

Prepare Perform Recover

## RMATA

Low Level Laser Therapy  
and Sports Performance

April 12, 2018



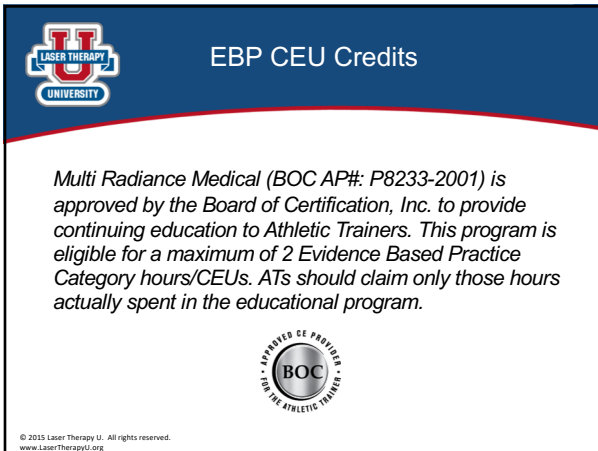
## Discussant



**John Bruno**  
ATC  
Clinical Director, Sports Medicine & Rehab  
Clinical Director, Government & Military  
Multi Radiance Medical


John C. Bruno, ATC is a certified athletic trainer credentialed by the National Athletic Trainer's Association. He possesses extensive clinical and practical experience rehabilitating many orthopedic and sports medicine injuries. **Conflict of Interest/Financial Disclosure Statement:** John Bruno is an employee of Multi Radiance Medical, a device manufacturer. His experience includes working as an athletic trainer at the college, professional and clinic levels. He is the Clinical Director, Sports Medicine and Rehab for Multi Radiance Medical. John's responsibilities include training and lecturing on the science, and clinical application of Super Pulsed Laser technology to rehabilitation professionals. His experiences and education make him uniquely qualified to speak about integrating therapeutic laser into a comprehensive rehabilitation program.

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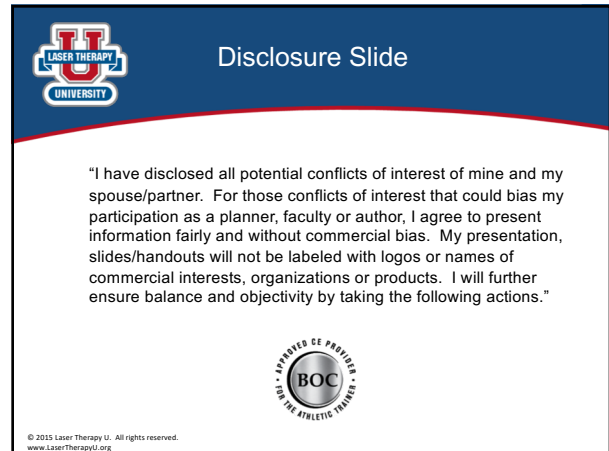


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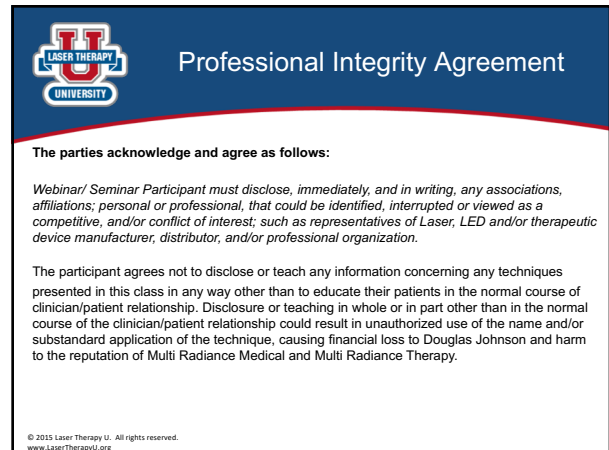
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Version 1.0, September, 2015

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## Agenda



### Game ON!!!

Competitive Edge

- Understand and differentiate between efficacy and effectiveness
- Review the POC Process and related studies
- Explain the simple method of action
- Explore the mechanism of action, parameter optimization, biphasic dose response, thermal profile and depth of penetration time profile
- Discuss the evidence based and translational research studies available
- Present findings of The Comparative Study
- Recent publications
- Questions and answers

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## Agenda

- **Part One- Laser Basics**
- **Part Two- Physiological Effects of Photobiomodulation**
- **Part Three- Discuss evidence and available translational research**
- **Part Four- Review Proof of Concept; Recent publications and Discuss optimal Dose**

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## Part 1 : Laser Basics

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## Photobiomodulation

noun

1. A form of light therapy that **utilizes non-ionizing forms of light sources**, including lasers, LEDs, and broadband light, in the visible and infrared spectrum.
2. "It is a **non-thermal process** involving endogenous chromophores eliciting **photophysical** (i.e., linear and nonlinear) and **photochemical** events at various biological scales."—from [WALT website](#)
3. This process results in beneficial therapeutic outcomes including but not limited to the **alleviation of pain or inflammation**, **immunomodulation**, and promotion of wound healing and tissue **regeneration**."



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**NAALT**  
NORTH AMERICAN ASSOCIATION FOR LASER THERAPY

**WALT**  
WORLD ASSOCIATION FOR LASER THERAPY

## Photobiomodulation

WALT is the international reference body for accreditation of standards in research and education in laser therapy across all disciplines

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## What is in a Name?

Any modality that utilizes photons (packets) of light (typically red and/or infrared light) for the relief of pain, to accelerate healing and decrease inflammation

**Photobiomodulation**

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PubMed

Google Scholar

- Low level laser therapy
- Low reactive-level laser therapy
- Low intensity laser therapy
- Low level light therapy
- Low energy laser irradiation
- Photobiomodulation
- Photobiostimulation
- Biomodulation
- Biostimulation
- Cold laser
- Soft laser
- Laser therapy
- Phototherapy
- Cold Laser Therapy

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## NOT Known As:

- Class IV Laser Therapy
- High Intensity Laser Therapy
- Class 4 Laser Therapy
- Deep Tissue Laser Therapy
- Hot Laser Therapy
- High Power Laser Therapy

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## Light effects on tissue

- **Photothermal**
  - Light energy converted to thermal energy. (*dermal ablation, surgery*)
- **Photomechanical**
  - Mechanical destruction tissue (*tattoo removal*)
- **Photochemical**
  - Physiological response within the tissue


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## Wavelength-

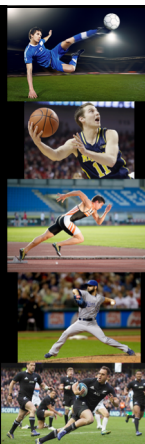
- Therapeutic sweet spot exists between 600 nm and 1100 nm, where the absorption of light is not limited by melanin, lipid or water absorption
- Depth of penetration is directly related to the wavelength

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## PBMT Effects

- Performance
- Fatigue
- Injury Prevention
- Endurance
- Strength
- Reduced DOMS
- Decreased catabolic effects
- Enhances cytoprotection




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## Summary Part 1


- **Photobiomodulation** – Light penetrates through the skin, absorbed by mitochondria, energy transformed into biochemical energy, and assists cells to enhance healing and restore normal cell function
- **Wavelength** determines **depth of penetration**
- **Biphasic dose response** either stimulatory or inhibitory
- PBM is a **non-thermal** process

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## Part 2: Physiological Effects of Photobiomodulation

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## Efficacy vs Effectiveness

**Mechanism of Action:**  
Identification of ATP, NO, or ROS







**Optimization of Key Parameters:**  
Chromophores, power, wavelength, pulsing, etc.

**Bi-phasic Dose Response:**  
Stimulation vs inhibition


**Thermal Profile**  
Safety, skin temperature and ROS

**Depth of Penetration Time Profile**  
Penetration vs absorption vs heat

**Evidence Based and Translational Clinical Trials**

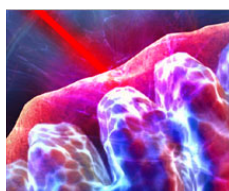







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## Phototherapeutic Effect

- **Photobiomodulation**
  - a chain of chemical reactions is triggered by exposure to light
- This process has **ONLY** been shown to occur with **LOW LEVEL** laser and LED devices




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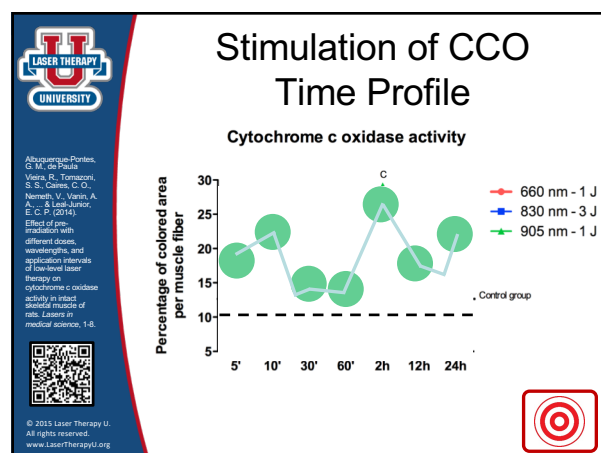
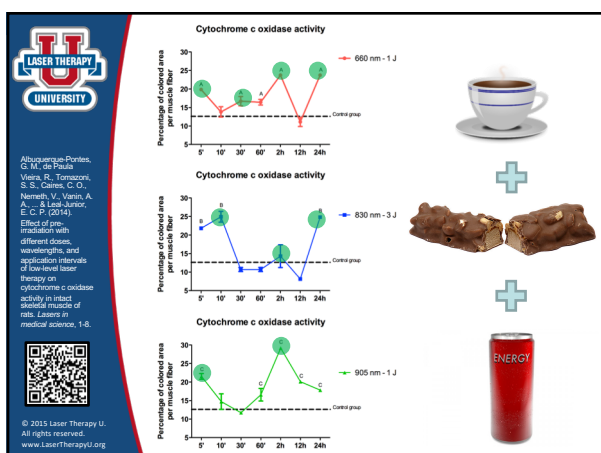
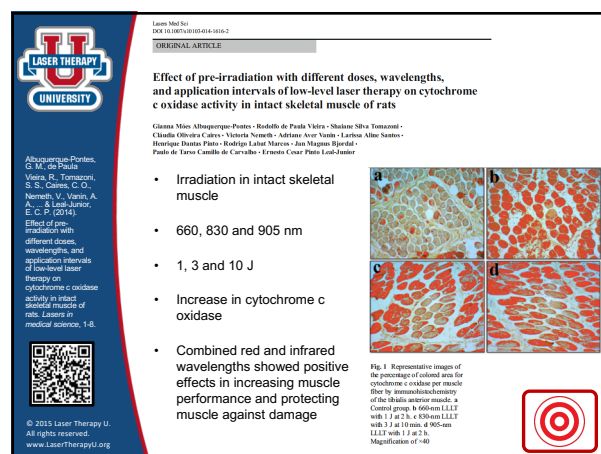
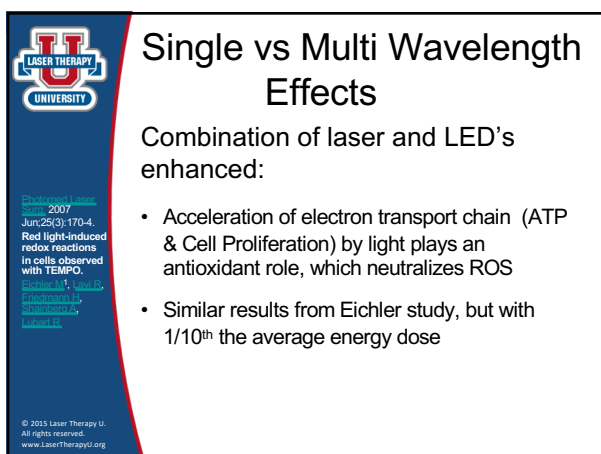
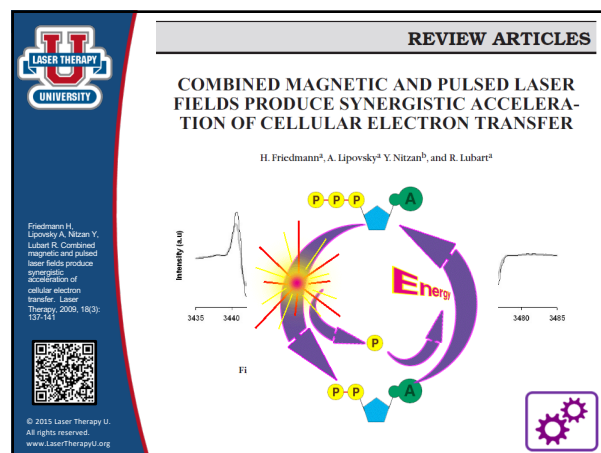
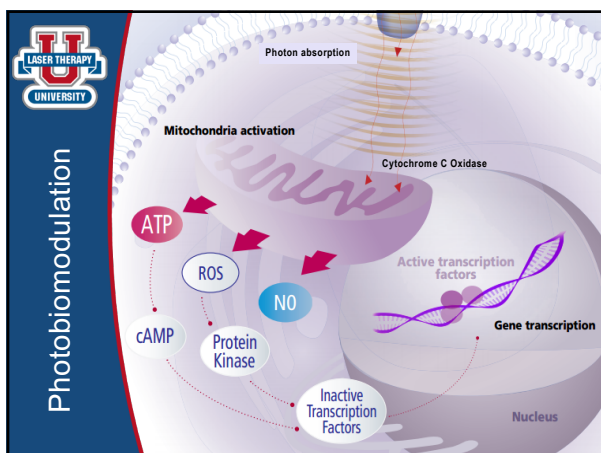
## Simple Method of Action:

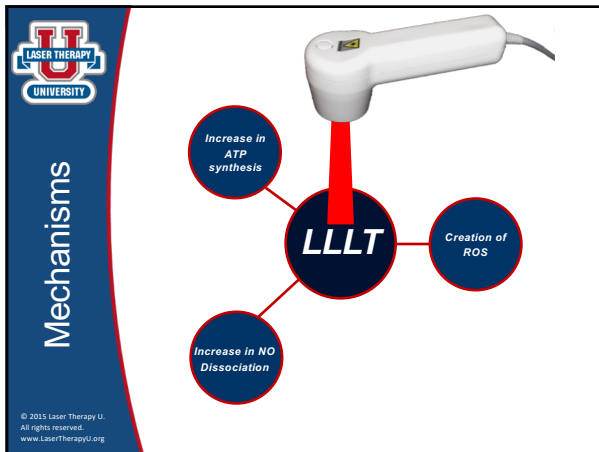
1. Light penetrates through skin and is **absorbed** by the mitochondria in the cell
2. Light energy is transformed into biochemical energy
3. The additional energy assist cells to enhance healing and to restore normal cell functional



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**Role of Nitric Oxide**

NO has both a direct and indirect impact on pain sensation

- Directly**, acting as a neurotransmitter it is essential for normal nerve cell action potential in impulse transmission activity

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L.I. Filippin et al., Nitric oxide and repair of skeletal muscle injury, Nitric Oxide (2009), doi:10.1016/j.niox.2009.08.002

**Role of Nitric Oxide**

- Indirectly**, the vasodilation effect of NO can
  - Enhance nerve cell perfusion and oxygenation
  - Inhibit the release of histamine and other inflammatory mediators from mast cells
  - Inhibition of prostaglandin synthesis

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L.I. Filippin et al., Nitric oxide and repair of skeletal muscle injury, Nitric Oxide (2009), doi:10.1016/j.niox.2009.08.002

**Increases in Microcirculation and Tissue Oxygenation**

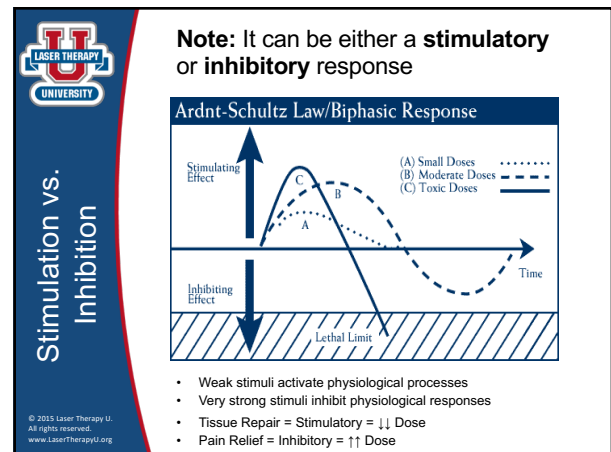
- The increase of blood flow after laser therapy is an important factor in pain relief<sup>1</sup>:
  - Molecular oxygen is generated due to laser-induced photodissociation of HbO<sub>2</sub> in blood vessels<sup>2</sup>
  - Increases lymphatic drainage, the activity of **neutrophils**, macrophages, fibroblasts, and the metabolism of damaged or defective cells

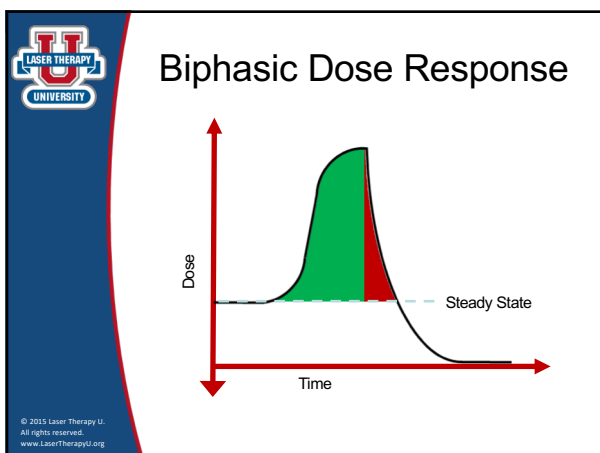
<sup>1</sup> Maegawa Y, Itoh T, Hosokawa T, Yaegashi K, Nishi M. Effects of near-infrared low-level laser irradiation on microcirculation. Lasers Surg Med. 2000;27(6):427-37.  
<sup>2</sup> The Physics of Biomedical Effect of Blood Oxyhemoglobin Photodissociation M. M. Asimov, R. M. Asimov, A. N. Rubimov, A. I. Gishrecht, pp.33-38, Pub. Date: 2012- 05-28

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**The Basics of Dose:**  
**Stimulation vs Inhibition**

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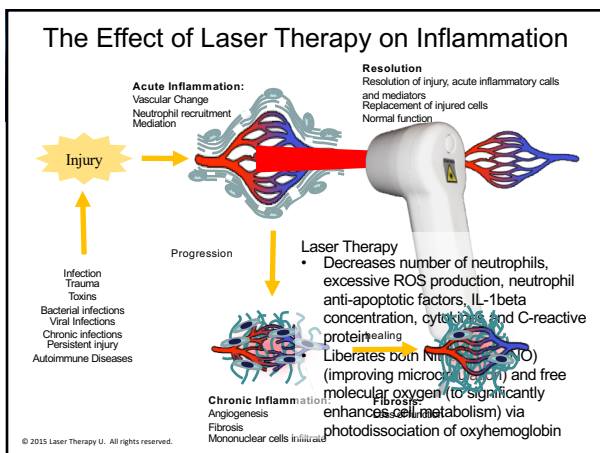
**Inflammation and Repair**

- Injured cells and tissues emit enzymes that encourage the receipt of photons more readily than healthy cells and tissues<sup>1</sup>

Chronic inflammation

<sup>1</sup>PHOTOBIOLOGICAL FUNDAMENTALS OF LOW-POWER LASER THERAPY T. Kizu; Laser Technology Research Center of Russian Acad. Sci., N2002-Troitsk, Moscow Region, Russian Federation <http://www.equibioelectronics.htm> (2002) PHOTOBIOLOGICAL FUNDAMENTALS OF LOW-POWER LASER THERAPY

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**Proposed Laser Effects on Pain Relief**

- Peripheral/Local
  - Reduced release of **Bradykinin (BK)** & **prostaglandin (PG)**
  - Decreased **C fiber** activity by blocking depolarization
- Central/ Spine
  - Reduced release of **Substance P** and **Acetylcholine**
- Systemic Effect
  - Stimulation release of  **$\beta$ -endorphins**

Laser Accelerated INFLAMMATION PAIN REDUCTION AND HEALING by Richard Martin, BS, CLT, Practical PAIN MANAGEMENT, Nov/Dec 2003, p. 20-25.

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**Monochromatic Lasers and General Uses**

- Infrared**
  - Musculoskeletal Disorder and Pain Relief
- Red**
  - Wound healing and Pain Relief
- Green**
  - Laser Puncture
- Blue**
  - Dermatology and Anti-bacterial


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**True or False:**

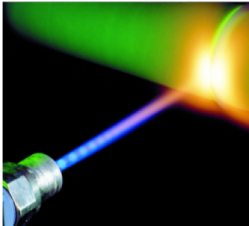
**More Light = Better Outcomes**

**< = >**

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## Tissue Response Laser Therapy



Before any reactions can occur, the photons must be **absorbed** by the target tissue (Law of Conservation)

One photon can activate one enzyme molecule which in turn can process thousands of substrate molecules

A very small amount of energy can cause very significant biological effects


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## Summary Part 2




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## Summary Part 2


- Stimulation of **CCO** is **maximized** at all time points when multiple wavelengths are applied
- Infrared** wavelengths is best for managing musculoskeletal disorders and pain
- More** light absorbed at the target tissue equates to better outcomes
- PBM **decreases** C fiber activity by blocking depolarization

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## Part 3: What is the Evidence

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## Laser and Heat:


- Increased power and density are needed to provide adequate energy at the deeper tissue targets
- Since heat is a generated **byproduct** of light, the more intense the light, greater the amount of heat (This is how surgical lasers work!)
- Increased power can cause tissue heating at the surface layers
- Heat is an unwanted and inefficient byproduct of creating light



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## Safety




Skin Color	Skin Temperature Elevated Greater than 22.3°C			
	Placebo	10 J	30 J	50 J
Light	No	No	No	No
Medium*	No	No	Yes	Yes
Dark**	N/A	N/A	N/A	N/A

\* Joensen, et al measured a significant increase in skin temperature, as much as 22.3°C, while administering higher doses of light with both CW and SPL devices.

\*\* NOT Tested by Joensen, et al

Joensen J, Hendrik L, Johnson M, Iversen V, Lopes-Martins R and Bjordal J. The thermal effects of therapeutic lasers with 810 and 904 nm wavelengths on human skin. *Photomedicine and Laser Surgery*. March 2011; 29(3): 145-153. doi:10.1089/pho.2010.2793



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## Super Pulsed Laser and Heat:

- The pulse duration should be lower than the thermal relaxation time (TRT) of the target structure to prevent unselective damage to the surrounding tissue
- Biological tissue is "aware" of incident energy pulses only if they are over one millisecond in width
- At 100 ns the pulse duration is such at very little thermal influence is recognized

IMPACT OF PULSE WIDTH ON TREATMENT OUTCOMES

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## Safety

Skin Color	Skin Temperature Elevated Greater than 22.3°C			
	Placebo	10 J	30 J	50 J
Light	No	No	No	No
Medium	No	No	No	No
Dark	No	No	No	No

Area 1: Mdx. 30.3, Med. 29.8  
Area 2: Mdx. 30.4, Med. 30.1  
Area 3: Mdx. 30.5, Med. 30.2

Area 1: Mdx. 30.9, Med. 30.5  
Area 2: Mdx. 31.1, Med. 30.6  
Area 3: Mdx. 30.8, Med. 30.3

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## Thermal Time Profile

Skin color

Temperature (°C)

Light  
Medium  
Dark

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## Heat, High Powered Laser and Phototoxicity

Surface Temperature	<45 °C	45 °C	45-55 °C	> 55 °C
Immediately Post treatment	--	--	• Mild Edema • Erythema • Damaged area	• Permanent Edema • Severe Erythema • Damage area (burn) Leg Rise *
24 hrs Post treatment	--	• Mild Edema • Erythema • Damaged area	• Permanent Edema • Permanent damaged area (Ulcer, wound)	• Severe damaged Area • Contractures paralysis • Death *

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## Heat, High Powered Laser and Phototoxicity

45°C  
Phototoxic Level

↑ 22.3°C  
Rise in Skin Temperature

33°C  
Normal Skin Temperature

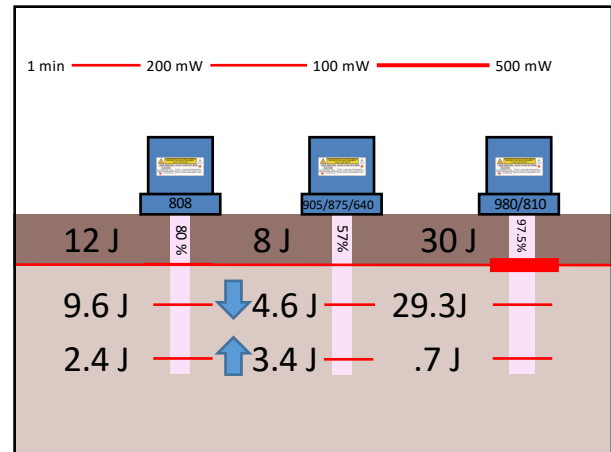
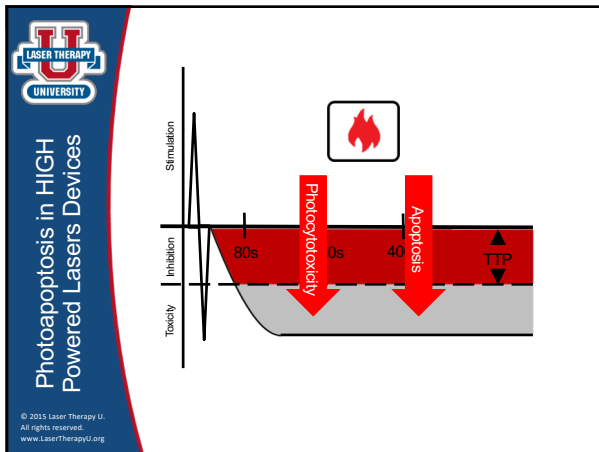
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## Heat, High Powered Laser and Phototoxicity

↑ ROS ↑ ROS ↑ ROS

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### Skin Penetration Profiles

- Joensen, J., Øvsthus, K., Reed, R. K., Hummelsund, S., Iversen, V. V., Lopes-Martins, R. A. B., & Bjordal, J. M. (2012). Skin penetration time-profiles for continuous 810 nm and Superpulsed 904 nm lasers in a rat model. Photomedicine and laser surgery, 30(12), 688-694.
- Leal-Junior EC, Albuquerque-Pontes GM. Depth penetration profile of phototherapy with combination of super-pulsed laser, red and infrared LEDs on human skin. Lasers Med Sci [peer review process]
- Anders, J. J., Moges, H., Wu, X., Erbele, I. D., Alberico, S. L., Saidu, E. K., ... & Pryor, B. A. (2014). In vitro and in vivo optimization of infrared laser treatment for injured peripheral nerves. Lasers in surgery and medicine, 46(1), 34-45.

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### Summary Part 3

- Cytotoxicity** can occur by high powered lasers when skin temperatures reach a minimum of 45°C.
- Grandinetti found the TTP **did not increase an additional 22.3°C** in any skin type
- The beneficial effects of PBM are **not created or influenced by photo-thermal reactions** and therefore must be photochemical or photophysical in nature.
- Khan and Arany recently identified an **apoptosis pathway** for high powered lasers.

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### PART 4: Recovery and Performance

Evaluating Outcomes and Standard of Care

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### Standard of Care

**RICE**

(Rest Ice Compression Elevation)

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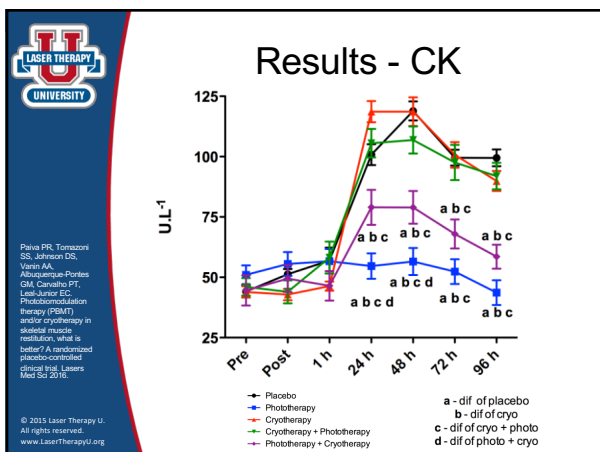
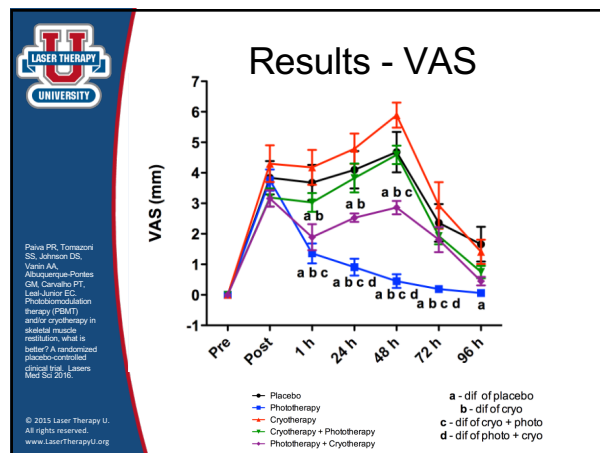
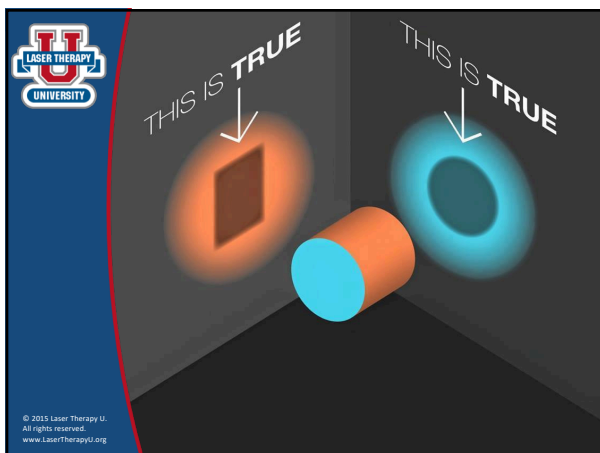
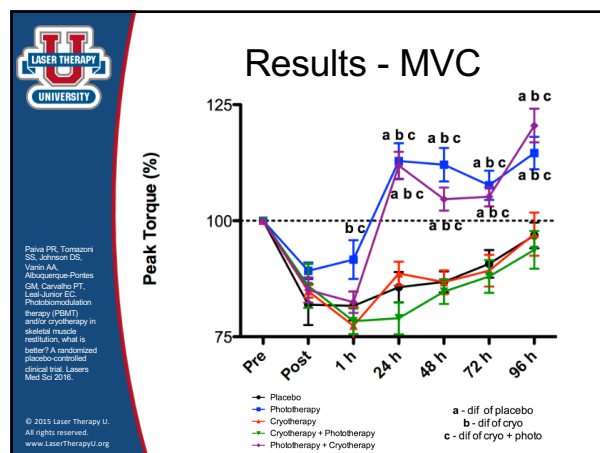
**Photobiomodulation therapy (PBMT) and/or cryotherapy in skeletal muscle restitution, what is better? A randomized placebo-controlled clinical trial**

Paulo Roberto Vicente de Paiva, Shalane Silva Tomazoni, Douglas Scott Johnson, Adriane Avelar Vanin, Gianna M6es Albuquerque-Pontes, Paulo de Tarso Camillo de Carvalho, Ernesto Cesar Pinto Leal-Junior

- 50 Subjects
- Randomized, double blinded, placebo controlled study
- Intervention: Eccentric exercise of the quadriceps via Biodes
- Intervention:
  - Phototherapy 40 J to 6 points on the quad
  - Cryotherapy ice 20 minutes to quad
  - PBM + Cryotherapy
  - Cryotherapy + PBM
  - Placebo
- Data Collected:
  - MVC (strength)
  - DOMS (pain)
  - CK (muscle damage)
- Assessments
  - Baseline, 1, 24, 48, 72, and 96 hours




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Photobiomodulation therapy (PBMT) and/or cryotherapy in skeletal muscle restitution, what is better? A randomized placebo-controlled clinical trial

- PBMT alone was the best modality for post-exercise recovery ( $p < 0.05$ ) compared to all comparators
  - Improved MVC
  - Decreased DOMS
  - Reduced CK activity
- PBMT+Cryotherapy was also significantly better than placebo, cryotherapy and cryotherapy + PBMT ( $p < 0.05$ ).
  - Improved MVC
  - Decreased DOMS
  - Reduced CK activity
- Cryotherapy, cryotherapy+PBMT and placebo did not improve any measured outcomes
- We conclude that PBMT used as single treatment is the best modality for enhancement of post-exercise recovery.




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## Why ice inhibits inflammation:

- Nick DiNubile: "Seriously, do you honestly believe that your body's natural inflammatory response is a mistake?"
- Inflammation is the first physiological process in the repair and remodeling of tissue. Without it, nothing after can happen
- Macrophages release the hormone Insulin-like growth Factor (IGF-1) into the damaged tissues, which helps muscles and other injured parts heal
- Ice prevents the body from releasing IGF-1
- It is IMPOSSIBLE to have tissue repair or remodeling without inflammation




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## Swelling/Edema

**Arch Phys Med Rehabil. 1998 Nov;79(11):1415-20.**


Low-level laser treatment can reduce edema in second degree ankle sprains. Stergioulas A.



47 soccer players with second degree ankle sprains, selected at random, were divided into the following groups:

- Group 1 (n = 16) was treated with the conventional initial treatment (RICE, rest, ice, compression, elevation),
- Group 2 (n = 16) was treated with the RICE method plus placebo laser, and the
- Group 3 (n = 15) was treated with the RICE method plus an 820-nm GaAlAs diode laser with a radiant power output of 40 mW at 16 Hz.
- Before the treatment, and 24, 48, and 72 h after, the volume of the edema was measured.


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## Swelling/Edema


**Arch Phys Med Rehabil. 1998 Nov;79(11):1415-20.**

Low-level laser treatment can reduce edema in second degree ankle sprains. Stergioulas A.




- **RESULTS:** A three by three repeated measures ANOVA with a follow up post hoc test revealed that the group treated with the RICE and an 820-nm GaAlAs diode laser presented a statistically significant reduction in the volume of the edema after 24 h (40.3 +/- 2.4 mL, p < 0.01), 48 h (56.4 +/- 3.1 mL, p < 0.002), and 72 h (65.1 +/- 4.4 mL, p < 0.001).
- **CONCLUSIONS:** LLLT combined with RICE can reduce edema in second-degree ankle sprains.

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## The Better Option?

- *GOAL: Prevent the further progression of inflammation, edema and swelling*
- < 48 hours



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## Efficacy vs Effectiveness

**Efficacy** is a measure of the quality of scientific evidence supporting a categorical "modality"


**Effectiveness** relates to how individual devices function – in practice – as related to the reported efficacy

**Example:**  
Laser therapy has a proven efficacy of over 50 years and 5500+ studies




**IN GOD  
WE TRUST  
ALL OTHERS  
BRING  
DATA**

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## Weighing the Evidence and Statistical vs Clinical Significance




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## Weighing The Available Research




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## Weighing The Available Research

- LLLT is over 50 years old
- Over 5500 published articles on PBM
- Over 250+ randomized, double blind studies
- 200+ studies are added each year to PubMed
- A new study every day and a half


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## Levels of Evidence




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## EBP: Level I Support

1. Gam, A. N., Thorsen, H., & Lønnberg, F. (1993). *The effect of low-level laser therapy on musculoskeletal pain: a meta-analysis*. Pain, 52(1), 63-66.
2. Chow, R. T., Johnson, M. I., Lopes-Martins, R. A., & Bjordal, J. M. (2009). *Efficacy of low-level laser therapy in the management of neck pain: a systematic review and meta-analysis of randomised placebo or active-treatment controlled trials*. The Lancet, 374(9705), 1897-1908.
3. Fulop, A. M., Dhimmer, S., Deluca, J. R., Johanson, D. D., Lenz, R. V., Patel, K. B., & Enwemeka, C. S. (2010). *A meta-analysis of the efficacy of laser phototherapy on pain relief*. The Clinical journal of pain, 26(8), 729-736.
4. Ljunggren, E. A., Bjordal, J. M., Tuner, J., Chow, R. T., & Couppe, C. (2003). *A systematic review of low level laser therapy with location-specific doses for pain from chronic joint disorders*. Australian Journal of Physiotherapy, 49(2), 107.
5. Enwemeka, C. S., Parker, J. C., Dowdy, D. S., Harkness, E. E., Harkness, L. E., & Woodruff, L. D. (2004). *The efficacy of low-power lasers in tissue repair and pain control: a meta-analysis study*. Photomedicine and Laser Therapy, 22(4), 323-329.


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## EBP: Level I Support

1. Chow, R. T., & Barnsley, L. (2005). *Systematic Review of the literature of low-level laser therapy (LLL) in the management of neck pain*. Lasers in surgery and medicine, 37(1), 46-52.
2. Bjordal, J. M., Johnson, M. I., Iversen, V., Aimbire, F., & Lopes-Martins, R. A. B. (2006). *Low-level laser therapy in acute pain: a systematic review of possible mechanisms of action and clinical effects in randomized placebo-controlled trials*. Photomedicine and Laser Therapy, 24(2), 158-168.
3. Vernon, H., & Schneider, M. (2009). *Chiropractic management of myofascial trigger points and myofascial pain syndrome: a systematic review of the literature*. Journal of manipulative and physiological therapeutics, 32(1), 14-24.
4. Jang, H., & Lee, H. (2012). *Meta-analysis of pain relief effects by laser irradiation on joint areas*. Photomedicine and laser surgery, 30(8), 405-417.

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## Practice Guidelines



Location	CW IR 620, 830, 1060		SPL 904	
	Power Density (mW/cm <sup>2</sup> )	Dose (Joules)	Power Density (mW/cm <sup>2</sup> )	Dose (Joules)
Finger, toe, TMJ	15 - 105	.5 - 15	6 - 42	.2 - 1.4
Knee	30 - 210	6 - 180	12 - 60	1.2 - 84
Cervical Spine	50 - 350	11 - 360	24 - 60	.8 - 56
Lumbar Spine	180 - 500	48 - 480	30 - 210	15 - 105

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General Settings For Photobiomodulation in				
	Joules (J)	SPL	CW	LED/IRED
Acute <48 Hours	Stimulatory	.8	8	16
Swelling/edema	Inhibitory	>2.4	>24	>48
Inflammation	Stimulatory	.8	8	16
Spasms	Inhibitory	>2.4	>24	>48
Pain (Local and Systemic)	Inhibitory	>2.4	>24	>48
Tissue Repair (Local)	Stimulatory	.8	8	16
Tissue Repair (Systemic)	Stimulatory	.8	8	16
BOM	Inhibitory	>2.4	>24	>48




## Remember Light is not Light


**CAUTION**

\*\*\* All published protocols are product specific !!!

\*\*\* All protocols may require modifications and/or adaptation !!!





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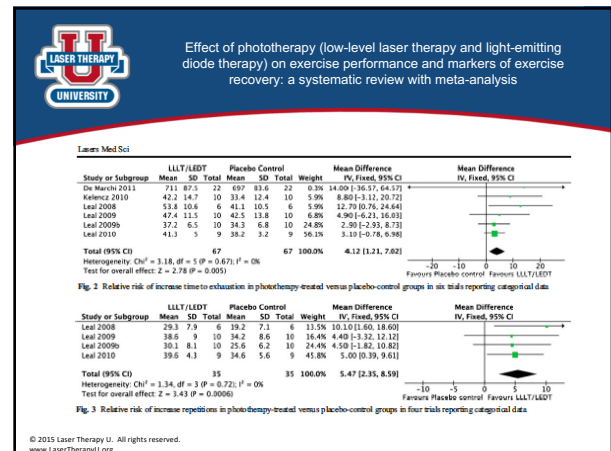



## EBP: Level I Support

1. Leal-Junior, E. C. P., Vanin, A. A., Miranda, E. F., de Carvalho, P. D. T. C., Dal Corso, S., & Bjordal, J. M. (2015). *Effect of phototherapy (low-level laser therapy and light-emitting diode therapy) on exercise performance and markers of exercise recovery: a systematic review with meta-analysis*. Lasers in medical science, 30(2), 925-939.


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## Statistical and Clinical Significance

- Statistical significance relates to how likely the observed effect is due to **chance** instead of a "true" difference between treatments or groups
- The role of bias and its potential impact on the results need to be considered
- Clinical significance relates to the **magnitude** of the observed effect and whether the magnitude or "effect size" is big enough to consider changes to clinical care



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## Translational Research



- The smallest benefit of value to patients is called the minimal clinically important difference (MCID)
- Patient-centered concept, capturing both the magnitude of the improvement and also the value patients place on the change



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**Standardized Outcome Measures in Clinical Practice**

4-Square Step Test  
6-Minute Walk Test  
10-m gait speed  
ACN Back Index (similar to Oswestry Low Back Disability Index)  
Activities-specific Balance Confidence Scale  
Age and Stages Questionnaire  
Alberta Infant Motor Scale  
Berg Balance Scale  
Canadian Occupational Performance Measure  
Care Connections Measures (formerly Therapeutic Associates Outcomes System)  
Dafos Plan Questionnaire

Disabilities of Arm, Shoulder, and Hand (DASH)  
Dizziness Handicap Inventory  
Duke Activity Status Index  
Dynamic Gait Index  
Early Intervention Developmental Profile  
eCAT  
Fall Risk Inventory  
Falls Efficacy Scale  
Fatigue Symptom Inventory  
Fear-Avoidance Belief Questionnaire  
Fibromyalgia Impact Questionnaire  
Functional Independence Measure (FIM)  
Functional Reach Test  
Focus on Therapeutic Outcomes (FOTO) Measures

Foot and Ankle Disability Index  
Geriatric Depression Scale  
Get Up and Go Test  
Gillian Autism Rating Scale  
Hand Function Sort  
Harris Hip Score  
Hawall Early Learning Profile (WELP) Strands  
Hip Outcome Score  
"Home-grown" measures  
International Knee Documentation Committee (IKDC) form  
Johns Hopkins Acute Care Functional Scale  
Knee Osteoarthritis Care Scale (KOOS)  
Lifestyle Inventory  
Lifetime System  
Lower Extremity Functional Scale

Lysholm Knee Scale  
McGill Pain Questionnaire  
Mini Mental Exam  
Modified Falls Efficacy Scale  
Modified Oswestry Low Back Disability Index  
Musculoskeletal Function Assessment Questionnaire  
Neck Disability Index  
Orebro Musculoskeletal Pain Questionnaire  
Oswestry Low Back Disability Index  
Outcome Assessment and Information Set (OASIS)  
Outpatient Physical Therapy Improvement in Movement Assessment Log (OPTIMAL)  
Patient-Specific Functional Scale

Performance Assessment and Capacity Test (PACT)  
Pediatric Evaluation of Disability Inventory  
Penn Shoulder Score  
Roland-Morris Disability Questionnaire  
SF-36  
Shoulder Pain and Disability Index (SPADI)  
Simple Shoulder Test  
Smid Walking Speed  
Spine Function Sort  
Stroke Impact Scale  
Tampa Scale Kinesiophobia  
Timed 'Up & Go' Test  
Tinetti Balance Scale  
Tinetti Gait Index  
Unified Parkinson's Disease Rating Scale  
Upper Extremity Functional Scale  
Urinary Incontinence Scale  
Western Ontario and MacMaster Universities Osteoarthritis Index (WOMAC)

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**Powering Performance and Accelerating Recovery**

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**ORIGINAL ARTICLE**

**Phototherapy in skeletal muscle performance and recovery after exercise: effect of combination of super-pulsed laser and light-emitting diodes**

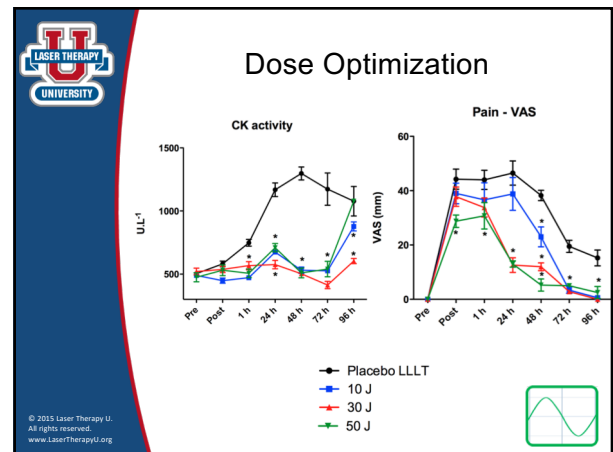
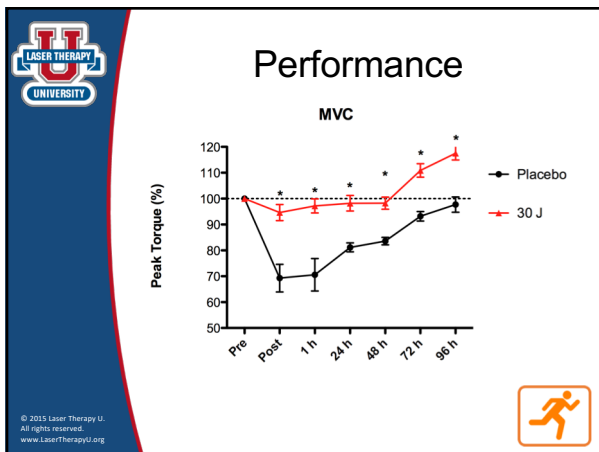
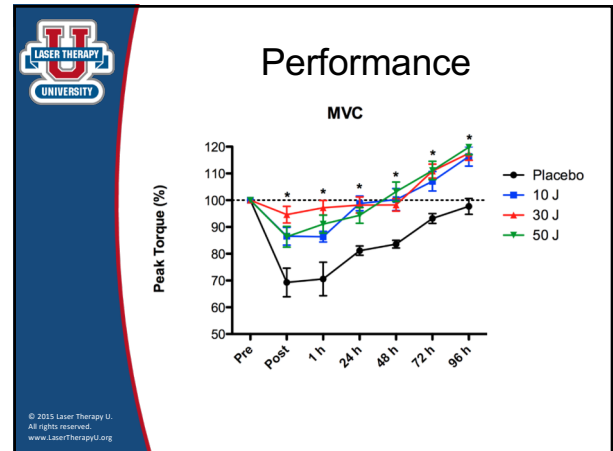
Foranado Cidre Antunes, F. Thiago De Muro, S. Shana Shu Tsement, Jackson José Vitor, Vanessa dos Santos Gonalves, Paulo Roberto Vitor de Paula, Henrique Santos Paulo, Eduardo Fochel Miranda, Paulo de Jesus Cavalli de Carvalho, Everson Cesar Pires Leal-Júnior

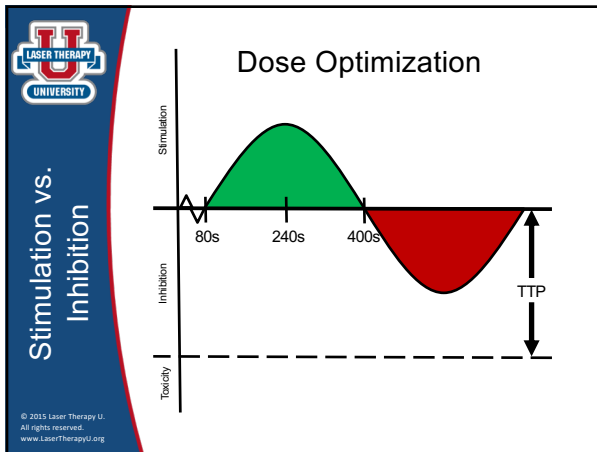
Received: 16 March 2014 / Accepted: 3 June 2014  
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Antunović, F. C., De Muro, T., Tsement, S. S., Vitor, A. A., de Santos, Grandinetti, V., de Paula, P. R. V., & Leal-Júnior, E. C. P. (2014). Phototherapy in skeletal muscle performance and recovery after exercise: effect of combination of super-pulsed laser and light-emitting diodes. *Lasers in medical science*, 1-10.

- Evaluated MR4 LaserShower for muscle performance
- 40 subjects, randomized, single blind experiment, 4 groups (3 active, 1 control)
- Eccentric exercise protocol for the knee (quadriceps)
- 6 points of irradiation along the entire muscle utilizing 250 Hz (2, 4 and 6 minutes)
- 1 single bout of treatment (or placebo)
- Treatment was done prior to exercise

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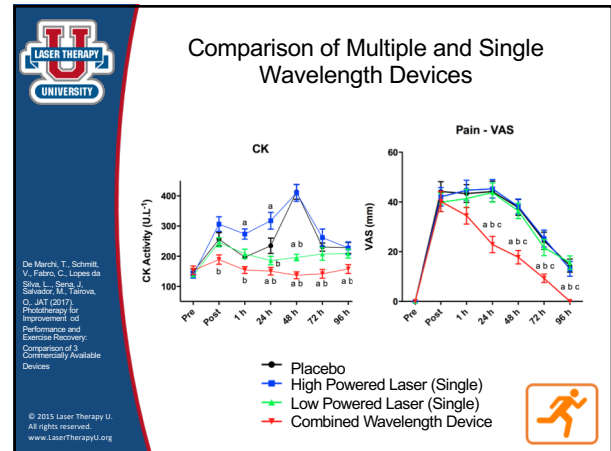
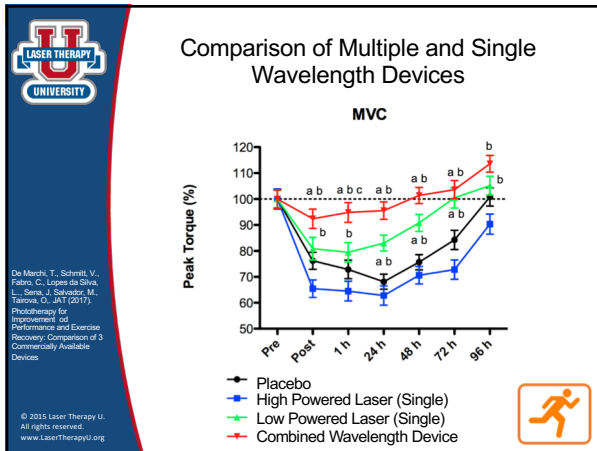


**Comparison of Multiple and Single Wavelength Devices**

- Randomized, double-blinded, placebo-controlled trial
- Direct comparison on the effect and effect size between three different, readily available phototherapy devices on skeletal muscle performance and post-exercise
- Forty healthy untrained male volunteers
- Four groups: Placebo, a Class 4 device, a class 3B device and a class 1M device. Single 180 J dose or placebo administered to the quadriceps prior to EE
- MVC, delayed onset muscle soreness (DOMS), and creatine kinase (CK) activity were analyzed at before, 1 minute, 1, 24, 48, 72 and 96 hours after EE

De Marchi, T., Schmitt, V., Fabro, C., Lopes da Silva, L., Senna, J., Salvador, M., Tavora, O., JAT (2017). Phototherapy for Improvement of Performance and Exercise Recovery: Comparison of 3 Commercially Available Devices

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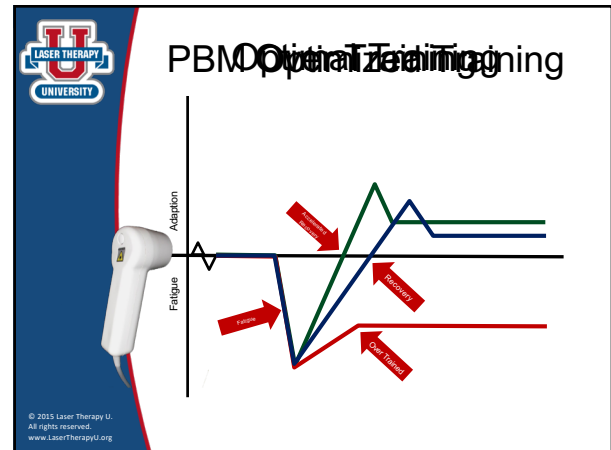
**Comparison of Multiple and Single Wavelength Devices**

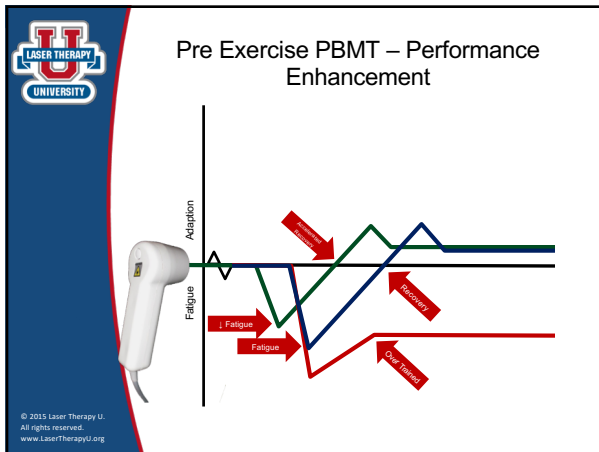
**Conclusions:**

- C-1M demonstrated superior and more consistent results than either the C-3B or C-4 groups in all outcome measures when compared to placebo
- The significant increasing in CK levels compared to placebo with the use of the C-4 device appears to have a damaging effect on the irradiated skeletal muscle and warrants further research to investigate this negative effect

De Marchi, T., Schmitt, V., Fabro, C., Lopes da Silva, L., Senna, J., Salvador, M., Tavora, O., JAT (2017). Phototherapy for Improvement of Performance and Exercise Recovery: Comparison of 3 Commercially Available Devices

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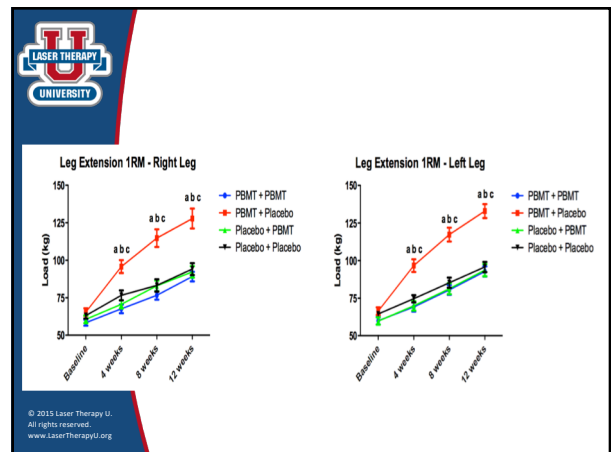
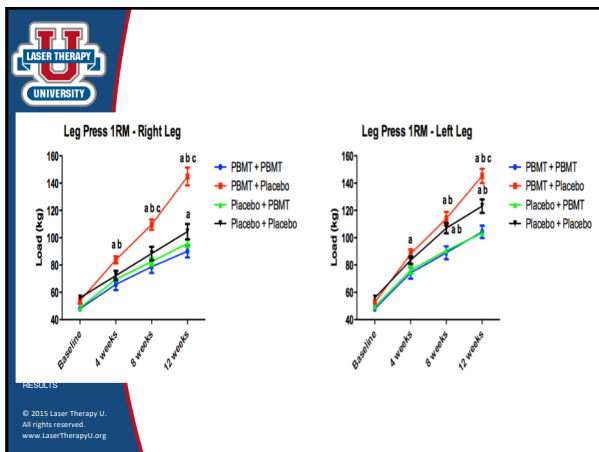
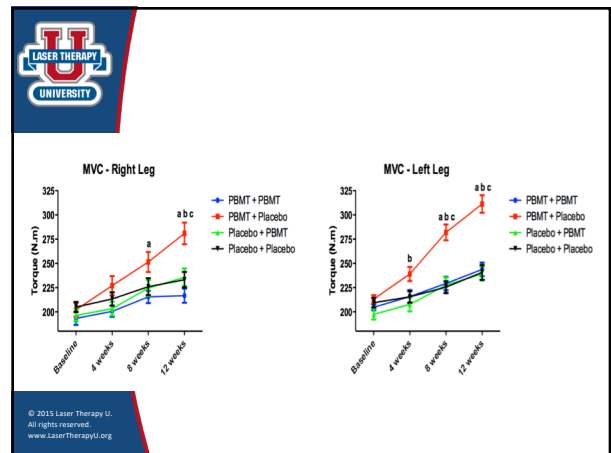


**ACUTE EFFECTS OF PHOTOTHERAPY APPLIED IN ASSOCIATION OF STRENGTH TRAINING: PRELIMINARY RESULTS**

- Thirty-six male volunteers
- Active intervention included Phototherapy (with red laser, 650 nm, 10 J/cm²)
- Volume of work was twice the control group
- Strength training was performed at 80% 1RM
- This test was repeated after 4 weeks.

Adriane Aver Vanin, Caroline dos Santos, Mariana Machado, Fernanda Cioella, Antonelli, Cristiano Cesar Pinto Leal-Júnior. (2015). ACUTE EFFECTS OF PHOTOTHERAPY APPLIED IN ASSOCIATION OF STRENGTH TRAINING: PRELIMINARY RESULTS.

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### Using Pre-Exercise Photobiomodulation Therapy Combining Super-Pulsed Lasers and Light-Emitting Diodes to Improve Performance in Progressive Cardiopulmonary Exercise Tests.

Eduardo Foschini Miranda, PhD, PT, Journal of Athletic Training, 2016

- The purpose of this study is to evaluate the acute effect of phototherapy combining lasers and LEDs on muscle performance during progressive stress test
- RTC crossover trial with 20 untrained male volunteers
- The irradiation was performed with a combination of lasers and LEDs at 12 sites
- Single treatment or Placebo
- Measures:
  - Time to exhaustion
  - Distance travelled
  - Pulmonary ventilation
  - Decreasing dyspnea

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### Using Pre-Exercise Photobiomodulation Therapy Combining Super-Pulsed Lasers and Light-Emitting Diodes to Improve Performance in Progressive Cardiopulmonary Exercise Tests.

Eduardo Foschini Miranda, PhD, PT, Journal of Athletic Training, 2016

Statistically significant improvements:

Time to exhaustion ( $p < 0.000$ )  
Distance travelled ( $p < 0.023$ )  
Pulmonary ventilation ( $p < 0.004$ )  
Decreasing dyspnea ( $p < 0.000$ )

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### Pitching Performance

- Laser 17.31 reps
- Placebo 15.38 reps
- 8 Responders, 2 Non-responders
- 16% improvement (15.65%)
- Laser ↑ 2 reps
- 80% treated with laser responded with an average to 16% Improvement ( $P < 0.023$ )
- If we apply this to the 100 pitch rule in baseball the non-responder would fatigue after 100 pitches and the responder pitchers would fatigue after 116 pitches.

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### Performance

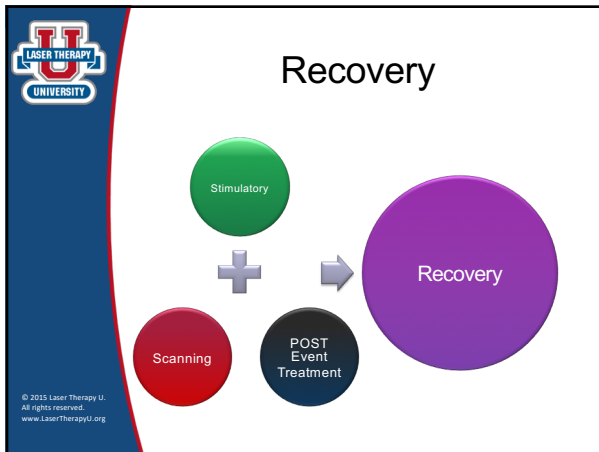
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### Strength

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### Endurance

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**Dose Adjustment**

- Be prepared to increase or decrease the dose in 1 minute increments to achieve the desired response

**+ / - 1 min Rule**

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**Dose Adjustment**

- Be prepared to adjust the frequency to change the dose rate to achieve the desired response
- $\downarrow$  Frequency =  $\downarrow$  Dose Rate =  $\uparrow$  Time
- $\uparrow$  Frequency =  $\uparrow$  Dose Rate =  $\downarrow$  Time

**$\Delta$  Frequency Rule**

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**Laser Therapy and Secondary Physical Agents**

- **Cryotherapy**
  - Do NOT combine Laser with Cryotherapy
  - If necessary, Laser first, then Cryotherapy
- **Heat therapies (US- HP)**
  - Use laser therapy **before**, increased blood flow causes increased absorption of light by hemoglobin resulting in decreased penetration
- **Exercise/Massage/ART/ASTM**
  - May do **before or after**
    - Reduce pain/spasm **prior** to ease treatment
    - **After** aggressive techniques

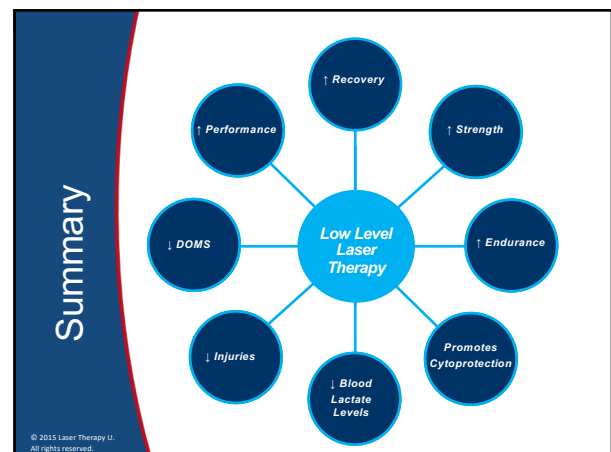
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**Contraindications:**


**Absolute Contraindications:**

- Pregnancy
- Cancer
- Fever (body temperature higher than 100.4°F/38°C)
- During stages of acute infection (including localized infections)
- Over hemorrhages
- In the vicinity of pacemakers

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## Summary Part 4

- A study must measure both **MVC** and **CK** to establish **bi-phasic dose** response.
- PBM should be done **before** and **after** exercise to improve endurance
- Miranda, et al, found pre-treatment with PBM **improved** performance during progressive stress testing
- Vanin, et al, found strength increased in the quads when PBM was applied **before** training

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## Summary:

- All devices are not created equal and not all light is therapeutic.
- Device comparisons should be limited to the physiological, mechanical and therapeutic impact it has on tissue not necessarily on device characteristics.
- Photobiomodulation is simply the absorption of light by cytochrome c oxidase (CCO) resulting in an increase in cellular activity.
- Heat is an unwanted byproduct of laser/light therapy; the more intense the light, the greater the amount of heat.
- Photochemical and photophysical effects are reduced in response to thermal build up, the lower the profile the greater the therapeutic value of the device.

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Website for Low Level Laser Therapy

[www.laser.nu](http://www.laser.nu)  
Swedish Laser Association

[www.naalt.org](http://www.naalt.org)  
North American Association for Light Therapy

[www.walt.org](http://www.walt.org)  
World Association for Laser Therapy

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