LEAP Ahead: The use of Light to Enhance Athletic Performance in Post and Pre-Season

Discussant

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 conditions and injuries.

John’s professional experience includes working as an athletic trainer at the college, professional and clinic levels. He worked with the New Jersey Nets, NY Cosmos, NY Giants, Fitness Institute, and Ramapo College. In 1982, he was named to the sports medicine staff for the NBA All-Star game. John has worked in sales for capital equipment and medical device companies in the rehab industry for over 30 years.

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.
Discussant

Conflict of Interest/Financial Disclosure Statement:
John Bruno is an employee of Multi Radiance Medical, a device manufacturer.

Off Label Use Statement:
This presentation may include material on specific uses that have not been approved by the FDA. The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each device he or she wishes to use in clinical practice.

Disclosures:
Travel expenses paid by, received salary from, and holds ownership interest with Multi Radiance Medical

Serves on Advisory Board for North American Association for Photobiomodulation Therapy and Laser Therapy

Patent issued for the use of light to reduce muscular fatigue
Define Photobiomodulation

Explain the simple method of tissue-light interactions

Discuss the evidence based and translational research studies available on PBM enhanced sports performance and recovery

Explore parameter optimization, biphasic dose response, thermal profile and depth of penetration time profile

TIPS: Translate the available research into “clinical” application

Review recent, relevant publications

Phototherapeutic Effect

Photobiomodulation is the process where 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

As Known As:

- 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

+70 MeSH Terms
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 assists cells to enhance healing and to restore normal cell functional
Does PBM Effect?

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

Energy production

- PBM demonstrates a modulatory effect on CCO activity
- Improves performance
- Protects skeletal muscle from exercise-induced muscle damage

Role of Nitric Oxide

NO has a direct effect on pain sensation
- Directly, acting as a neurotransmitter it is essential for normal nerve cell activity in impulse transmission activity.

Indirectly, the vasodilation effect of NO
- Enhances nerve cell perfusion and oxygenation
- Inhibits the release of histamine and other inflammatory mediators from its cells
- Inhibition of prostaglandin synthesis

L. Filippetti et al., NO has a direct effect on pain sensation. Nitric Oxide (2015), doi:10.1016/j.niox.2015.06.002


Weighing The Available Research


EBP: Level I Support

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


Systematic review with meta-analysis
- Trial quality was assessed with the ten-item PEDro scale
- The time until exhaustion increased significantly compared to placebo by 4.12 s (95% CI 1.21–7.02, p < 0.005)
- Number of repetitions increased by 5.47 (95% CI 2.35–8.59, p < 0.0006) after phototherapy

The most significant and consistent results
- Red or infrared wavelengths
- Treatment before exercises
- Power outputs between 50 and 200 mW
- Doses of 5 and 6 J per point (spot)

Effects of PBM

Pre Post

Changing the Paradigm

- Laser is not just for Rehabilitation
- Improve Performance through all phases of training
- Enhance Recovery
- Prevention/Protection
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.

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**Proof of Concept**

- Strength
- Endurance
- Field Studies

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


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

- **Objectives:**
  - To investigate the acute effects of Phototherapy applied in association of strength training.
  - To evaluate the acute effects of Phototherapy applied in association of strength training.

- **Methodology:**
  - **Participants:** Thirty-six male volunteers.
  - **Intervention:** Active intervention included Phototherapy with combination of super‐pulsed laser, red and infrared LEDs, with dose of 30 J and/or placebo.
  - **Exercise:** Volunteers performed leg press exercise, twice per week, for 4 weeks, defined as 72‐hours interval.
  - **Training:** Strength training was performed with 80% of the maximal load defined through 1RM at baseline.
  - **Outcome:** This test was repeated after 4 weeks.

- **Results:**
  - Strength and power improvements were observed in the intervention group.
  - Endurance and field studies also showed significant improvements.

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

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

Statistically significant improvements:

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

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.

Standardized Outcome Measures in Clinical Practice
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

Light effects on tissue

- **Photophysical**
  - Mechanical changes to the cell (i.e.: membrane permeability, concentration gradients)
- **Photochemical**
  - Physiological response within the tissue (cell metabolism, protein synthesis)
- **Photothermal**
  - Light energy converted to thermal energy (dermal ablation, surgery)
Laser and Heat:

• Increased power and density are often needed to provide adequate energy at deeper tissue targets

• Since heat is a generated byproduct of light, the more intense the light, the greater the amount of heat (This is how surgical lasers work!)

• Increased power can cause tissue heating at the surface layers

Heat and Phototoxicity

45°C
Phototoxic Level

↑ 22.3°C
Rise in Skin Temperature

33°C
Normal Skin Temperature


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 (manufactured by LiteCure - USA), a class 3B device (manufactured by Thor - UK) and a class 1M device (manufactured by MultiRadiance Medical – USA)

• Single 180 J dose or placebo administered to the quadriceps prior to EEx

• 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

Comparison of Multiple and Single Wavelength Devices

Conclusions:

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


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

PaivaPR, Tomazoni SS, Johnson DS, Vanin AA, Albuquerque-Pontes GM, Carvalho PT, Leal-Junior EC.

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

Results - MVC

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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.
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.

The Effect of Post-Exercise Cryotherapy on Recovery Characteristics: A Systematic Review and Meta-Analysis

- Review and meta-analysis.
- Critically determine the possible effects of different cooling applications on recovery characteristics post 96 hours (hrs).
- N = 36 articles.
- Cochrane’s risk of bias tool demonstrated a high risk of performance bias and detection bias.
- DOMS and RPE and objective characteristics like blood plasma markers and blood plasma cytokines, were performed.

Pooled data from 27 articles revealed there was no evidence that cooling affects any objective recovery variable in a significant way during a 96 hrs recovery period.

REJECTED
The Better Option?

- GOAL: Prevent the further progression of inflammation, edema and swelling
  - < 48 hours
  - 5-1000 Hz 2 min

Elimination of Swelling/Edema

Inhibitory

Woodpecker

Ohshiro’s Proximal Priority

Scan each distal lymph node from Distal → Proximal

Treat Proximal → Distal
Elimination of Swelling/Edema
Upper Extremity

<table>
<thead>
<tr>
<th>No.</th>
<th>Primary Treatment area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Axilla</td>
</tr>
<tr>
<td>2</td>
<td>Medial anterior forearm</td>
</tr>
<tr>
<td>3</td>
<td>Dorsal radial aspect of the wrist</td>
</tr>
</tbody>
</table>

Elimination of Swelling/Edema
Lower Extremity

<table>
<thead>
<tr>
<th>No.</th>
<th>Primary Treatment area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inguinal</td>
</tr>
<tr>
<td>2</td>
<td>Popliteal fossa</td>
</tr>
<tr>
<td>3</td>
<td>Lateral posterior malleolus</td>
</tr>
</tbody>
</table>

Muscle Spasms and Trigger Points

Inhibitory Adapted Pöntinen’s Principle

Adapted Pöntinen’s Principle

Reassess and repeat PRN
### Method

<table>
<thead>
<tr>
<th>Method</th>
<th>Dose</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Pöntinen’s Principle</td>
<td>Spasms: at palpable spasms in affected area, active and latent</td>
</tr>
</tbody>
</table>

### Range of Motion

![Range of Motion Diagram](image)

**Inhibitory**

**PhotoProbe**

**Static**

**ROM**

### Increasing Range of Motion

<table>
<thead>
<tr>
<th>No of Articulare Points</th>
<th>Affected Joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3 Fingers</td>
<td></td>
</tr>
<tr>
<td>1-4 Wrist</td>
<td></td>
</tr>
<tr>
<td>4 Elbow</td>
<td></td>
</tr>
<tr>
<td>4-5 Shoulder</td>
<td></td>
</tr>
<tr>
<td>1-4 Cervical Spine</td>
<td></td>
</tr>
<tr>
<td>2-4 Thoracic Spine</td>
<td></td>
</tr>
<tr>
<td>3-4 Lumbar Spine</td>
<td></td>
</tr>
<tr>
<td>4-5 Hip</td>
<td></td>
</tr>
<tr>
<td>3-4 Knee</td>
<td></td>
</tr>
<tr>
<td>3-4 Ankle</td>
<td></td>
</tr>
<tr>
<td>2-3 Toes</td>
<td></td>
</tr>
</tbody>
</table>
Laser/Light Benefits

- Non-invasive
- Drug-free
- Minimal contraindications
- Safe
- Can be Self-Administered

Pre Exercise PBMT – Performance Enhancement

Optimal Training

Over Training

PBM Optimized Training
PBM Effects

• Prevention of over training
• Reduces injuries

Priority Principle™: Functional Strength (Performance)

<table>
<thead>
<tr>
<th>Method</th>
<th>Dose</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>30 J per point, 180 J per muscle (large), 90 J per muscle (small)</td>
<td>Performance Method: Performance, Strength, Endurance, or Recovery</td>
</tr>
</tbody>
</table>

Performance

Performance
Summary

Decrease in Peroxidation of lipids

Influences Cutaneous Receptors

Activation of protein synthesis (RNA, DNA)

Improvement of cellular potential

Increase in adenosine triphosphate (ATP) formation

Increase in enzymatic formation and activation

Normalization of specific and non-specific immune factors

Normalization and synthesis of Prostaglandin

↓ DOMS

↑ Performance

↑ Strength

↑ Endurance

↓ Injuries

↑ Strength

↑ Recovery

↑ Performance

↑ Strength

↑ Endurance

↓ Injuries

Low Level Laser Therapy

Laser Specific Resources:

Contacts:

jbruno@multiradiance.com
Email address for John Bruno
www.lasertherapyu.org
Website for Low Level Laser Therapy