PHOTOBIOMODULATION AND RED LIGHT THERAPY RESEARCH REFERENCES

Alex Whelan, MD - The Testosterone Replacement Clinic/Peak Performance Cryo & Recovery

Photobiomodulation and Sports: Results of a Narrative Review

Laura Marinela Ailioaie and Gerhard Litscher (2021 - Life)

Study Intentions

The review aimed to evaluate the effects of Photobiomodulation (PBM) in sports, particularly its potential to enhance athletic performance and aid in recovery. The researchers analyzed 61 studies, focusing on the physiological and biochemical effects of PBM on muscle recovery, inflammation, fatigue, and performance in both human and animal subjects.

Main Results

1. **Positive Effects on Athletes:**
    - PBM increased muscle performance, reduced fatigue, and enhanced recovery in 25 out of 39 human studies.
    - It showed significant benefits in reducing oxidative stress, inflammation, and muscle damage markers like creatine kinase (CK) and lactate dehydrogenase (LDH).
2. **Optimized Application:**

    - PBM was most effective when applied with doses between 10–60 J before exercise, particularly in enhancing performance and recovery.
    - Infrared (810–905 nm) and red light (660–670 nm) were identified as optimal wavelengths for non-invasive muscle stimulation.
3. **Animal Studies:**
    - Experiments demonstrated PBM's role in reducing pro-inflammatory cytokines, improving mitochondrial function, and accelerating tissue repair.
4. **Limitations of Some Studies:**
    - Fourteen studies reported inconclusive or negative results, often due to insufficient PBM dosage, inappropriate timing of application, or technological limitations in devices.

Implications

- PBM offers a promising, non-invasive method for enhancing athletic performance and recovery without side effects or the need for drugs.
- Standardizing PBM protocols, including dose, wavelength, and timing, is critical for maximizing its benefits.
- Future research should explore innovative devices and techniques, such as 3D/4D motion analysis and nanotechnology, to further optimize PBM application in sports.

The findings suggest PBM has great potential as an ergogenic and therapeutic tool, but further studies are needed to refine its clinical applications and fully understand its mechanisms.

Photobiomodulation in Human Muscle Tissue: An Advantage in Sports Performance?

Cleber Ferraresi, Ying-Ying Huang, and Michael R. Hamblin (2016 - Journal of Biophotonics)

Study Intentions

This review examines the effects of photobiomodulation (PBM), which involves red or near-infrared light, on human muscle tissue to enhance sports performance. The study aims to assess whether PBM improves muscle performance and recovery, reduces muscle damage, and increases fatigue resistance.

Main Results

1. **Performance Enhancement**: PBM applied before or after exercise increased the number of repetitions, improved muscle strength, and reduced fatigue in many cases. PBM also enhanced mitochondrial ATP synthesis, which provides energy for muscle work.
2. **Reduction in Muscle Damage**: PBM showed a significant decrease in biomarkers of muscle damage, such as creatine kinase (CK) and delayed onset muscle soreness (DOMS).
3. **Mixed Results on Optimal Parameters**: While some studies demonstrated clear benefits, results varied depending on PBM wavelength, dose, and timing (pre-conditioning vs. post-exercise).

4. **Application in Sports**: PBM improved exercise recovery and protected against oxidative stress, potentially offering advantages for athletes. However, the variability in outcomes suggests the need for standardized protocols.

Implications

The findings suggest PBM can be a valuable tool for improving athletic performance and muscle recovery. However, due to the inconsistencies in study results and methods, further research is needed to define optimal treatment parameters. If widely adopted, the use of PBM in sports could raise ethical and regulatory concerns, particularly with international competition rules, such as those of the World Anti-Doping Agency.

A Holistic Perspective on How Photobiomodulation May Influence Fatigue, Pain, and Depression in Inflammatory Bowel Disease: Beyond Molecular Mechanisms

E-Liisa Laakso and Tatjana Ewais (2023 - Biomedicines)

Study Intentions

The study explores the potential of photobiomodulation (PBM) therapy as a complementary treatment for managing fatigue, pain, and depression in patients with inflammatory bowel disease (IBD), specifically Crohn's disease and ulcerative colitis. The authors adopt a holistic biopsychosocial framework, emphasizing the need to look beyond molecular mechanisms by considering the integrated roles of the neuroimmune system, microbiome-gut-brain axis, and other systemic pathways.

Main Results

1. **PBM and Inflammation**: PBM may modulate inflammatory processes in IBD by altering the gut microbiome, reducing cytokine levels (e.g., TNF-α, IL-6), and affecting local and systemic inflammation.
2. **Pain Management**: PBM demonstrated potential in reducing both inflammatory and non-inflammatory pain by modulating neural and inflammatory pathways.
3. **Fatigue and Depression**: PBM could alleviate central and peripheral fatigue and improve depression by influencing mitochondrial function, oxidative stress, and neuroinflammatory markers.
4. **HRQoL Improvements**: Early evidence suggests that PBM positively impacts health-related quality of life (HRQoL), including physical, emotional, and social functioning.

Implications

The study posits that PBM may serve as a non-invasive adjunct to traditional treatments for IBD, targeting multifactorial symptoms holistically. Future clinical trials are needed to confirm its efficacy, optimize treatment parameters, and explore its long-term benefits. PBM could potentially enhance physical activity and overall well-being in IBD patients, while its minimal adverse effects make it an attractive therapeutic option.

Effect of low-level laser therapy on pain, quality of life and sleep in patients with fibromyalgia: study protocol for a double-blinded randomized controlled trial

Paulo de Tarso Camillo de Carvalho, Ernesto Cesar Pinto Leal-Junior, Ana Carolina Araruna Alves, Caroline Sobral de Melo Rambo, Luciana Maria Malosa Sampaio, Claudia Santos Oliveira, Regiane Albertini, and Luis Vicente Franco de Oliveira (2012 - Trials)

Study Intentions:

The study aimed to evaluate the effects of low-level laser therapy (LLLT) on tender points in fibromyalgia patients and assess its impact on pain, quality of life, and sleep. The researchers hypothesized that LLLT could alleviate pain through its analgesic and anti-inflammatory properties, improving both physical and mental well-being.

Methodology:

The study involved 120 fibromyalgia patients randomized into two groups: an intervention group receiving LLLT and a control group receiving placebo treatments. Both groups underwent a standardized 50-minute exercise program following laser therapy. Pain and

quality of life were measured using tools like the Visual Analog Scale, McGill Pain Questionnaire, Fibromyalgia Impact Questionnaire (FIQ), and polysomnography.

Main Results:

The study protocol aimed to identify whether LLLT reduced pain intensity (measured on various scales), improved sleep (via polysomnography), and enhanced quality of life (measured by FIQ and other questionnaires). Data were to be analyzed using ANOVA and paired t-tests, with a significance level of 5%.

Implications:

This research seeks to establish a standardized therapeutic protocol for LLLT in fibromyalgia treatment. If effective, the findings could contribute to managing chronic pain and improving the daily lives of fibromyalgia patients. Moreover, it could lead to broader acceptance and integration of LLLT in clinical practice.

Low-Intensity Laser and LED (Photobiomodulation Therapy) for Pain Control of the Most Common Musculoskeletal Conditions

Marcelo F. de Oliveira, Douglas S. Johnson, Timothy Demchak, Shaiane S. Tomazoni, Ernesto C. Leal-Junior (2022 - European Journal of Physical and Rehabilitation Medicine)

Study Intentions

The study aimed to evaluate the efficacy of photobiomodulation therapy (PBMT) using low-intensity laser and LED in controlling pain associated with common musculoskeletal conditions. The research focused on both acute and chronic pain and sought to present up-to-date evidence on PBMT as a non-invasive, drug-free, and safe alternative to traditional pain management methods like opioids.

Main Results

PBMT was found to effectively reduce pain and improve physical function in conditions such as:

- Non-specific knee pain
- Osteoarthritis
- Fibromyalgia
- Temporomandibular disorders
- Neck and low back pain
- Post-operative pain after total hip arthroplasty

Clinical trials demonstrated significant improvements in pain reduction and physical function when PBMT was added to standard rehabilitation protocols. For example, in knee osteoarthritis, PBMT reduced pain more effectively than placebo when applied at recommended doses. The therapy also showed promising results in fibromyalgia and post-operative pain management.

Implications

PBMT offers a promising alternative for managing musculoskeletal pain without the side effects associated with opioids or nonsteroidal anti-inflammatory drugs (NSAIDs). The authors advocate for its integration into multimodal rehabilitation programs, emphasizing the need for optimized treatment parameters. Further research is encouraged to refine dosage and improve its therapeutic efficacy across various conditions.

Muscular pre-conditioning using light-emitting diode therapy (LEDT) for high-intensity exercise: a randomized double-blind placebo-controlled trial with a single elite runner

Cleber Ferraresi, Thomas Beltrame, Fernando Fabrizzi, and others (2015 - Physiotherapy Theory and Practice)

Study Intentions

The study aimed to assess the effects of near-infrared LED therapy (LEDT) as a pre-conditioning tool for enhancing muscular performance during high-intensity exercise.

Specifically, it evaluated how LEDT influenced oxygen uptake (VO2) kinetics, blood and urine markers of muscle damage, fatigue, and metabolic efficiency in a single elite runner.

Main Results

1. **Improved VO2 Kinetics**: LEDT shortened the muscular VO2 adaptation time, reduced oxygen deficits, and enhanced the VO2 response during exercise.
2. **Enhanced Exercise Performance**: The effective LEDT condition increased the time to exercise exhaustion by 45-70% compared to placebo conditions.
3. **Reduced Muscle Damage and Fatigue**: Lower levels of creatine kinase (CK) and lactate in both blood and urine suggested reduced muscle damage and fatigue.
4. **Improved Metabolic Function**: LEDT modulated markers in urine (e.g., alanine, glycine, and creatinine) indicative of improved energy metabolism and renal function.

Implications

The results suggest that pre-conditioning with LEDT can enhance athletic performance by improving oxygen utilization, reducing muscle fatigue, and mitigating damage. This has potential applications for optimizing training regimens in athletes. However, as a pilot study involving one participant, further research is needed to generalize the findings to larger populations.

Photobiomodulation Therapy (PBMT) Improves Performance and Accelerates Recovery of High-Level

Rugby Players in Field Test: A Randomized, Crossover, Double-Blind, Placebo-Controlled Clinical Study

Henrique D. Pinto, Adriane A. Vanin, Eduardo F. Miranda, Shiane S. Tomazoni, Douglas S. Johnson, Gianna M. Albuquerque-Pontes, Ivo de O. Aleixo Junior, Vanessa dos S. Grandinetti, Heliodora L. Casalechi, Paulo de Tarso C. de Carvalho, and Ernesto Cesar P. Leal Junior (2016 - *The Journal of Strength and Conditioning Research*)

Study Intentions

The study aimed to evaluate the effects of pre-exercise photobiomodulation therapy (PBMT) on performance and recovery in high-level rugby players during an anaerobic field test. It intended to confirm prior laboratory findings in a real-world sports setting. The hypothesis was that PBMT could improve sprint performance, accelerate blood lactate clearance, and reduce perceived fatigue.

Main Results

1. **Performance Improvement:**
   PBMT significantly improved the average sprint time and reduced fatigue during the Bangsbo Sprint Test (BST) compared to placebo and control conditions.
2. **Lactate Clearance:**
   PBMT enhanced the percentage decrease in blood lactate levels post-exercise, indicating better metabolic recovery.

3. **Perceived Fatigue:**
   Athletes reported significantly lower fatigue scores after receiving PBMT compared to placebo and control phases.
4. **Fatigue Index:**
   The fatigue index was reduced in the PBMT group, demonstrating sustained performance across multiple sprints.

Implications

The findings suggest that PBMT can serve as a practical pre-exercise intervention to enhance performance and recovery in high-intensity sports like rugby. The therapy may reduce the risk of overuse injuries and improve recovery time between matches, making it a valuable tool for athletes and sports teams. Further research is encouraged to explore its benefits in other sports and real-world scenarios.

Photobiomodulation—Underlying Mechanism and Clinical Applications

Claudia Dompe, Lisa Moncrieff, Jacek Matys, Kinga Grzech-Leśniak, Ievgeniia Kocherova, Artur Bryja, et al. (2020 - The *Journal of Clinical Medicine*)

Study Intentions

The study aimed to explore the mechanisms and clinical applications of photobiomodulation (PBM), also known as low-level laser therapy (LLLT). It specifically examined how PBM influences cell behavior, focusing on tissue repair, pain relief, inflammation reduction, and stem cell differentiation.

Main Results

1. **Mechanisms of PBM:**
    - PBM stimulates cellular processes by increasing ATP production and activating mitochondrial enzymes like cytochrome c oxidase.
    - PBM enhances cell proliferation, differentiation, and tissue repair by modulating signaling pathways involving reactive oxygen species (ROS), nitric oxide (NO), and calcium ions.
2. **Applications in Medicine and Dentistry:**
    - PBM accelerates wound healing, promotes bone and tissue regeneration, and reduces pain and inflammation.
    - It has shown efficacy in treating conditions such as diabetes, neural diseases, dermatological conditions, and oral mucositis.
    - PBM improves outcomes in dentistry by aiding in implant stability and reducing post-surgical discomfort.
3. **Stem Cell Modulation:**
    - PBM promotes the differentiation of stem cells into various cell types, including osteoblasts and neurons, improving tissue healing in conditions like bone fractures and spinal cord injuries.

4. **Optimization Parameters:**
    - The effectiveness of PBM depends on factors like wavelength (600–1100 nm), energy density, and application duration. Red and near-infrared light are particularly effective.

Implications

The study highlights PBM as a promising non-invasive therapy for enhancing tissue repair, managing chronic conditions, and improving surgical outcomes. Further research is needed to standardize PBM parameters for specific medical applications and understand its full therapeutic potential.

Photobiomodulation: The Clinical Applications of Low-Level Light Therapy

Dr. Graeme Ewan Glass (2021 - *Aesthetic Surgery Journal)*

Study Intentions

The study reviews the clinical efficacy and regulatory framework of Low-Level Light Therapy (LLLT), a non-invasive treatment using red/near-infrared light to stimulate cellular processes. LLLT is widely marketed for applications such as skin rejuvenation, acne

treatment, wound healing, body contouring, and hair regrowth, though its commercialization has outpaced rigorous scientific validation.

Main Results

- **Skin Rejuvenation**: Clinical trials suggest LLLT improves skin elasticity and reduces wrinkles by stimulating collagen and elastin synthesis.
- **Acne Treatment**: LLLT, particularly with blue and red light, effectively reduces inflammatory lesions through bacterial inactivation and anti-inflammatory mechanisms.
- **Wound Healing**: Experimental and clinical data demonstrate enhanced wound repair, attributed to improved fibroblast activity and reduced inflammation.
- **Hair Regrowth**: Meta-analyses show LLLT improves hair density and thickness in androgenic alopecia, although data is limited by industry ties.
- **Body Contouring**: Some studies report reduced subcutaneous fat with LLLT, but mechanisms and efficacy remain unclear due to heterogeneity in study designs.

Implications

While LLLT shows promise in multiple clinical domains, its rapid commercialization outpaces the establishment of robust, independent clinical evidence. The study highlights the need for well-designed, adequately powered trials to determine its full therapeutic potential and optimize treatment protocols.

Conclusion

Photobiomodulation via LLLT is a growing field with demonstrable benefits in aesthetic and therapeutic applications. However, challenges persist in establishing uniform clinical standards and verifying efficacy independently of commercial interests. Further research is essential to maximize its clinical utility.

Short-Term Effects of Whole-Body Photobiomodulation on Pain, Quality of Life and Psychological Factors in a Population Suffering from Fibromyalgia: A Triple-Blinded Randomised Clinical Trial

Santiago Navarro-Ledesma, James Carroll, Patricia Burton, González-Muñoz Ana (2022 - *Pain Therapy*)

Study Intentions

The study aimed to evaluate the short-term effects of whole-body photobiomodulation (PBM) therapy on individuals with fibromyalgia (FM). Researchers hypothesized that PBM would reduce pain, improve quality of life (QoL), and positively influence psychological factors such as kinesiophobia (fear of movement) and self-efficacy.

Methods

- **Design:** A triple-blinded, placebo-controlled clinical trial with 42 participants diagnosed with FM.
- **Intervention:** Participants received 12 whole-body PBM or placebo sessions over 4 weeks using a NovoTHOR light bed.
- **Measurements:** Pain, QoL, physical activity, and psychological factors (kinesiophobia, self-efficacy, and pain catastrophizing) were assessed at baseline, midway through treatment, immediately after treatment, and at a 2-week follow-up.

Main Results

- **Pain Reduction:** Statistically significant pain reduction immediately after treatment ($p < 0.001$) and at the 2-week follow-up ($p < 0.001$).
- **Quality of Life:** Significant improvements after six sessions, immediately post-treatment, and at follow-up ($p < 0.001$).
- **Psychological Factors:** Kinesiophobia and self-efficacy showed significant improvements post-treatment and at follow-up. Pain catastrophizing did not show any changes.

Implications

This study suggests that whole-body PBM therapy may be an effective multifactorial treatment for fibromyalgia, offering benefits in pain management, QoL, and psychological well-being. The results support PBM as a promising therapeutic option for FM, though further research, particularly on long-term effects, is required.

The Effectiveness of Photobiomodulation Therapy Versus Cryotherapy for Skeletal Muscle Recovery: A Critically Appraised Topic

Stephan R. Fisher, Justin H. Rigby, Joni A. Mettler, and Kevin W. McCurdy (2019 - *Journal of Sport Rehabilitation*)

Study Intentions

This research aimed to critically appraise whether photobiomodulation therapy (PBMT) is more effective than cryotherapy for skeletal muscle recovery after strenuous exercise. PBMT, previously referred to as low-level laser or LED therapy, has shown potential in accelerating muscle recovery by reducing muscle soreness and inflammation, contrasting with the mixed effectiveness of cryotherapy.

Key Findings

The study reviewed three double-blinded, randomized, placebo-controlled trials and two animal studies, all of which indicated PBMT's superiority over cryotherapy. Specific findings included:

- PBMT reduced markers of muscle damage (e.g., creatine kinase and blood lactate) and inflammation more effectively than cryotherapy.
- It enhanced post-exercise muscle performance and reduced delayed onset muscle soreness (DOMS).
- Shorter recovery times (24–96 hours) were observed with PBMT, along with sustained muscle function.

Implications

The findings suggest that PBMT is a superior post-exercise recovery modality compared to cryotherapy. Athletes and sports practitioners may benefit from integrating PBMT to reduce recovery time and enhance muscle function. Future research should focus on refining treatment parameters for PBMT and exploring its effects in combination with other recovery modalities.

Strength of Recommendation

Based on consistent results, the study provides a Grade B recommendation for using PBMT over cryotherapy for post-exercise muscle recovery.