Pain: Clinical Evidence and Mechanisms of Action of Far Infrared Therapy

1. **Far infrared therapy inhibits vascular endothelial inflammation via the induction of heme oxygenase-1** (Lin, Liu et al 2008)

   "The induction of HO-1 contributes to the ability of FIR therapy to inhibit the expression of EC adhesion molecules and the adhesion of monocytes to vascular endothelium."

2. **Far-infrared mitigates vascular endothelial growth factor-induced proliferation in human umbilical vein endothelial cells via the generation of nitric oxide and reactive oxygen species** (Hsu, Chen et al 2008)

   "FIR treatment induced the phosphorylation of endothelial nitric oxide synthase (eNOS) and increased nitric oxide (NO) in HUVEC," suggesting that "FIR, through its nonthermal effects, induces NO and ROS generation to mitigate VEGF-induced proliferation in HUVEC."

3. **Biological effect of far-infrared therapy on increasing skin microcirculation in rats** (Yu, Chiu et al 2006)

   "FIR Therapy promoted skin blood flow through a mechanism closely related to L-arginine/NO pathway."

4. **Nitric oxide is negatively correlated to pain during acute inflammation** (Hamza, Wang et al 2010)

   Nitric Oxide is found to be analgesic for inflammatory pain in the acute phase after injury.

5. **Modulation of pain in osteoarthritis: the role of nitric oxide** (Hancock and Riegger-Krugh 2008)

   "NO-based intervention may produce substantial pain relief without undesirable side effects by increasing circulation, decreasing nerve irritation, and decreasing inflammation in joints."

6. **Role of the peripheral heme oxygenase-carbon monoxide pathway on the nociceptive response of rats to the formalin test: evidence for a cGMP signaling pathway** (Nascimento and Branco 2007)

   "The HO-CO pathway modulates the nociceptive response in both phases of formalin test. The local peripheral pathway inhibition leads to hypernociception and the activation of the pathway leads to an expressive antinociception on the two phases of the formalin test."

Pain: Clinical Evidence and Mechanisms of Action of Far Infrared Therapy

7. **Antinociception synergy between the peripheral and spinal sites of the heme oxygenase-carbon monoxide pathway** (Nascimento and Branco 2009)

   "…an antinociceptive synergy exists between peripheral and spinal HO pathways, which may reduce the doses required and side effects."

8. **Nrf2-mediated haeme oxygenase-1 up-regulation induced by cobalt protoporphyrin has antinociceptive effects against inflammatory pain in the formalin test in mice** (Rosa, Egea et al, 2008)

   "Nrf2-mediated HO-1 expression induced an antinociceptive effect at peripheral sites" in the formalin test in mice. So, treatments that induce the expression of peripheral HO-1 could be relevant in the reduction of inflammatory pain.

9. **Role of the haeme oxygenase/carbon monoxide pathway in mechanical nociceptor hypersensitivity** (Steiner, Branco et al. 2001)

   "…endogenously CO produced by HO plays an anti-hyperalgesic role in inflamed paws, probably by increasing the intracellular levels of cyclic GMP in the primary afferent neurone."

10. **Efficacy of low-level laser therapy in the management of neck pain: a systematic review and meta-analysis of randomized placebo or active-treatment controlled trials** (Chow, Johnson et al 2009)

    Low-level laser therapy (LLLT) of various infrared wavelengths, 632.8nm, 670nm, 780nm, 820nm, 830nm, and 904nm, have been used clinically for pain relief. "Anti-inflammatory effects of red and infrared laser irradiation have been shown by reduction in specific inflammatory markers (prostaglandin E2, interleukin 1ß, tumour necrosis factor α), in in-vitro and in-vivo animal studies and in man…. Laser-mediated anti-inflammatory effects… could result in decreased pain and increased mobility.

11. **Infrared therapy for chronic low back pain: a randomized, controlled trial** (Gale, Rothbart et al 2006)

    An infrared therapy device of 800nm-1200nm wavelengths was evaluated for its benefits on patients' chronic low back pain compared with a placebo device; "The IR therapy unit used was demonstrated to be effective in reducing chronic low back pain, and no adverse effects were observed."

Pain: Clinical Evidence and Mechanisms of Action of Far Infrared Therapy

12. **Low Level Laser Therapy (LLLT) for Chronic Low Back Pain (LBP)**. (Hadi, Ali et al, 2009)
LLLT of 890nm was evaluated for its benefits on chronic low back pain compared with a placebo device; the patients in the laser treatment group experienced "significant symptomatic relief without any side effect."

13. **The effect of low-level laser in knee osteoarthritis: a double-blind, randomized, placebo-controlled trial** (Hegedűs, Viharos et al, 2009)

LLLT of 830nm was evaluated for its benefits on patients with osteoarthritis compared with a placebo device; an increase in local microcirculation and skin temperature was found after treatment, and the patients experienced improvements in joint flexion, pressure sensitivity and pain scored.

14. **The Effects of Repeated Thermal Therapy for Patients with Chronic Pain**
(Masuda, Koga et al, 2005)

Systemic warming with far-infrared sauna was used to treat patients with chronic pain as part of a multidisciplinary treatment. The patients experienced some pain relief and improved anger score after treatment.

15. **The effect of Infrared sauna in patients with rheumatoid arthritis and ankylosing spondylitis** (Oosterveld, Rasker et al, 2009)

"…infrared treatment has statistically significant short-term beneficial effects and clinically relevant period effects during treatment in RA and AS patients without enhancing disease activity. IR has good tolerability and no adverse effects."

16. **The effect of local infrared therapy on hematomas and on pain during needling hemodialysis with arteriovenous fistulas** (Shipley T 2013)
"Patients have objectively recorded a reduced pain score on needling an AVF under the influence of FIR, as well as improvement in haematoma resolution. We surveyed 40 patients on our HD unit who underwent FIR of their AVF because of pain associated with needling. Patient testimonials have been integral to developing our service further"