

**The Role of Infrared Thermography in pain measurement.**

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**KeyWords**Pain , **infrared** ,**Body temperature**, **vasodilation**, **vasoconstriction**, **nervous**, **Physiological Mechanisms****ABSTRACT**

Infrared thermography (IRT) is a non-invasive, objective technology used to evaluate pain and stress by quantifying surface temperature changes. It operates by monitoring peripheral blood perfusion, which is regulated by sympathetic nervous system responses to painful stimuli. IRT detects localized inflammation as areas of hyperthermia, while capturing subtle microcirculation oscillations as small as 0.1°C. By focusing on highly vascularized, hairless "thermal windows" like the eyes or ears, researchers can accurately correlate temperature variations with pain levels. Ultimately, IRT refines animal welfare in biomedical research by providing real-time, contact-free assessment of pain and analgesic efficacy.

## The Role of Infrared Thermography in pain measurement.

**Infrared thermography (IRT)** has emerged as an innovative, **noninvasive technology** that objectively evaluates pain by detecting and quantifying the intensity of **infrared radiation** emitted from the body's surface. This technique converts thermal radiation into digital images, where a color-coded numerical scale represents temperature distribution. By measuring these surface temperatures, researchers can estimate **core body temperature (T<sub>core</sub>)** and identify physiological shifts triggered by painful or stressful stimuli.

## The Vascular Connection to Pain

The effectiveness of IRT lies in its ability to monitor **blood perfusion**, which is regulated by the mechanisms of **vasodilation and vasoconstriction**. Under normal conditions, the skin acts as the primary thermoregulating organ, with the venous plexuses on its surface regulating blood flow to maintain a constant internal temperature.

When an animal experiences pain, the **central nervous system (CNS)** orchestrates endocrine and autonomous responses that alter peripheral blood flow. These changes are often mediated by the **sympathetic nervous system**, which can cause reflex activation of noradrenergic nerves, leading to vasoconstriction (to maintain heat) or vasodilation (to dissipate heat) depending on the context of the stressor or injury.

## Physiological Mechanisms of Thermal Variation

IRT objectively captures the body's reaction to pain through two primary pathways:

- **Inflammatory Responses:** Localized pain from lesions, fractures, or surgical incisions often involves an inflammatory process. This triggers the release of **pro-inflammatory mediators**—such as histamine, quinines, and prostaglandins—which result in **hyper perfusion and hypermetabolism**. IRT detects these as areas of **hyperthermia** (increased temperature) in the damaged tissue.

- **Microcirculation Oscillations:** Subtle temperature changes captured by IRT are caused by oscillations in **arteriolar microcirculation**, which adapt to the specific metabolic requirements or pathological states of tissues. Because IRT is sensitive enough to detect variations as small as **0.1°C**, it can identify early or subtle signs of discomfort even before clinical signs of infection or illness appear.

## The Importance of "Thermal Windows"

To gain the most accurate data, scientists focus on **"thermal windows."** These are specialized regions of the body—such as the **ears of rabbits, the eyes of calves, and the tails and paws of rodents**—that lack fur and are highly vascularized. Because these areas are crucial for heat dissipation, they provide a clear correlation between the **degree of pain and temperature variation**. For instance, monitoring the auditory canal or the tear caruncle allows for precise

measurement of thermal responses during surgical procedures or recovery.

### Advancing Animal Welfare

By providing an objective and quantitative tool for evaluating pain, IRT supports the "3Rs" (**Replacement, Reduction, and Refinement**) in scientific research. It allows for better **analgesic management** by verifying the efficacy of drugs through thermal shifts in real-time. Ultimately, IRT bridges the gap between clinical and preclinical pain assessment, ensuring more ethical and accurate outcomes in biomedical research.

### Conclusion

Infrared Thermography (IRT) represents a significant advancement in veterinary medicine and biomedical research, offering a completely non-invasive, objective, and quantifiable method for pain assessment. By translating complex sympathetic nervous system responses and localized inflammatory pathways into precise visual temperature data, IRT can identify subtle physiological shifts as small as 0.1°C before clinical symptoms manifest. Utilizing specialized, highly vascularized "thermal windows" ensures data accuracy by minimizing external interference from fur or hair. Ultimately, by eliminating the stress of physical handling and allowing real-time monitoring of analgesic efficacy, IRT successfully bridges the gap between clinical observation and ethical research, serving as a vital tool for the refinement of animal welfare standards.

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