Spectroradiometric Analyses of Commercial Photobiomodulation Technologies

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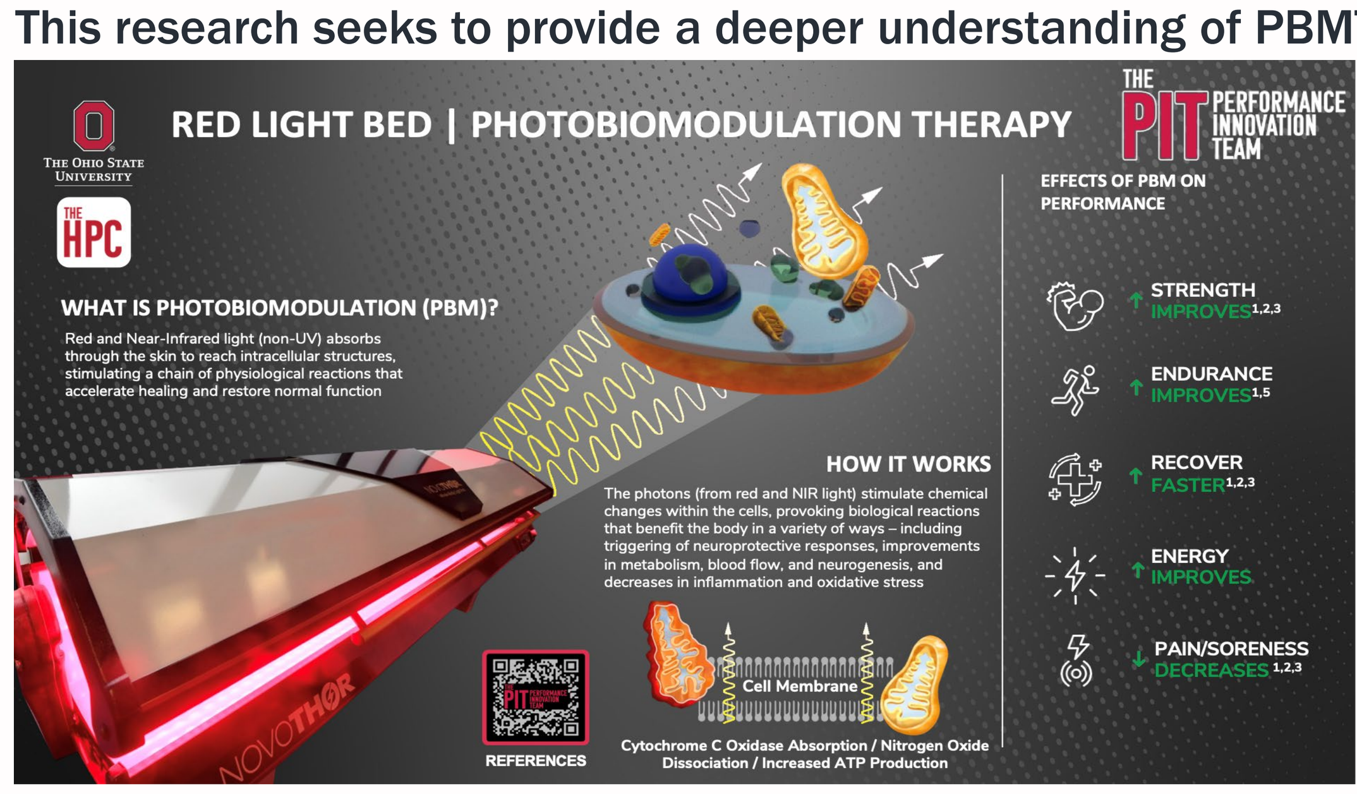
Introduction

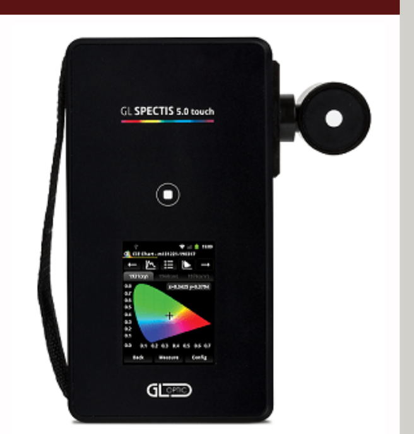
Photobiomodulation Therapy (PBMT) utilizes specific wavelengths of red and near-infrared light to penetrate tissues and stimulate cellular processes, potentially enhancing musculoskeletal (MSK) repair, function, and recovery. Current understanding suggests that PBMT can increase ATP production, reduce inflammation, and improve neurogenesis and blood flow. Despite its promising applications in areas like MSK rehabilitation and performance enhancement, there is limited empirical validation of the spectral and irradiance outputs of PBM devices.

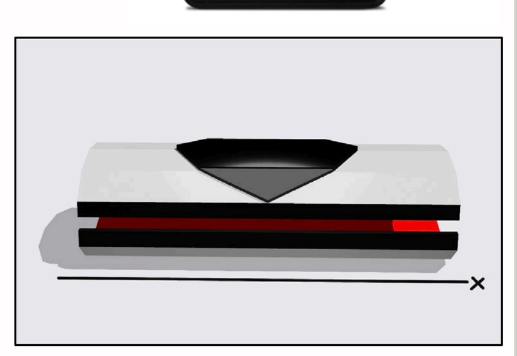
This study aims to fill that gap by investigating the wavelengths and irradiance profiles of various commercial PBM devices, including full-body light beds, panel-based devices, and wearables. Key questions include the consistency of irradiance across devices, differences in irradiance during treatment, and differences between treatment recommendations. For full-body light beds, the study examines potential irradiance differences between the top and bottom canopies and individual patient differences. This research seeks to provide a deeper understanding of PBMT to inform future research pursuits and usage recommendations in military and clinical contexts alike.

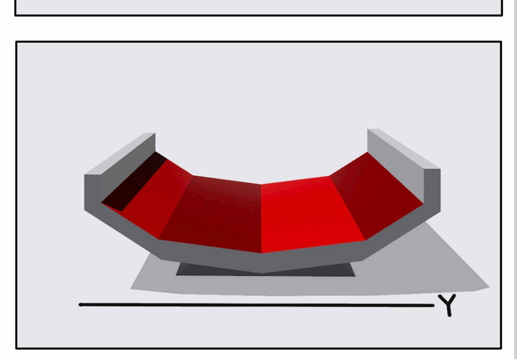


Methodology and Materials

The **GL SPECTIS 5.0 Touch VIS-IR** was utilized to measure the wavelengths and irradiance values of each device. This spectroradiometer has a spectral range of 380 – 1050nm, a National Institute of Standards and Technology (NIST) traceable calibration, and a radiometric accuracy within 4%. Measurements were taken across the horizontal and vertical axes of each PBM device at specified intervals. Measurements were repeated, isolating the respective device wavelengths, and averaged to mitigate potential sensor/LED placement variability. Time series measurements were recorded at 30-second intervals for 20-minutes. For panel-based devices, measurements were taken at each manufacturer-recommended treatment depths, while for wearables, measurements were restricted to the LED surface, reflecting the constant treatment depth characteristic of this device category.







Full Body PBMT Beds

NovoTHOR XL

https://www.novothor.com/images/index-faq.png

ARRC LED

https://arrcled.com/devices/

TheraLight

https://www.theralight.com/theralight-360

Wearable Devices

Kineon

https://kineon.io/cdn/shop/files/The_MOVE_Pro.png?v=1700824308&width=1920

Tommie Copper

https://www.tommiecopper.com/infrared-red-light-therapy-joint/

Panel-Based Devices

Joovv Mini 3.0

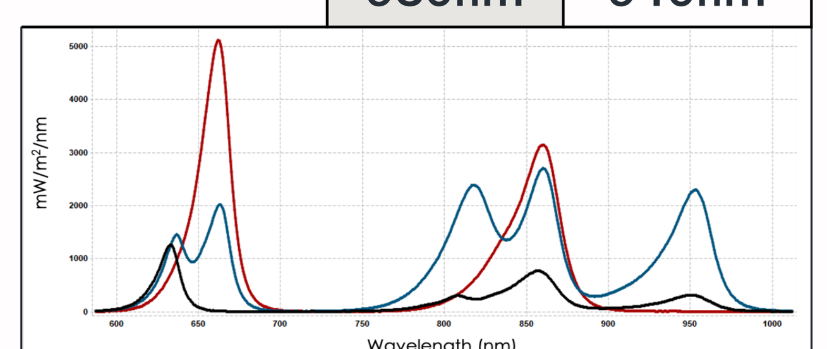
https://joovv.com/cdn/shop/products/joovv-mini-3-0-setup-mini-stand-001_1000x.png?v=1601928292

BIOMAX 900

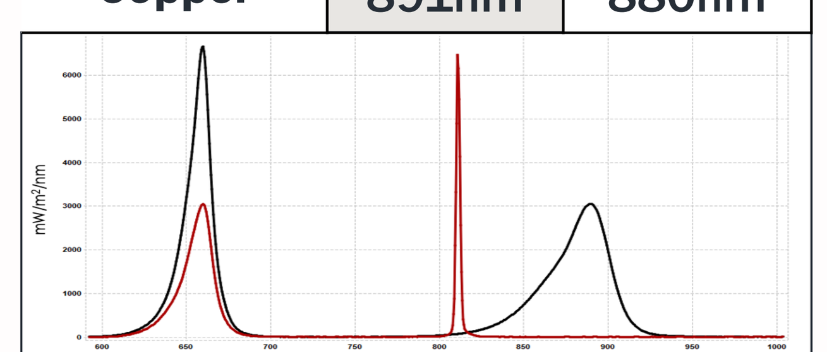
https://platinumtherapylights.com/cdn/shop/files/BIOMAX-900_1_a3917681-2e62-4668-8e6a-e39826762db6.png?v=1721922667

Results: Spectral Analyses

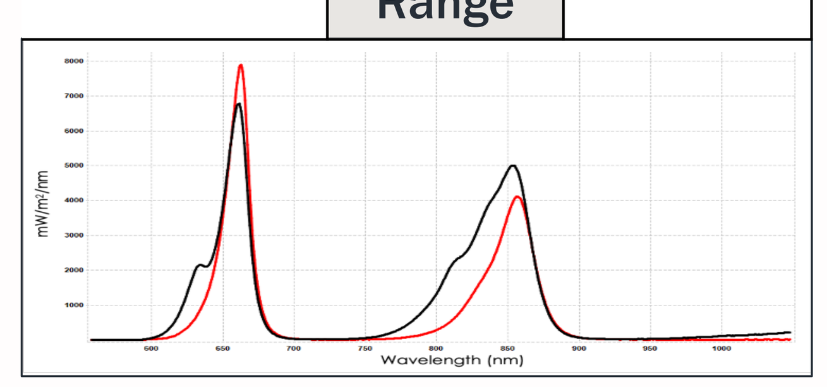
	Actual	Reported
NovoTHOR XL	661nm	660nm
	860nm	860nm
ARRC LED	636nm	635nm
	667nm	660nm
	817nm	850nm
	860nm	890nm
	951nm	950nm
TheraLight	634nm	633nm
	808nm	810nm
	858nm	850nm
	950nm	940nm



	Actual	Reported
Kineon	660nm	660nm
	811nm	808nm
Tommie Copper	660nm	660nm
	891nm	880nm



	Actual	Reported
Joovv Mini 3.0	663nm	660nm
	857nm	850nm
BIOMAX 900	634nm	630nm
	661nm	660nm
	810nm	810nm
	836nm	830nm
	853nm	850nm
	Out of Range	1060nm



Results: PBMT Beds

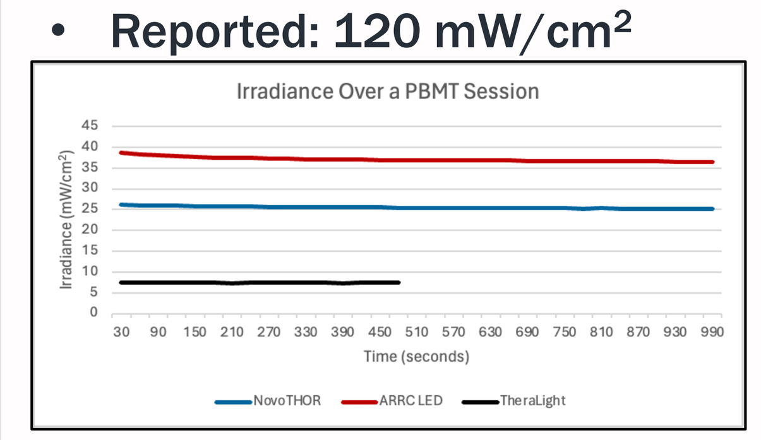
Irradiance Analyses

20-Minute PBMT Session

NovoTHOR XL
- Average: **23.24 mW/cm²**
- Reported: 30 mW/cm²

ARRC LED
- Average: **32.95 mW/cm²**
- Reported: 76 mW/cm²

TheraLight
- Average: **7.42 mW/cm²**
- Reported: 120 mW/cm²

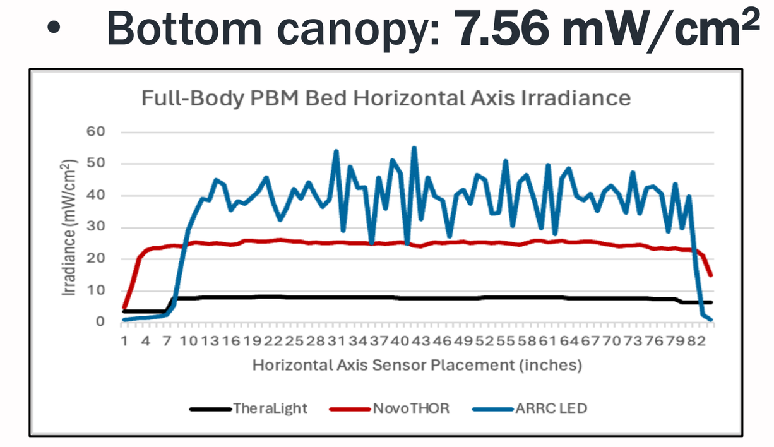


Horizontal Axis Averages

NovoTHOR XL
- Top canopy: **25.08 mW/cm²**
- Bottom canopy: **23.96 mW/cm²**

ARRC LED
- Top canopy: **36.48 mW/cm²**
- Bottom canopy: **33.05 mW/cm²**

TheraLight
- Top canopy: **7.67 mW/cm²**
- Bottom canopy: **7.56 mW/cm²**

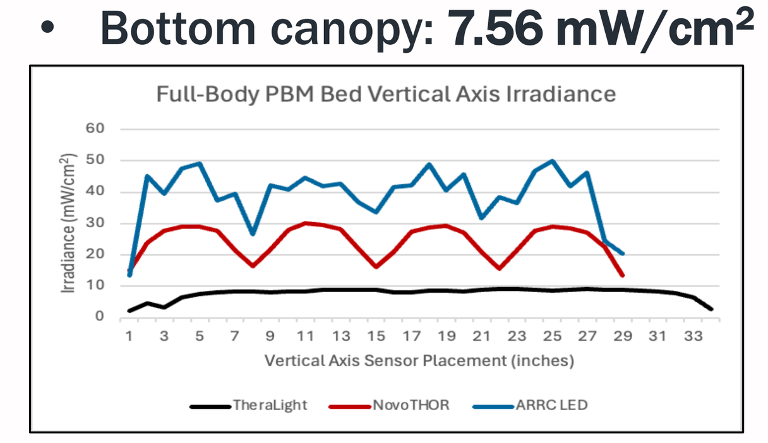


Vertical Axis Averages

NovoTHOR XL
- Top canopy: **25.08 mW/cm²**
- Bottom canopy: **23.96 mW/cm²**

ARRC LED
- Top canopy: **36.48 mW/cm²**
- Bottom canopy: **33.05 mW/cm²**

TheraLight
- Top canopy: **7.67 mW/cm²**
- Bottom canopy: **7.56 mW/cm²**



Results: Wearable Devices

Irradiance Analyses

Kineon
- Average: **39.60 mW/cm²**
  Reported: 25 mW/cm²

Tommie Copper
- Average: **55.21 mW/cm²**
  Reported: 153 mW/cm²

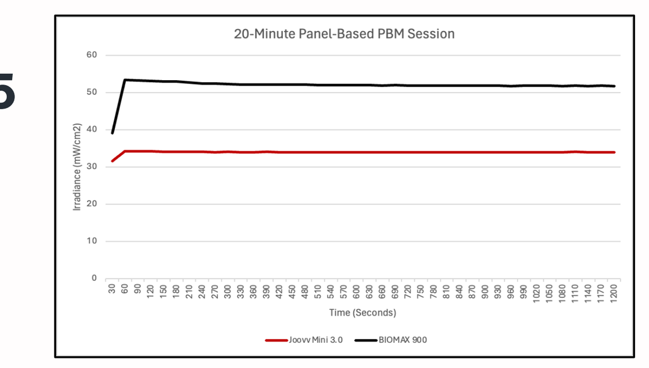
Results: Panel Based Devices

Irradiance Analyses

20-Minute PBMT Session

Joovv Mini 3.0
- Average: **33.95 mW/cm²**
- Reported: 100 mW/cm²

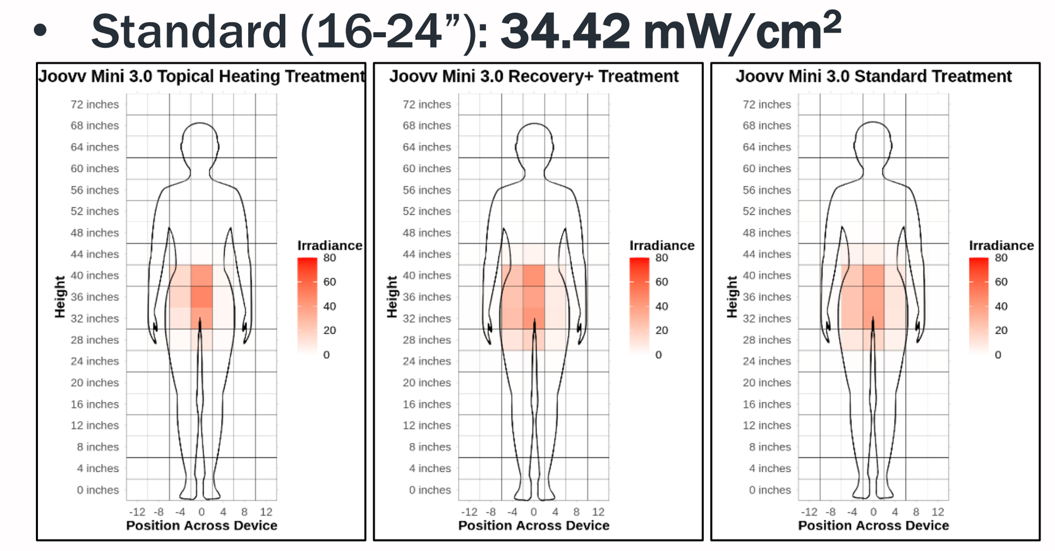
BIOMAX 900
- Average: **51.85 mW/cm²**
- Reported: 153 mW/cm²



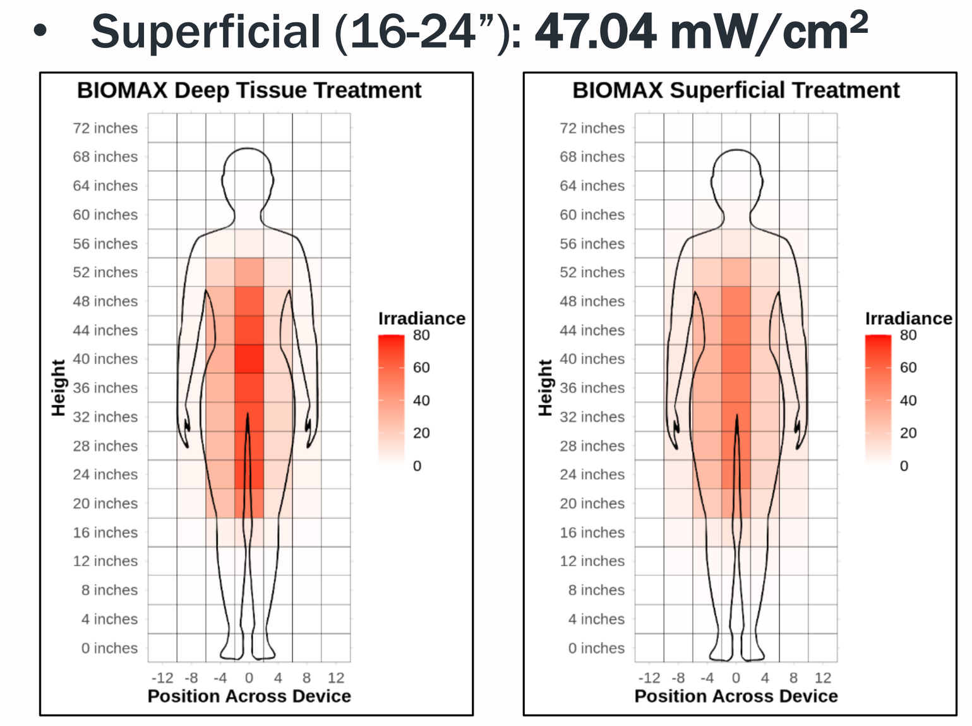
Irradiance Analyses

Treatment Distances

Joovv Mini 3.0
- Topical Heating (4-6"): **33.28 mW/cm²**
- Recovery+ (12-14"): **34.14 mW/cm²**
- Standard (16-24"): **34.42 mW/cm²**



BIOMAX 900
- Deep Tissue (8-15"): **56.65 mW/cm²**
- Superficial (16-24"): **47.04 mW/cm²**



Discussion

- **Need for Validation:** The inconsistencies in irradiance data emphasize the importance of independent validation of manufacturer-reported specifications to ensure accurate and reliable information for researchers and end-users.
- **Treatment Stability:** Devices maintained reasonably consistent irradiance levels over a 20-minute PBM session, with little to no decay observed throughout individual sessions or over a full day of treatments. These data imply that photobiomodulation therapy efficacy could be investigated as a product of time spent in treatment, without concern that treatment is time variable.
- **Effectiveness of Panel-Based Devices:** While panel-based PBM devices are marketed for their ability to provide treatment from various angles and distances, the actual treatment effectiveness was found to be confined to the area directly in front of the device. Recommendations for treatment may need to account for the concentration of treatment within a defined space.
- **PBM Bed Performance:** Among the PBM beds tested, the ARRC LED bed exhibited the highest irradiance, suggesting it delivers the most intense light therapy. However, the NovoTHOR PBM bed demonstrated the highest consistency in irradiance across different treatment zones and measurements, indicating this device may produce the most reliable and uniform treatment distributions.

Conclusion: This study provides valuable data to inform Operational Units in decision-making when employing this novel, noninvasive therapy.

Considerations for Selecting PBMT Devices

Full-Body Photobiomodulation Light Beds
- **Application:** Whole-body treatments for various conditions, typically involving 15 to 20-minute sessions lying down with minimal clothing.
- **Space/Power Requirements:** Requires a private room and 220-240V outlets.
- **Cost:** Ranges between $50,000 – $140,000.

Wearable Photobiomodulation Devices
- **Application:** Targeted treatments for single spots or specific areas, usually in a wearable strap or brace form factor. Treatment times vary.
- **Space/Power Requirements:** Portable and rechargeable.
- **Cost:** Ranges between $150 – $500.

Panel-Based Photobiomodulation Devices
- **Application:** Partial/targeted body area treatments. Coverage area depends on the panel size. Typically involves 15 to 20-minute sessions while standing with minimal clothing.
- **Space/Power Requirements:** Portable devices that plug into standard outlets.
- **Cost:** Ranges between $500 – $2,000+.

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