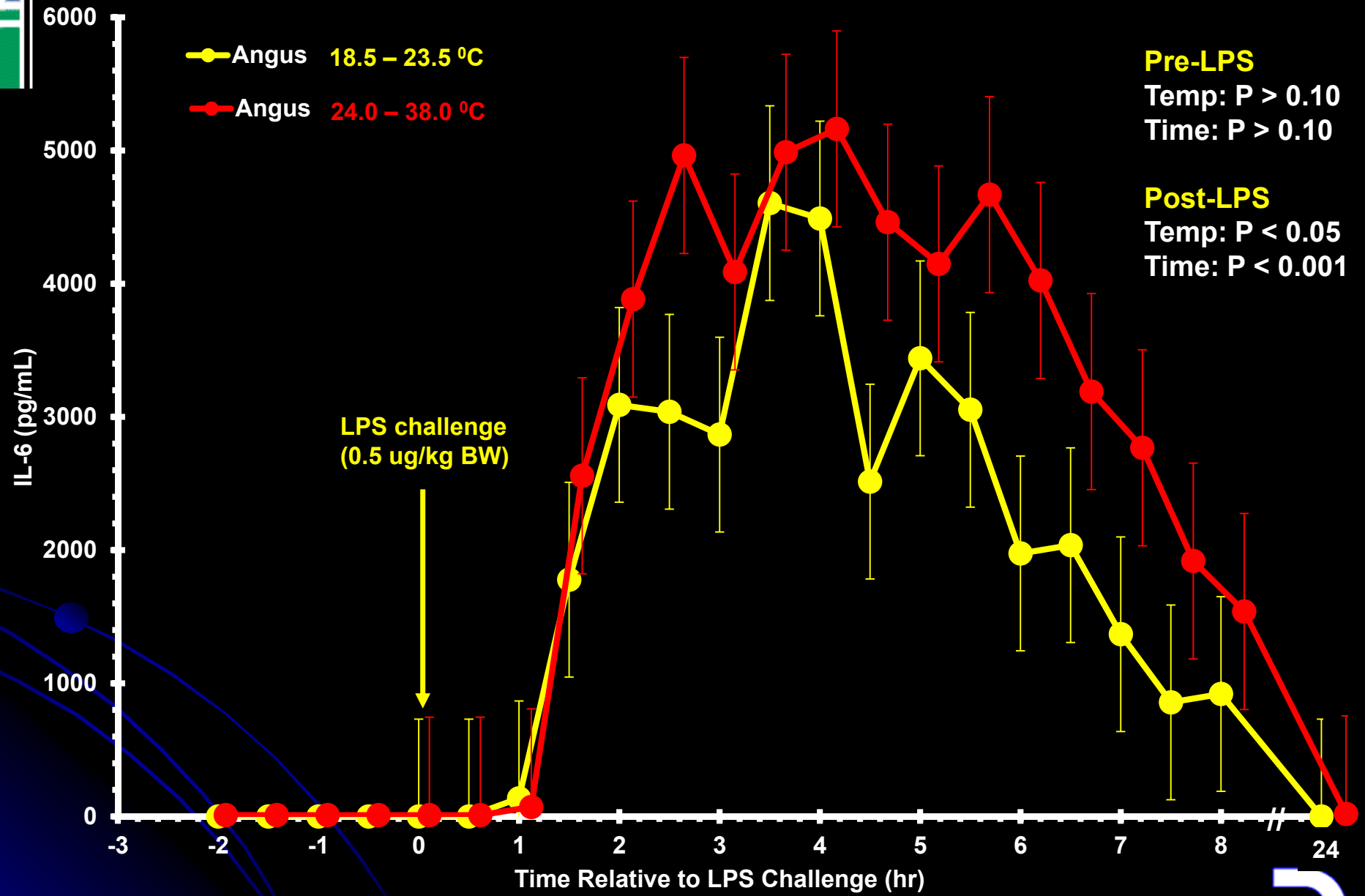


Serum TNF- α : Thermoneutral vs Heat Stress



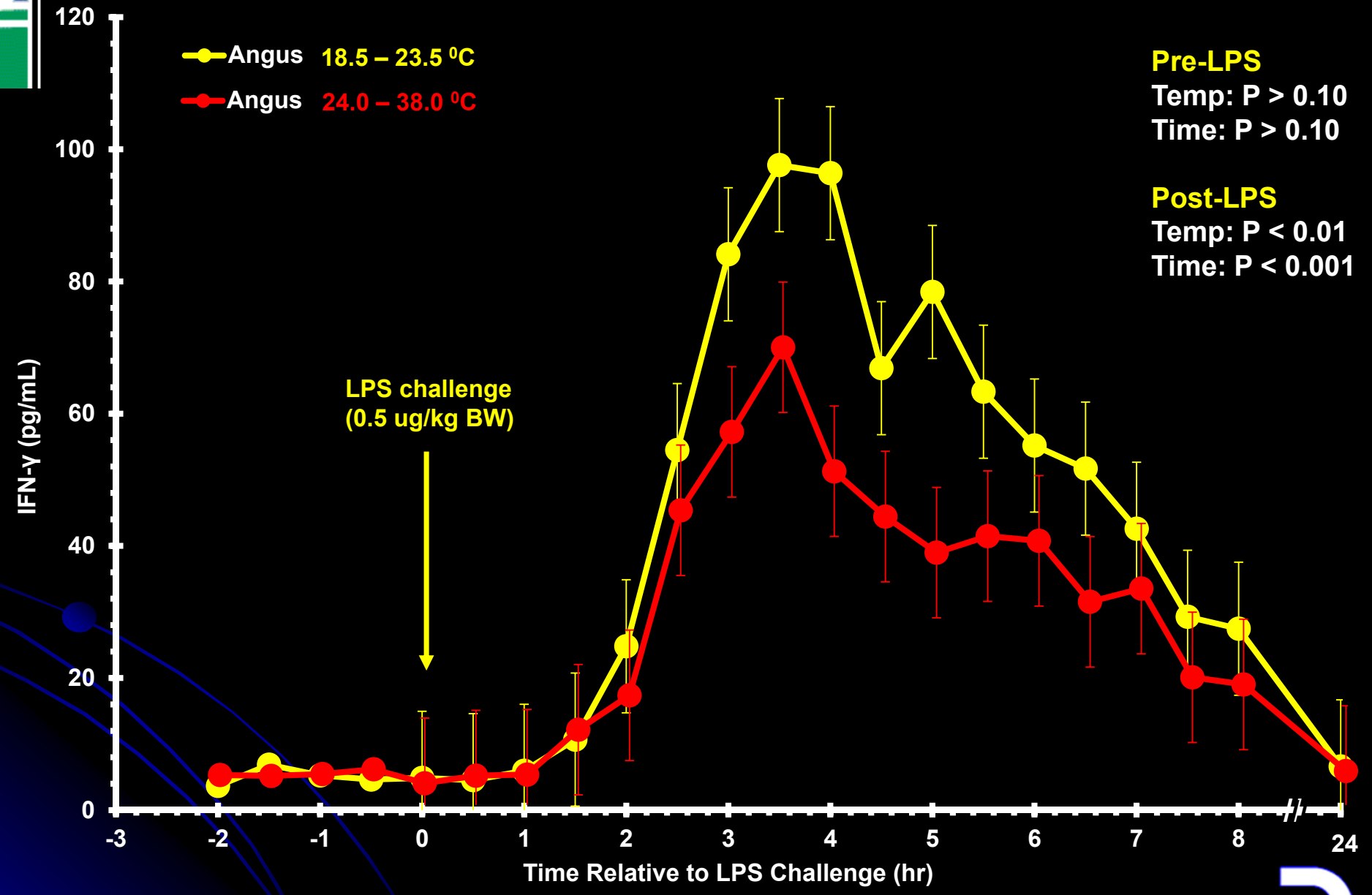


Serum IL-6: Thermoneutral vs Heat Stress





Serum IFN- γ : Thermoneutral vs Heat Stress





Summary: Heat Stress Effects

Exposure to heat stress **reduced overall sickness scores while prolonging the actual febrile response to LPS.**

Serum concentrations of **cortisol were actually reduced** by exposure to heat stress during the LPS challenge.

While serum **concentrations of TNF- α and IL-6 were increased** by heat stress, serum **concentrations of IFN- γ were reduced.**





Implications

These data demonstrate even a **highly conserved biological response, such as the innate immune response**, can be altered by exposure to environmental stressors.

Altering these basic immunological responses most likely **reflect the animal's attempt to re-prioritize biological activities** in a manner that enhances their chances of survival.

Understanding these alterations will aid in our ability to more effectively manage the health and well-being of livestock under diverse environmental conditions.





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- **Cattle Temperament: Effect on the stress, immune and metabolic responses to an immune challenge**



A group of cattle, including several brown and white cows, are gathered behind a green metal fence. The background shows a lush green field with rolling hills and trees under a bright sky. The text "Does cattle temperament influence an animal's stress, innate immune, and metabolic profiles?" is overlaid on the image in yellow, with the word "metabolic" highlighted in a green oval.

Does cattle temperament influence an animal's stress, innate immune, and metabolic profiles?



Materials and Methods

At 10 mo of age, twenty-four Brahman bulls were selected from a pool of 60 based on temperament score (average of exit velocity - EV, and pen score - PS) measured 28 days prior to weaning:

8 most Calm (0.87 ± 0.15 EV and 1.00 ± 0.00 PS)

8 most Temperamental (3.70 ± 0.29 EV and 4.88 ± 0.13 PS)

8 Intermediate (1.59 ± 0.12 EV and 2.25 ± 0.16 PS)

Bulls were fitted with indwelling rectal temperature monitoring devices, loaded onto trailer and transported approximately 770 km; 9 hours.





Materials and Methods

The following day bulls were **fitted with indwelling jugular catheters** approximately 24 hr before the beginning of the study for serial blood collection to evaluate their response to a LPS administration (0.5 $\mu\text{g}/\text{kg}$).

Blood samples were collected at **30-min intervals from -2 to 8 hr and at 24 hr relative to the LPS challenge at time 0.**



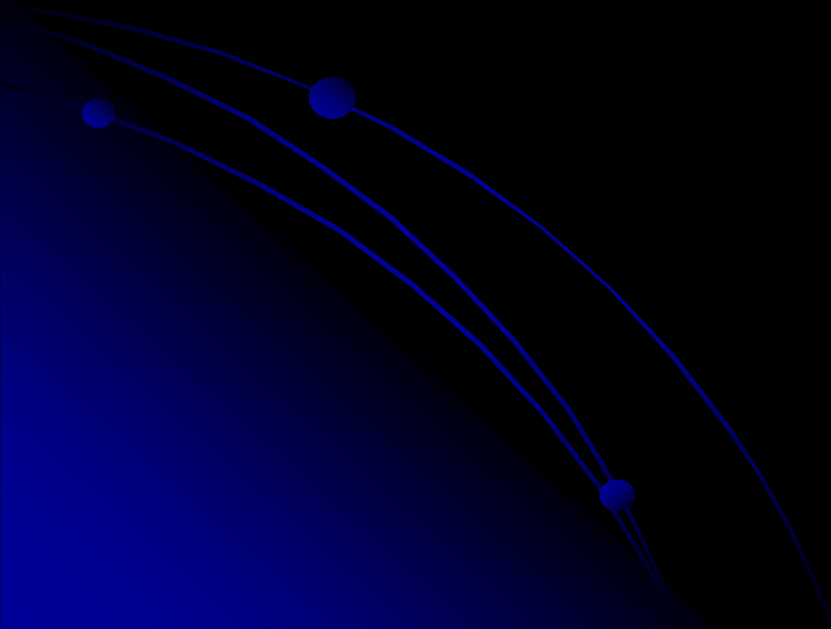


Results

Physiological Response

Rectal Temperature Response to Endotoxin

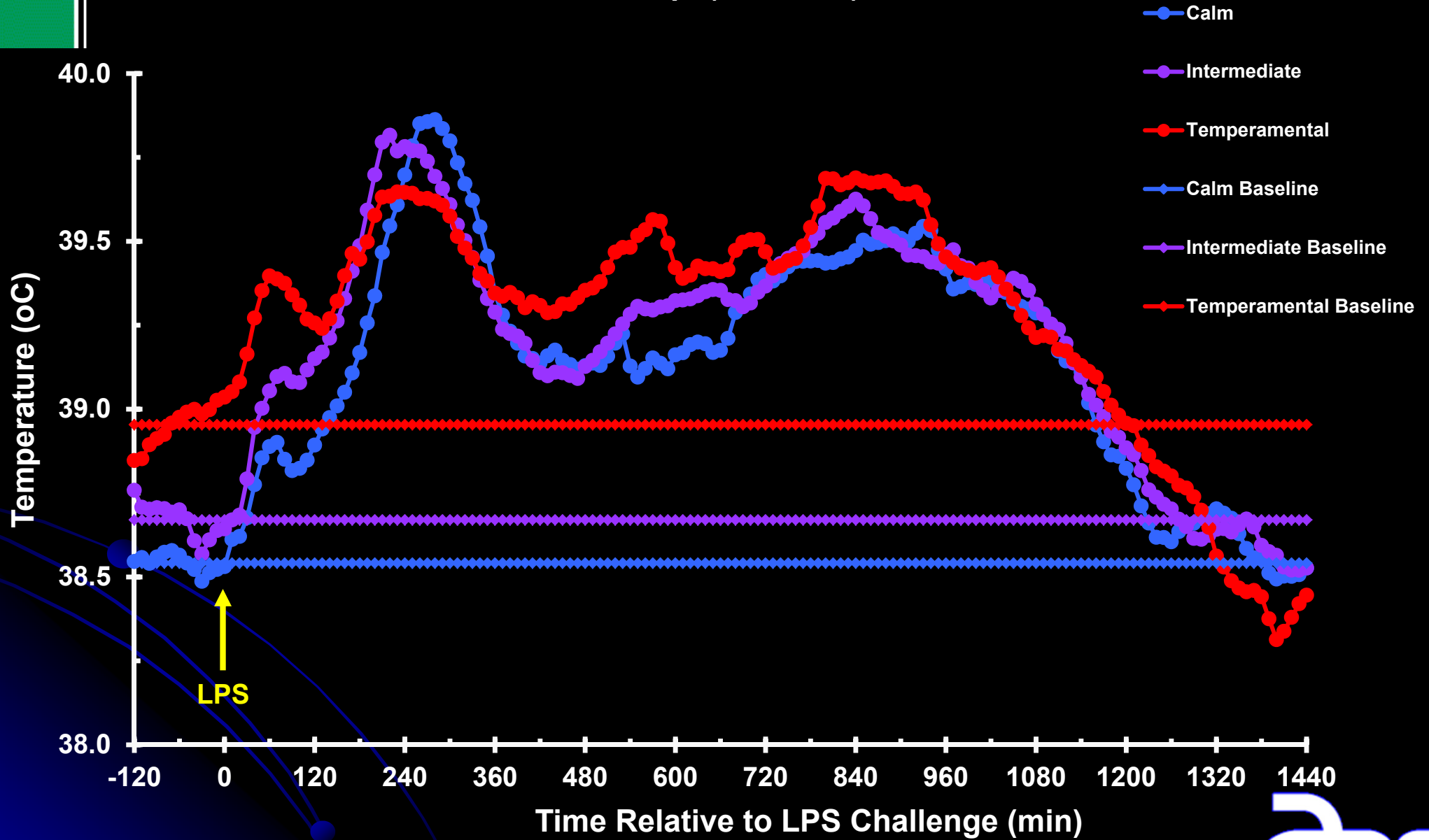
Sickness Scores





Rectal Temperature Response: LPS Challenge

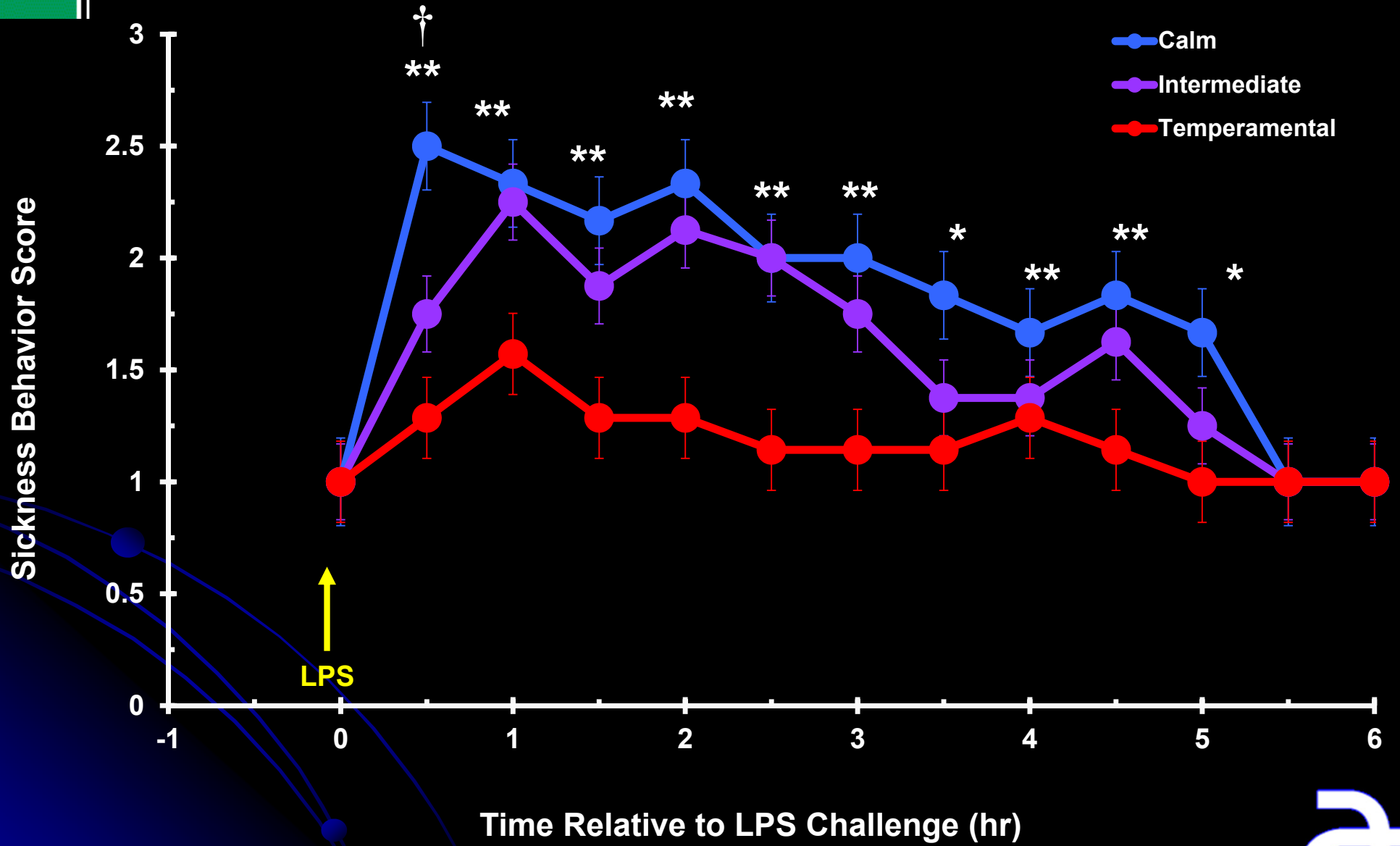
Temp (P < 0.001)





Sickness Scores

Temp (P < 0.001)



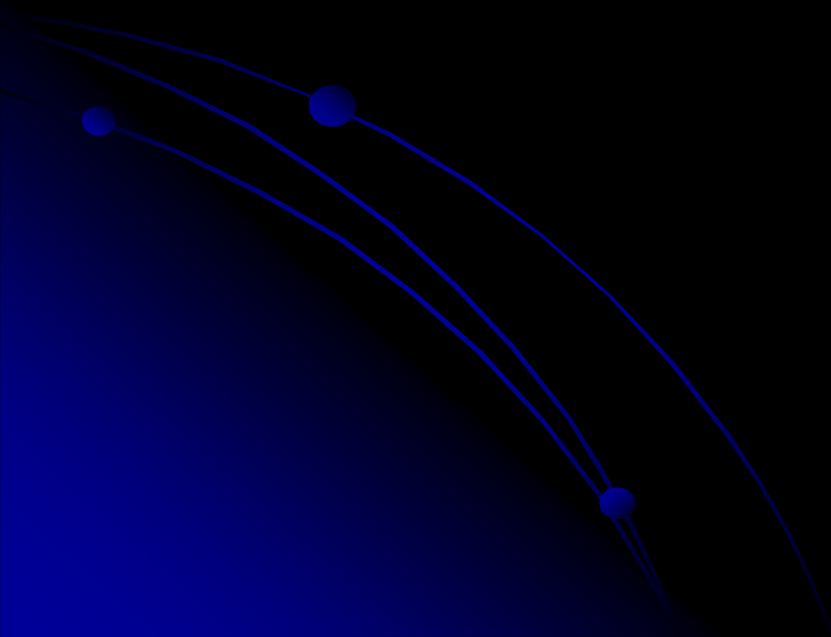


Results

Stress Response

Cortisol

Epinephrine

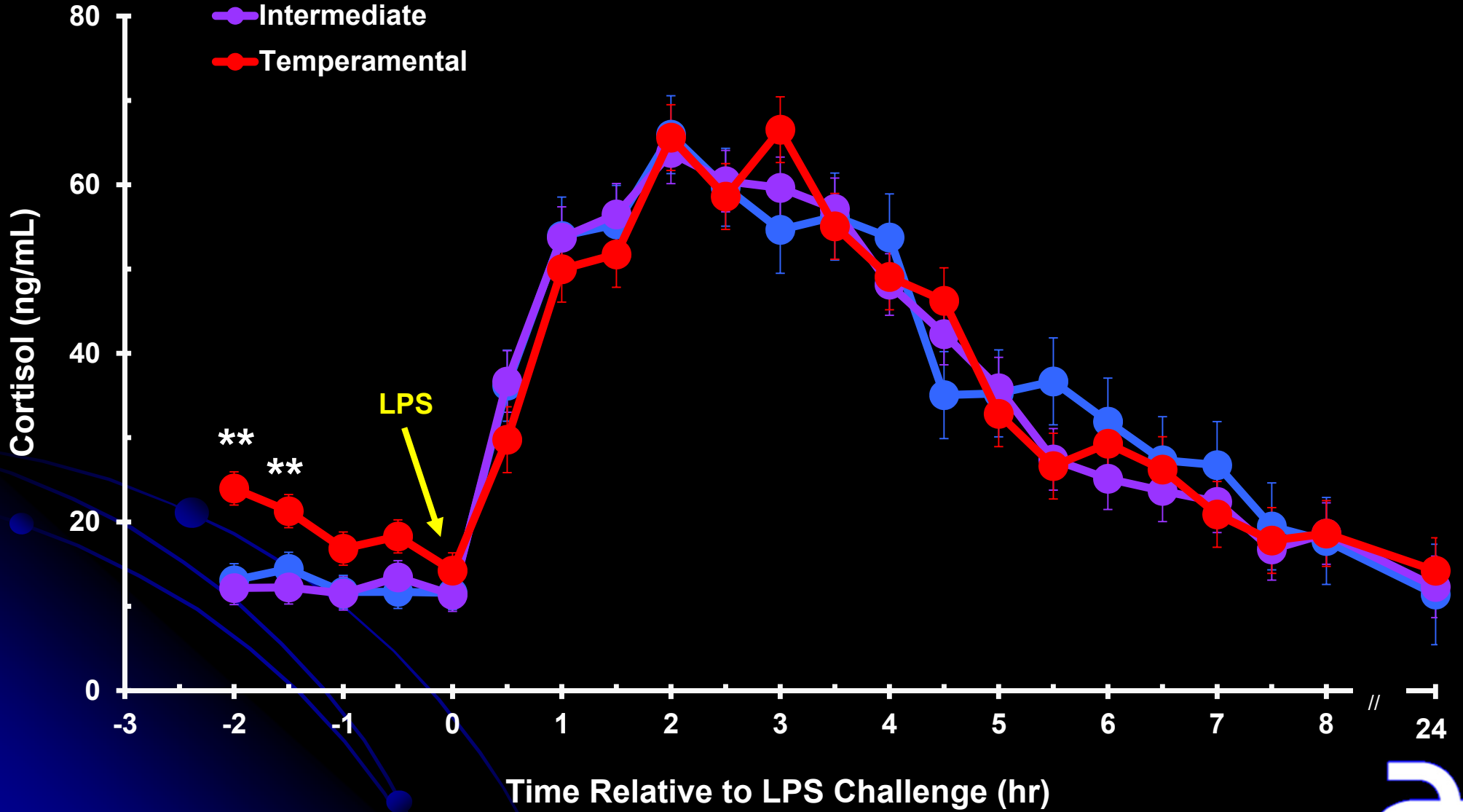




Serum concentration of Cortisol

Temp x Time (P > 0.10)

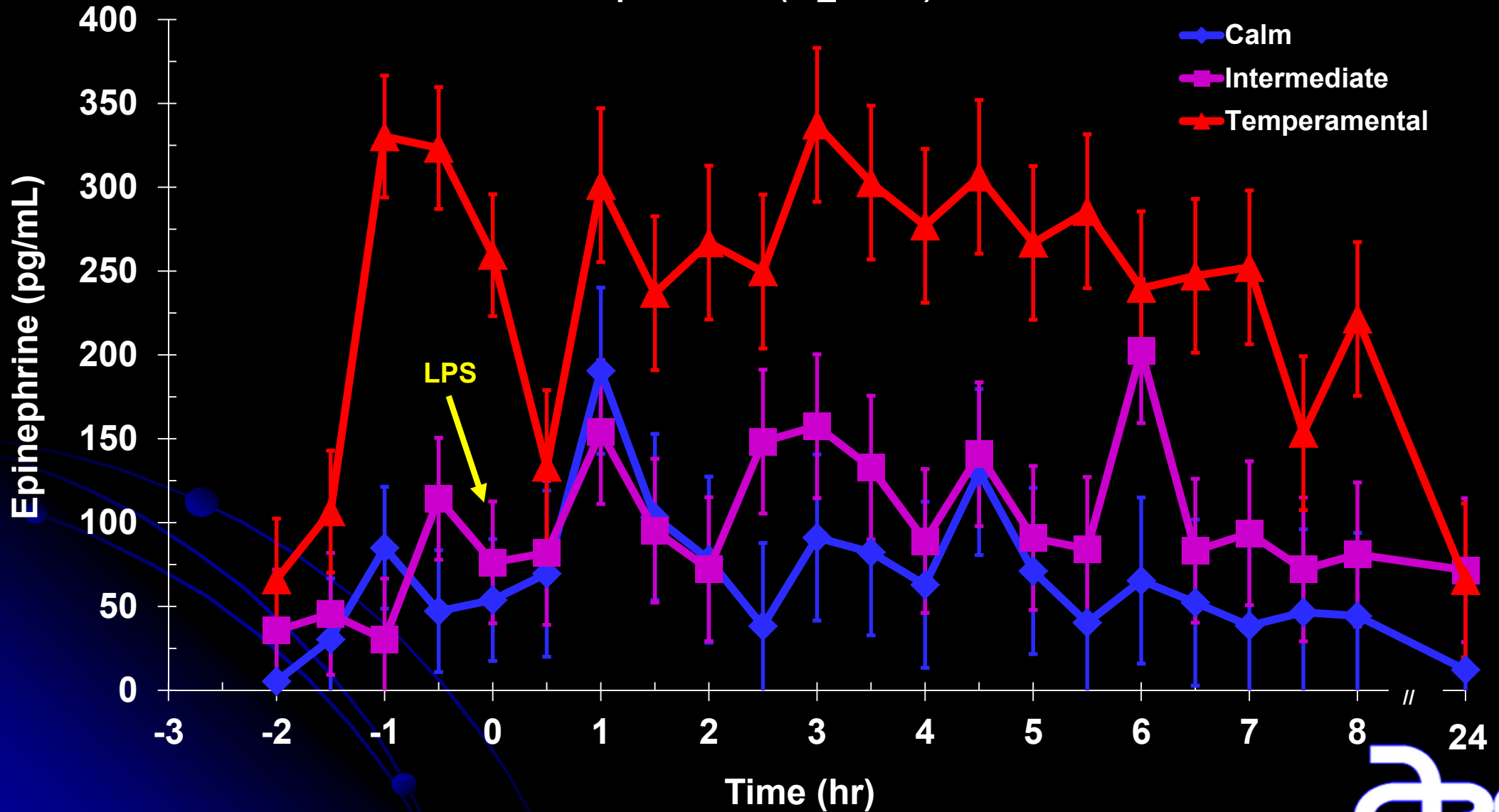
- Calm
- Intermediate
- Temperamental





Serum concentration of Epinephrine

Temperament: ($P \leq 0.004$)





Results

Cytokine Responses

Tumor Necrosis Factor-alpha

Interleukin-6

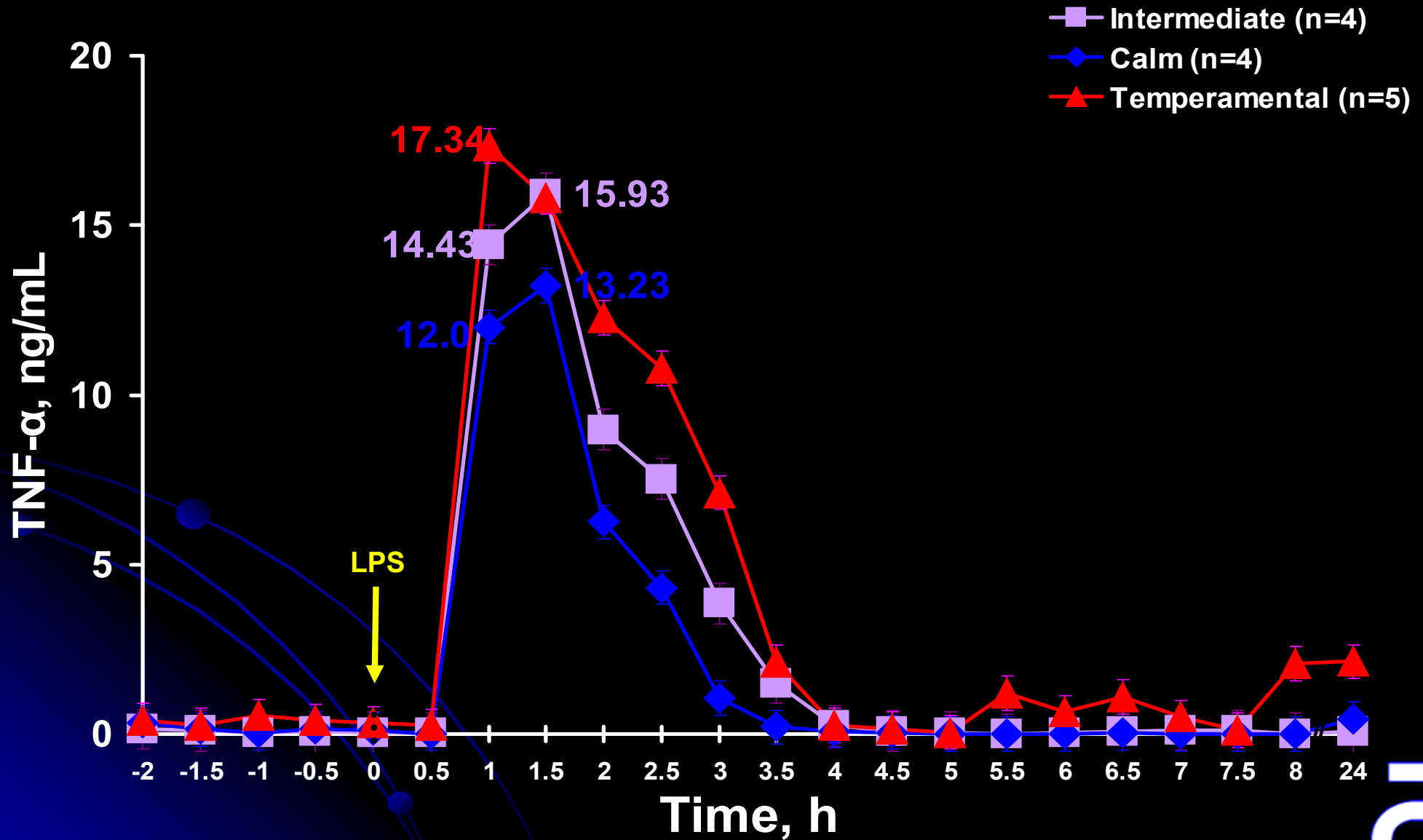
Interleukin-4





Serum concentration of TNF- α

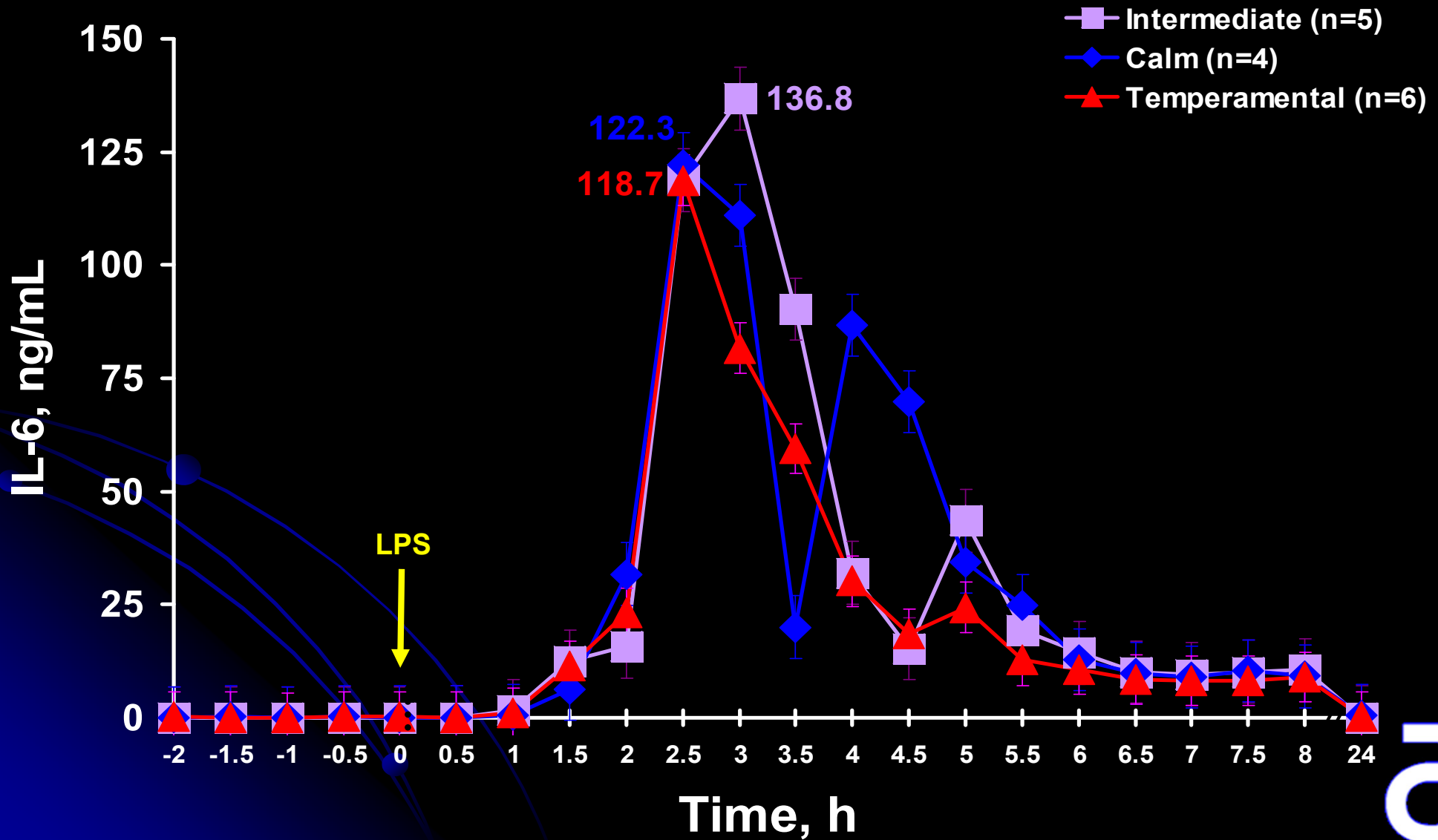
Temp x Time (P < 0.005)





Serum concentration of IL-6

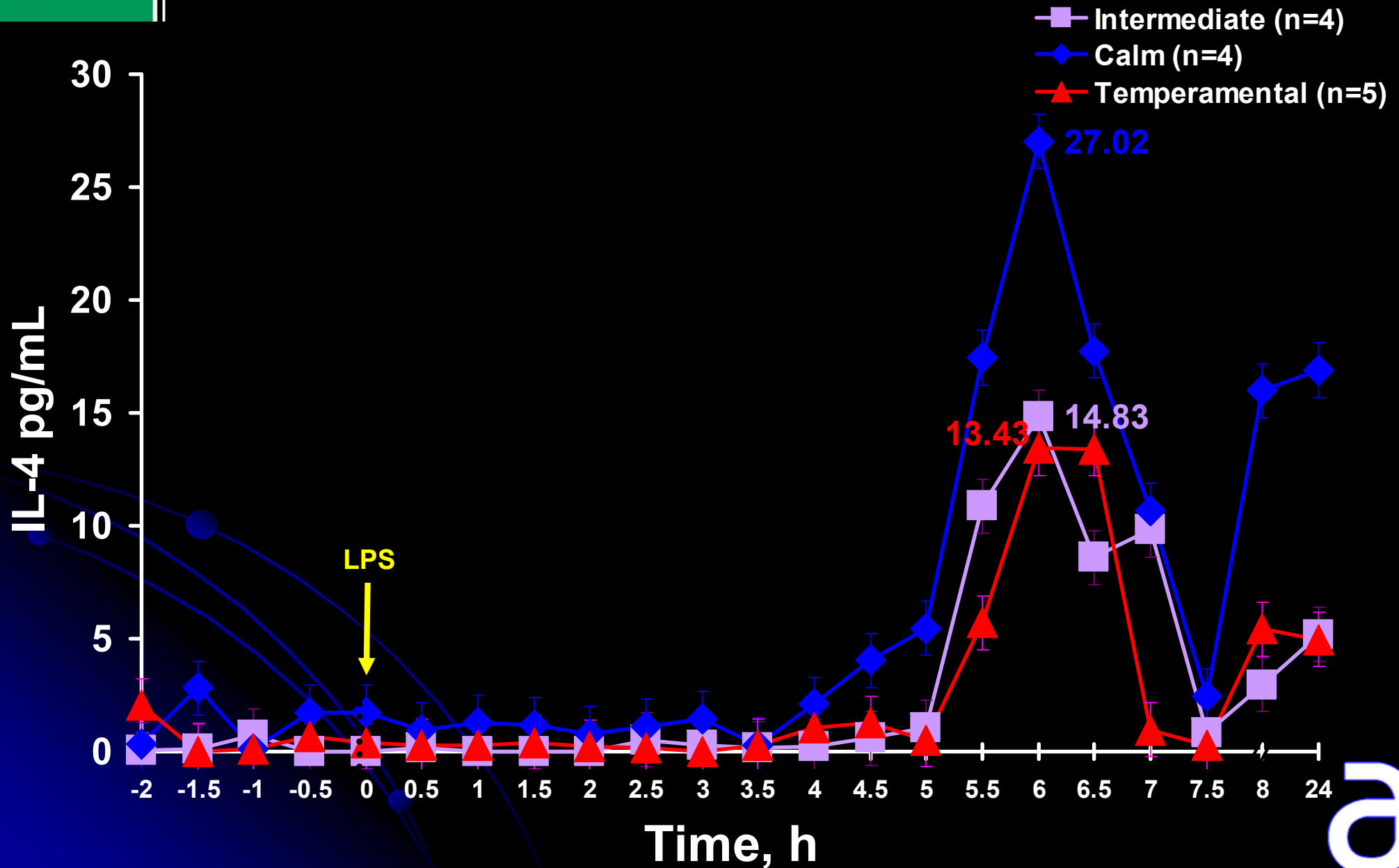
Temp x Time (P < 0.005)





Serum concentration of IL-4

Temp x Time (P < 0.005)



What is potentially modulating the differences observed between calm and temperamental cattle?





Results

Metabolic Response

Glucose

Insulin

Non-esterified fatty acids (NEFAs)

Blood urea nitrogen (BUN)

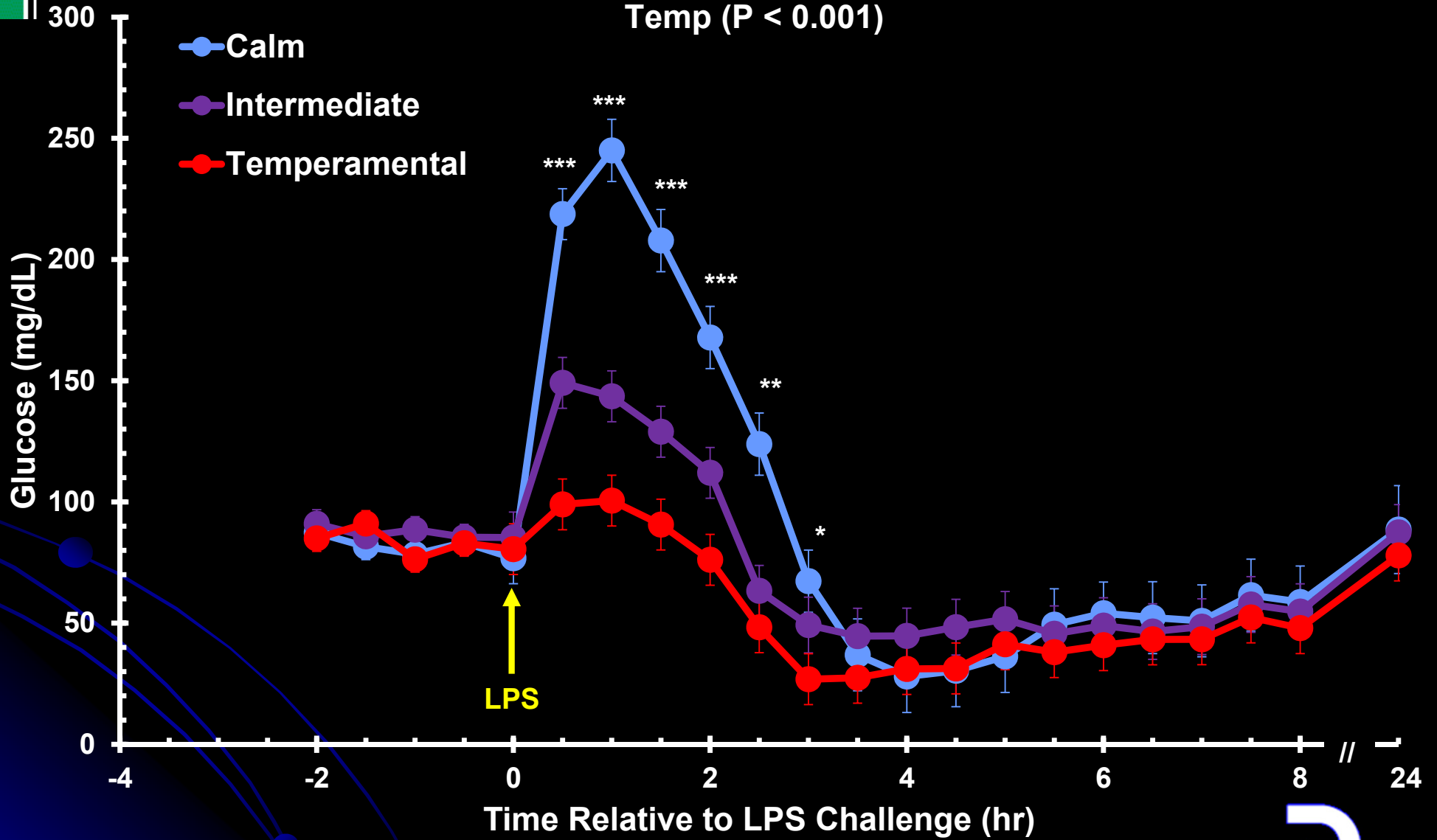
Insulin Sensitivity (RQUICKI)





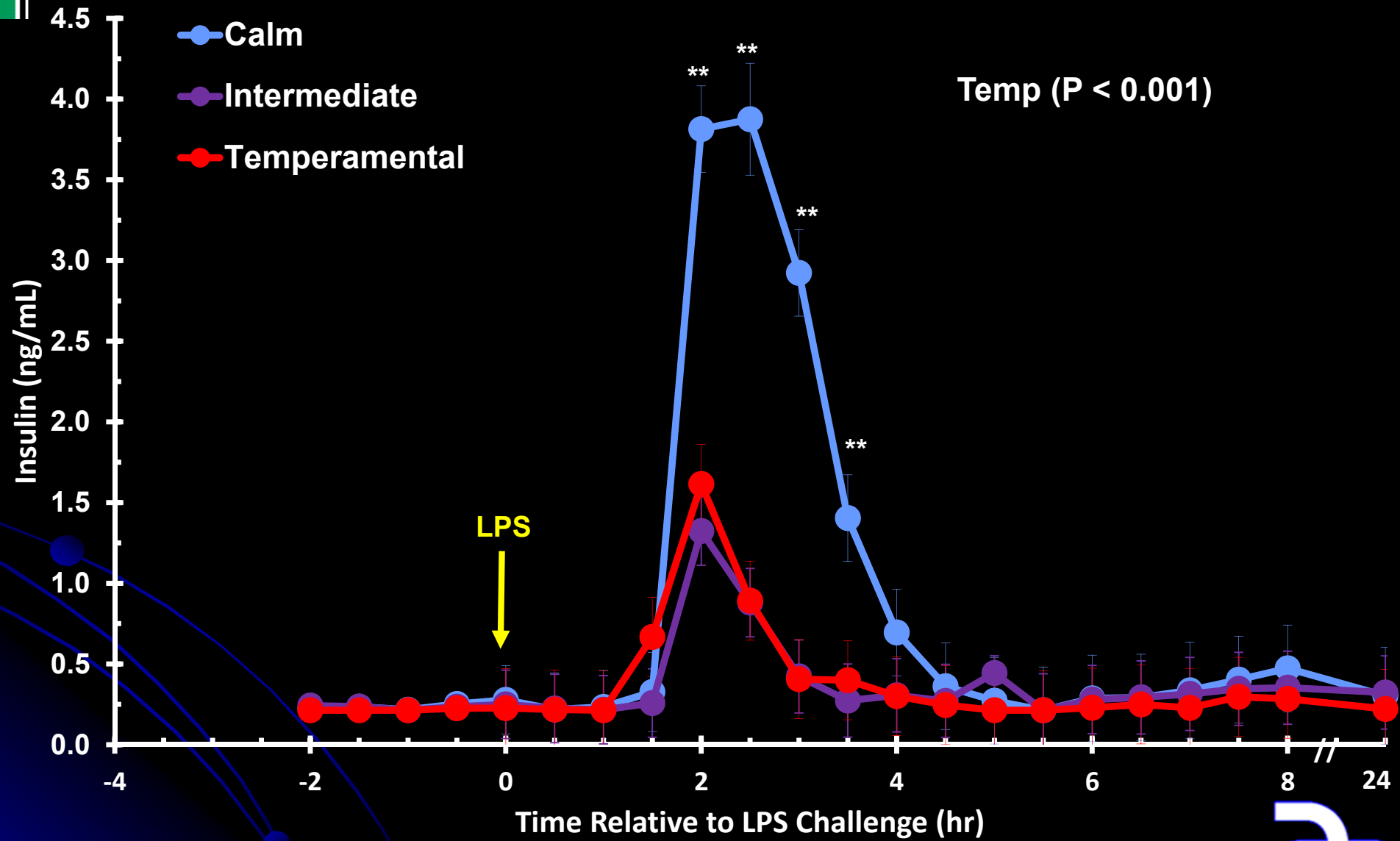
Glucose

Temp (P < 0.001)





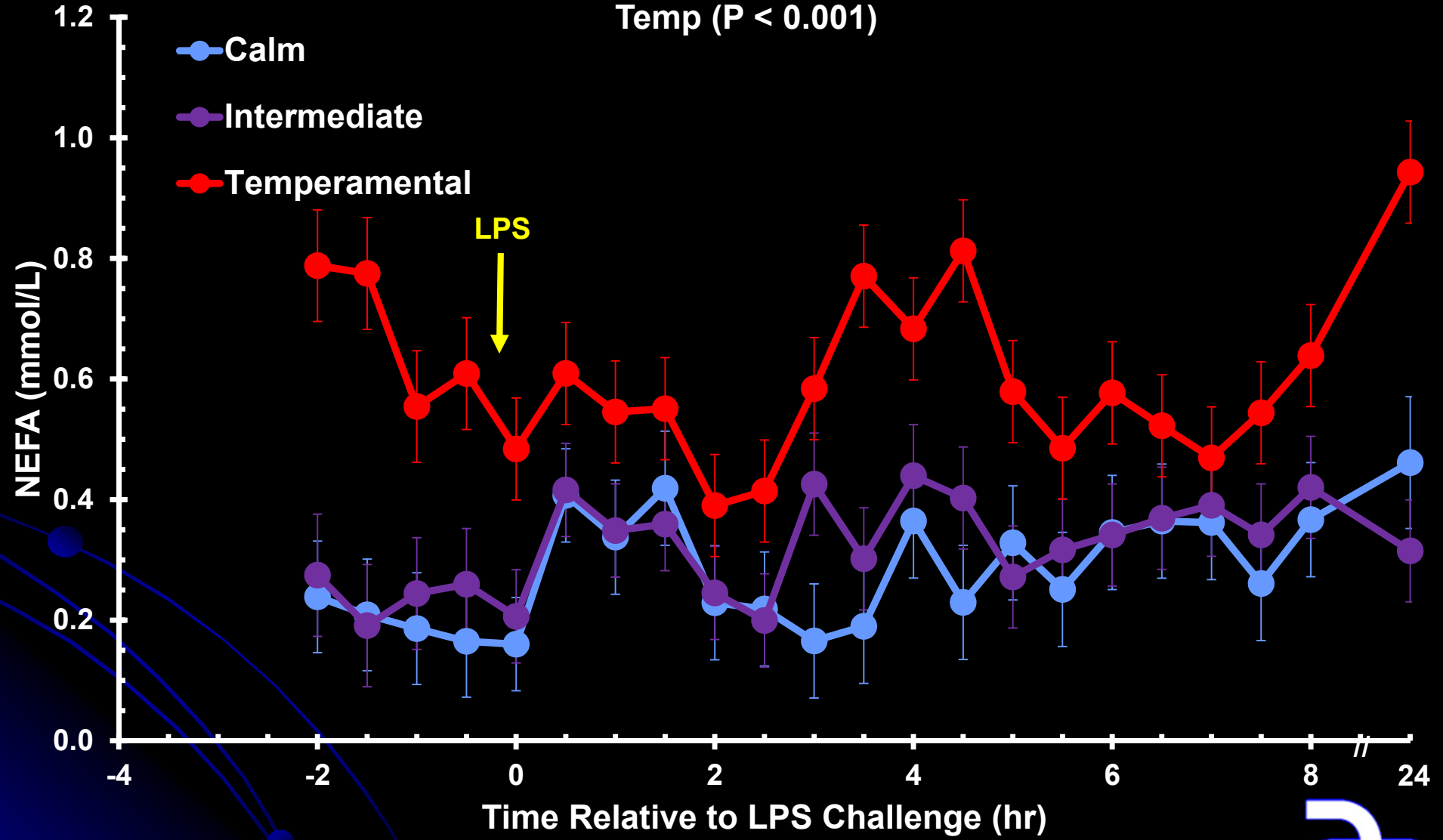
Insulin





NEFAs

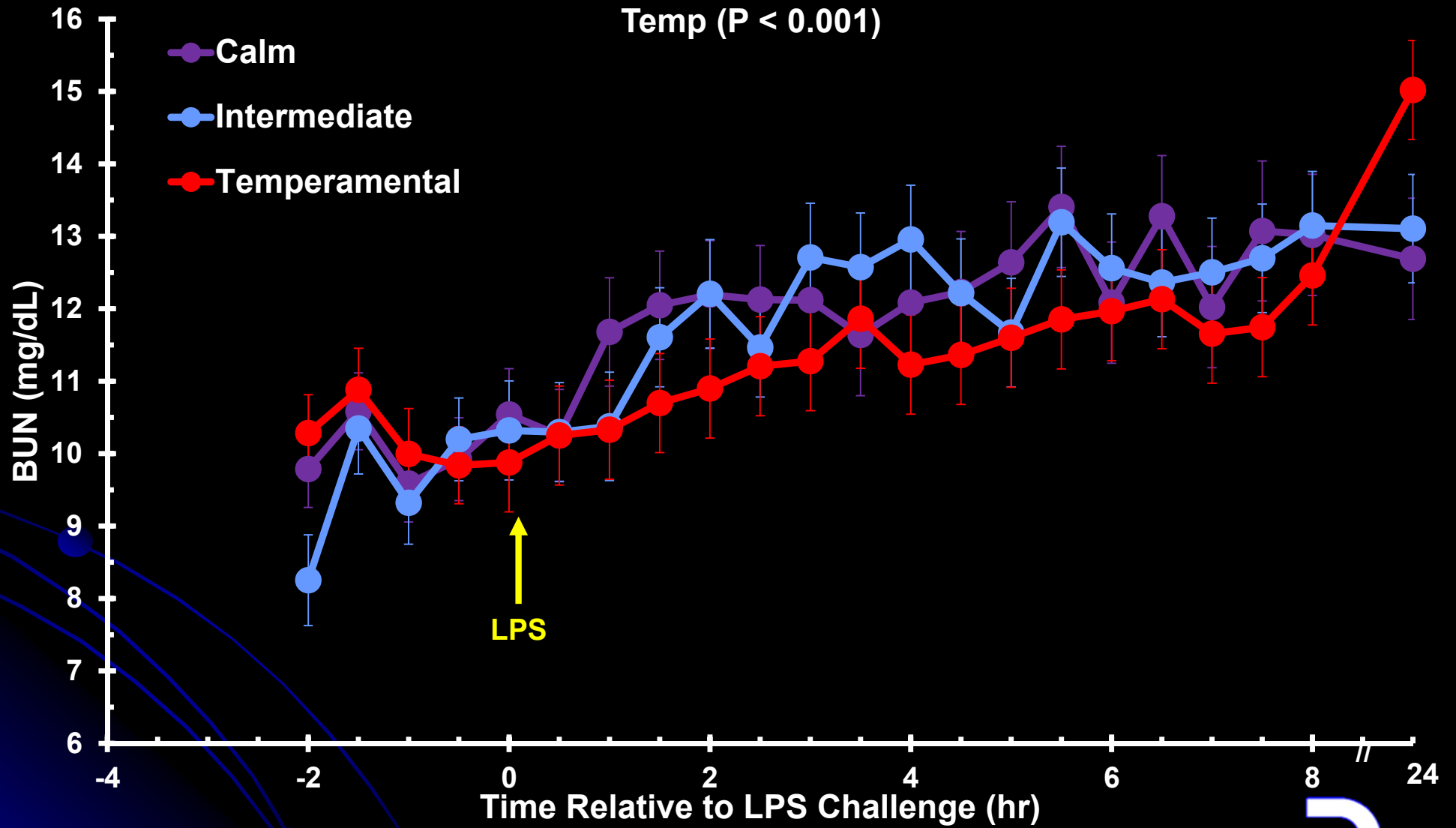
Temp (P < 0.001)





BUN

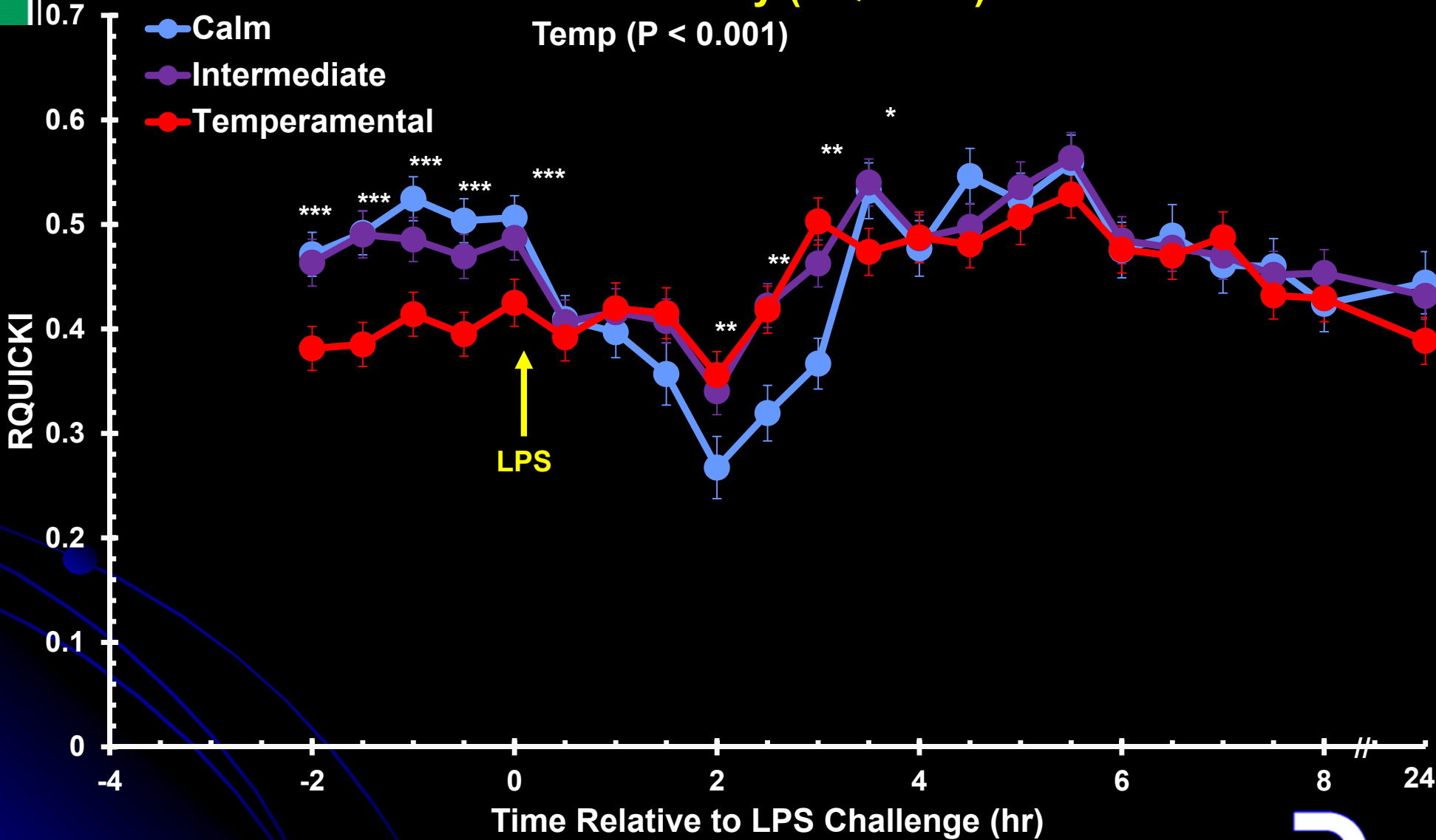
Temp (P < 0.001)





Insulin Sensitivity (RQUICKI)

Temp (P < 0.001)





Summary - Implications

- **Temperamental calves (Immune and stress parameters):**
 - **Elevated basal body temperature (exacerbated during handling).**
 - **False febrile diagnosis**
 - **Reduced body temperature response to LPS.**
 - **Use of body temperature as indicator of health status could be misleading**
 - **Limited to no sickness behavior response to LPS.**
 - **Could make actual detection of disease difficult**
 - **Elevated basal cortisol and epinephrine concentrations.**
 - **False indication of stress response**





Summary - Implications (cont.)

- **Temperamental calves (Metabolic parameters):**
 - **Significantly lower glucose response to LPS.**
 - **Perhaps suggesting less of a need for glucose??**
 - **Increased basal concentrations of NEFAs.**
 - **Increased lipolysis/reduced lipogenesis?**
 - **NEFAs being used as an energy source??**
 - **Reduced BUN concentrations.**
 - **Indicative of less protein degradation?**
 - **Reduced insulin sensitivity.**
 - **Overall metabolic shift/re-programming??**



Overall Conclusion

Clearly, significant variations exist within the livestock populations related to stress regulation, metabolic responses, and overall immunity that can be attributed to environment, animal management, and **naturally occurring variations (i.e., sexual dimorphism, breed effects, animal temperament).**

By utilizing this knowledge, we may be able to improve animal health and well-being by **specific trait selection or pre-programming of animals** in a manner that is more suitable for **specific production environments.**

Development of animal-type **specific management practices/nutritional strategies/vaccination protocols** will lead to enhanced health, well-being, and overall productivity in the beef industry.





Acknowledgement of Collaborators

Dr. Ronald D. Randel - Texas A&M AgriLife Research/Animal Science (Overton, Texas)

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Dr. Rhonda C. Vann - Mississippi Agricultural & Forestry Experiment Station (Brown Loam, Mississippi)

Dr. Nicole C. Burdick Sanchez – USDA ARS Livestock Issues Unit (Lubbock, Texas)



Questions?

