Advancing Patient Outcomes Through Evidence-Based Photobiomodulation

Photobiomodulation Therapy (PBMT) has emerged as one of the most extensively studied non-invasive treatment modalities in musculoskeletal medicine, rehabilitation, and pain management. Backed by hundreds of randomized controlled trials and systematic reviews, PBMT continues to demonstrate its potential to reduce pain, improve function, accelerate tissue healing, and support recovery across a wide range of clinical conditions.

At OrthoLazer®, we are committed to delivering care that is grounded in science. As the body of PBMT research continues to expand, staying informed on the latest clinical evidence is essential for providers, partners, and patients alike.

This document serves as a curated collection of recent publications, systematic reviews, meta-analyses, and clinical studies examining the efficacy and mechanisms of photobiomodulation therapy. The research presented here highlights both the growing evidence supporting PBMT and the ongoing advancements that are shaping its role in modern healthcare.

Our goal is simple: to provide transparent access to the science behind PBMT and support evidence-based conversations about how light therapy can help patients move better, recover faster, and live with less pain.

As the literature continues to evolve, OrthoLazer remains dedicated to evaluating emerging evidence and advancing the responsible clinical application of photobiomodulation therapy.

Top 10 Clinical Orthopedic PBMT Trials

1. Ahmed Alayat et al., 2017 – Chronic Neck Pain (MLS vs Conventional LLLT vs Placebo). Flagship MLS randomized trial demonstrating superior pain and functional outcomes with MLS therapy.

Abstract:

Background:
Multiwave locked system (MLS) laser therapy utilizes the synchronized emission of an 808 nm continuous laser and a 905 nm pulsed laser. It is postulated that MLS enables greater penetration and therapeutic benefit than single-wavelength low-level laser therapy (LLLT). Objective: The aim of this research was to evaluate the efficacies of MLS laser therapy and the 830 nm laser in the treatment of patients with chronic neck pain (CNP).

Materials and methods:

Seventy-five patients with CNP (mean age 46.28 ± 5.89, weight 83.78 ± 5.65 kg, height 1.72 ± 4.96 m, and duration of illness of 5.98 ± 1.44 months). They were randomized into three groups. Group I received MLS laser therapy and exercises, Group II received LLLT and exercises, and Group III received placebo laser therapy plus exercises (PL + EX). Neck pain levels and neck function were measured using the visual analogue scale (VAS) and neck disability index (NDI), respectively.

Results:

Both VAS and NDI were significantly reduced post-treatment for all treatment groups. After 6 weeks of treatment, MLS plus exercise showed a significantly greater decrease in pain and disability scores {Δ VAS (6.68) and Δ NDI (39.84)} compared to both LLLT plus exercise group {Δ VAS (5.72) and Δ NDI (37.88)} and PL + EX {Δ VAS (4.84) and Δ NDI (36.68)}.

Conclusions:

MLS laser therapy in conjunction with exercises decreased pain and increased functional activity following 6 months of therapy. MLS laser therapy in combination with exercises is a more effective therapy for CNP compared to exercise plus LLLT or exercise alone.

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2. Leonardo G. Langella et al., 2018 – Total Hip Arthroplasty Triple-Blind Trial. Reduced postoperative pain and inflammation after THA.

Abstract:

Background:

Total hip arthroplasty (THA) causes significant tissue trauma, triggering postoperative pain and an inflammatory response. Photobiomodulation therapy (PBMT) has previously demonstrated benefits in tissue repair, pain reduction, and modulation of inflammation. This study evaluated whether PBMT could improve early postoperative outcomes following THA.

Methods:

Eighteen patients undergoing THA were randomized into active PBMT and placebo groups. Treatment was administered 8–12 hours after surgery using a device combining a 905 nm super-pulsed laser, 875 nm infrared LEDs, and 640 nm red LEDs. PBMT was applied at five points along the surgical incision. Pain was measured using a Visual Analog Scale (VAS), and inflammatory markers (TNF-α, IL-6, and IL-8) were measured through blood analysis before and after treatment. Results: Compared with placebo, the PBMT group demonstrated:

- Significant reductions in postoperative pain (VAS)
- Significant decreases in pro-inflammatory cytokines TNF-α and IL-8
- No significant change in IL-6 levels

Conclusion:

The findings indicate that a single PBMT treatment produced measurable improvements in both pain and inflammatory response shortly after surgery. PBMT was effective in reducing acute postoperative pain and inflammation in patients following total hip arthroplasty, supporting its use as a non-pharmacologic adjunct to enhance recovery after orthopedic surgery.

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3. Rabie Abufoul et al., 2023 – Arthroscopic Rotator Cuff Repair. Double-blind sham-controlled study showing accelerated pain reduction and improved quality of life after cuff repair.

Abstract:

Objective:
To determine whether self-administered photobiomodulation therapy (PBMT) following arthroscopic rotator cuff repair could accelerate recovery and improve patient-reported outcomes during the first six months after surgery.

Methods:
Fifty patients undergoing primary arthroscopic rotator cuff repair were randomized to receive either an active PBMT device (n=22) or a sham device (n=28), in addition to standard postoperative rehabilitation. Patients self-administered treatment at home for three months following surgery. Outcomes assessed included pain (VAS), disability (QuickDASH), shoulder function (Constant-Murley Score), range of motion, and quality of life (SF-12).

Results:
While both groups demonstrated improvements in shoulder function and range of motion, the PBMT group experienced significantly faster and greater reductions in pain compared with the sham group. At both 3 and 6 months postoperatively, PBMT patients reported superior pain relief and were more likely to achieve clinically meaningful improvement thresholds. The PBMT group also demonstrated significantly greater improvements in disability scores and both physical and mental quality-of-life measures at six months. No device-related adverse events were reported.

Conclusion:
Photobiomodulation therapy significantly accelerated recovery following arthroscopic rotator cuff repair by reducing pain, decreasing disability, and improving quality of life. The authors concluded that PBMT is an effective, non-pharmacologic adjunct to postoperative rehabilitation that encourages active patient participation and may have broader applications across orthopedic recovery protocols.

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4. Victor Y. Fukuda et al., 2016 – Knee Osteoarthritis. Foundational OA PBMT study demonstrating improved pain and function.

Abstract:

Background:
Knee osteoarthritis (OA) is a leading cause of pain, disability, and reduced quality of life. While conventional therapies often focus on symptom management, low-level laser therapy (LLLT), now more broadly referred to as photobiomodulation therapy (PBMT), has been investigated as a non-invasive treatment option to reduce pain and improve joint function.

Objective:

To evaluate the short-term effectiveness of LLLT in reducing pain and improving functional outcomes in patients with symptomatic knee osteoarthritis. Methods: In this randomized, double-blind, placebo-controlled clinical trial, patients with knee OA were assigned to receive either active laser therapy or sham treatment. Clinical outcomes included pain intensity, functional capacity, and patient-reported symptoms measured before and after treatment.

Results:

Patients treated with active laser therapy experienced significantly greater reductions in pain and improvements in functional outcomes compared with the placebo group. Improvements were observed in pain during movement, overall symptom severity, and measures of physical function, supporting the therapeutic benefit of PBMT for knee OA management.

Conclusion:

Low-level laser therapy provided meaningful short-term improvements in pain and function in patients with knee osteoarthritis compared with placebo treatment. The authors concluded that PBMT may serve as an effective non-pharmacologic treatment option for managing OA symptoms and improving patient quality of life.

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5. Joanna Wyszynska et al., 2018 – High-Intensity Laser Therapy in Knee OA. Strong HILT evidence showing improvements in pain and disability.

Abstract:

Background:

As the number of clinical trials investigating HILT for knee osteoarthritis increased, the authors sought to systematically assess the evidence regarding its impact on pain and physical function.

Objective:

To evaluate the clinical effectiveness of high-intensity laser therapy (HILT) for the treatment of knee osteoarthritis by reviewing the available randomized controlled trials.

Methods:

Researchers conducted a systematic review of the literature through August 2017. Six clinical studies met inclusion criteria and were evaluated for methodological quality according to revised CONSORT guidelines. The included studies assessed a range of HILT treatment parameters and clinical outcomes related to pain and function in patients with knee osteoarthritis.

Results:

Across all six studies reviewed, HILT demonstrated positive therapeutic effects in patients with knee osteoarthritis. Consistent findings included:

- Significant reductions in knee pain
- Improvements in physical function and daily activities
- Enhanced patient-reported outcomes compared with control interventions

Despite variations in treatment protocols, every study reported beneficial effects of HILT on osteoarthritis symptoms and functional performance.

Conclusion:
The authors concluded that high-intensity laser therapy appears to be an effective treatment modality for reducing pain and improving function in patients with knee osteoarthritis. The review highlighted the growing body of evidence supporting laser-based therapies as non-invasive treatment options for managing OA symptoms.

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6. Marco Labanca et al., 2024 – Chronic Low Back Pain. Modern placebo-controlled MLS lumbar spine trial.

Abstract:

Background:
Chronic low back pain is one of the leading causes of disability worldwide. While Multiwave Locked System (MLS) laser therapy has shown promise across several musculoskeletal conditions, its independent effect on chronic non-specific low back pain had not been established in a rigorous placebo-controlled trial.

Objective:
To evaluate the effectiveness of MLS laser therapy on pain, functional performance, and disability compared with sham laser treatment in patients with chronic non-specific low back pain.

Methods:
Forty-five patients were randomized to receive either active MLS laser therapy or sham laser therapy over eight treatment sessions. Outcomes were assessed at baseline, immediately following treatment, and one month after treatment completion.

Researchers evaluated:

- Pain intensity using the Visual Analog Scale (VAS)
- Functional movement using kinematic and electromyographic analysis during forward bending
- Disability using the Roland-Morris Disability Questionnaire and Oswestry Disability Index

Results:
Both groups demonstrated improvements in pain and disability immediately after treatment and at follow-up. However, one month after treatment, the MLS group reported significantly lower pain levels compared with the sham group:

- MLS: VAS 2.2 ± 2.0
- Sham: VAS 3.6 ± 2.4
- Statistical significance: $p < 0.05$

No significant between-group differences were observed in functional movement assessments or disability scores.

Conclusion:
MLS laser therapy provided superior long-term pain reduction compared with placebo treatment in patients with chronic non-

specific low back pain. While both groups improved over time, the sustained reduction in pain observed in the MLS group suggests a clinically meaningful therapeutic effect beyond placebo.

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7. Banu Ordahan et al., 2018 – Plantar Fasciitis (HILT vs LLLT). Direct laser-to-laser comparison demonstrating stronger HILT trends.

Abstract:

Background:
Plantar fasciitis is one of the most common causes of chronic heel pain and functional limitation. Both low-level laser therapy (LLLT) and high-intensity laser therapy (HILT) have been used to manage pain and inflammation, but direct comparisons between the two treatment modalities had been limited.

Objective:
To compare the effectiveness of HILT and LLLT in reducing pain and improving function in patients with plantar fasciitis. Methods: Patients with plantar fasciitis were randomized to receive either HILT or LLLT treatment. Clinical outcomes included:

- Pain intensity measurements
- Functional assessments
- Heel pain and disability evaluations

Patients were assessed before and after completion of the treatment protocol to determine relative effectiveness between the two laser therapies.

Results:
Both treatment groups experienced significant improvements in pain and functional outcomes following therapy. However, the HILT group demonstrated greater reductions in pain scores and stronger improvements across several functional measures compared with the LLLT group. While both laser modalities were effective, the results suggested a clinical advantage favoring HILT for managing plantar fasciitis symptoms.

Conclusion:
High-intensity laser therapy and low-level laser therapy were both effective treatment options for plantar fasciitis. However, HILT produced greater overall improvements in pain and function, indicating that higher-power laser delivery may offer enhanced therapeutic benefits in chronic plantar fascia disorders.

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8. Güldeniz Kaydok et al., 2020 – Lateral Epicondylitis (HILT vs LLLT). Demonstrated superior grip strength and functional outcomes with HILT.

Abstract:

Background:
Lateral epicondylitis (tennis elbow) is a common overuse condition characterized by pain, reduced grip strength, and impaired upper-extremity function. Laser therapy has emerged as a non-invasive treatment option, but evidence directly comparing high-intensity laser therapy (HILT) and low-level laser therapy (LLLT) has been limited.

Objective:
To compare the effectiveness of HILT and LLLT in reducing pain and improving grip strength and functional outcomes in patients with lateral epicondylitis.

Methods:
Patients with clinically diagnosed lateral epicondylitis were randomized to receive either HILT or LLLT. Outcome measures included:

- Pain intensity assessments
- Hand grip strength measurements
- Functional disability evaluations
- Patient-reported outcome measures

Assessments were performed before and after completion of the treatment protocol.

Results:
Both treatment groups demonstrated significant improvements in pain and functional status following therapy. However, patients treated with HILT experienced greater gains in grip strength and superior improvements in functional outcomes compared with those receiving LLLT. Pain reduction was observed in both groups, but the overall clinical response favored HILT.

Conclusion:
Both high-intensity and low-level laser therapies were effective in treating lateral epicondylitis. However, HILT produced greater improvements in grip strength and upper-extremity function, suggesting that higher-energy laser therapy may offer enhanced benefits for tendon-related disorders.

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9. Wei-Tso Chia et al., 2025 – Total Knee Arthroplasty Recovery Trial. Reduced postoperative edema and improved early mobility after TKA.

Abstract:

Background:
Total knee arthroplasty (TKA) is highly effective for end-stage knee osteoarthritis but is frequently associated with substantial postoperative swelling, discomfort, and delayed functional recovery. Photobiomodulation therapy (PBMT) has been proposed as a non-invasive adjunct to improve postoperative outcomes.

Objective:

To evaluate the effects of PBMT on postoperative edema, mobility, pain, and functional recovery following primary total knee arthroplasty. Methods: In this prospective randomized clinical trial, 30 patients undergoing primary TKA were assigned to either:

- Standard postoperative care (control group)
- Standard care plus PBMT administered from postoperative day 1 through day 5

Postoperative swelling was measured using bioimpedance analysis, while functional recovery was assessed using the 2-Minute Walk Test (2MWT) and active range of motion (aROM). Pain was evaluated using the Visual Analog Scale (VAS).

Results:
Patients receiving PBMT demonstrated significantly lower bioimpedance ratios by postoperative day 6, indicating reduced swelling compared with controls. Functional recovery was also enhanced, with PBMT patients achieving greater walking distances during the 2-Minute Walk Test:

- PBMT group: 27 meters
- Control group: 16 meters

Although no significant differences were observed in pain scores or active range of motion, the PBMT group exhibited superior edema control and improved early ambulation.

Conclusion:
PBMT effectively reduced postoperative swelling and enhanced early mobility following total knee arthroplasty. The authors concluded that PBMT may be a valuable addition to conventional postoperative rehabilitation protocols, with the potential to accelerate functional recovery and shorten rehabilitation timelines

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10. Pedro Paulo Alfredo et al., 2021 – Shoulder Impingement Syndrome. Improved pain, ROM, and shoulder function with PBMT.

Abstract:

Background:
Shoulder impingement syndrome is a common musculoskeletal disorder characterized by pain, reduced range of motion (ROM), and functional limitation. Photobiomodulation therapy (PBMT) has been proposed as a non-invasive modality to reduce pain and improve tissue recovery, but its clinical effects in shoulder impingement require further clarification.

Objective:
To evaluate the effectiveness of PBMT in improving pain, shoulder range of motion, and functional outcomes in patients with shoulder impingement syndrome.

Methods:
Patients diagnosed with shoulder impingement syndrome were randomized to receive either active PBMT or a placebo/sham intervention in addition to standard care. Outcome measures included:

- Pain intensity (VAS)
- Shoulder range of motion (flexion, abduction, external rotation)
- Functional assessment scores (e.g., shoulder disability and patient-reported outcome measures)

Assessments were performed before and after the treatment period.

Results:
The PBMT group demonstrated significantly greater improvements in pain reduction compared with the control group. In addition, patients receiving PBMT showed enhanced shoulder range of motion across multiple planes of movement and improved functional outcome scores. The control group showed improvement over time but to a lesser degree than the PBMT group.

Conclusion:
Photobiomodulation therapy was effective in reducing pain and improving both range of motion and functional outcomes in patients with shoulder impingement syndrome. The authors concluded that PBMT may serve as a valuable adjunct to conservative rehabilitation strategies for shoulder impingement.

Essential Evidence Synthesis Papers

11. Mads B. Stausholm et al., 2019 – BMJ Open Meta-analysis (Knee Osteoarthritis). Demonstrated dose- and wavelength-dependent efficacy. Best outcomes: 785–860 nm at 4–8 J/point and 904 nm at 1–3 J/point.

Abstract:

Background:
Knee osteoarthritis (OA) is a prevalent degenerative joint disease associated with chronic pain, reduced mobility, and decreased quality of life. Photobiomodulation therapy (PBMT), previously referred to as low-level laser therapy (LLLT), has been widely studied as a non-pharmacologic treatment option, but treatment parameters and clinical efficacy have varied significantly across trials.

Objective:
To evaluate the overall efficacy of PBMT for knee OA and determine whether treatment outcomes are influenced by specific dosimetric parameters such as wavelength and energy dose.

Methods:
This systematic review and meta-analysis included randomized, placebo-controlled trials assessing PBMT for knee osteoarthritis. Outcomes evaluated included pain intensity, functional status, and global patient-reported improvement. Subgroup analyses were performed to investigate the impact of wavelength and energy dose on clinical outcomes.

Results:
PBMT demonstrated a statistically significant reduction in pain and improvement in function compared with placebo when

appropriate treatment parameters were used. Importantly, the analysis identified a clear dose-response relationship, showing that efficacy depended strongly on wavelength and energy delivery:

- Best outcomes were observed with:
  - 785–860 nm wavelengths at 4–8 J per point
  - 904 nm wavelength at 1–3 J per point

Treatments outside these parameters showed reduced or inconsistent clinical benefit.

Conclusion:
Photobiomodulation therapy is an effective treatment for knee osteoarthritis when applied using evidence-based dosing parameters. The study highlights that wavelength and energy density are critical determinants of clinical success, supporting a standardized, mechanism-based approach to PBMT dosing.

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12. Michael R. Hamblin & David J. Gendron, 2019 – Applications of Photobiomodulation Therapy to Musculoskeletal Disorders and Osteoarthritis. Comprehensive review covering OA, neck pain, low back pain, tendinopathy, shoulder disorders, rehabilitation applications, and biologic mechanisms.

Abstract:

Background:
Musculoskeletal disorders, including osteoarthritis, tendinopathies, neck and low back pain, and shoulder dysfunction, represent a major global cause of disability. Photobiomodulation therapy (PBMT), formerly known as low-level laser therapy (LLLT), has been increasingly investigated as a non-invasive treatment modality with potential analgesic, anti-inflammatory, and tissue-repair effects.

Objective:
To provide a comprehensive overview of the biological mechanisms and clinical applications of PBMT across a range of musculoskeletal conditions, with an emphasis on evidence from randomized controlled trials and systematic reviews.

Content and Methods:
This narrative review synthesizes findings from preclinical and clinical studies evaluating PBMT across multiple musculoskeletal indications, including:

- Knee osteoarthritis
- Neck and low back pain
- Shoulder disorders and rotator cuff disease
- Tendinopathies (e.g., lateral epicondylitis, plantar fasciitis)
- Rehabilitation and postoperative recovery settings

The review also explores mechanistic pathways underlying PBMT effects, including mitochondrial photoreception (cytochrome c oxidase activation), ATP production, modulation of reactive oxygen species, and downstream anti-inflammatory signaling.

Key Findings:
The authors report that PBMT has demonstrated clinically meaningful benefits in multiple randomized trials, particularly when appropriate dosimetry is applied. Across conditions, consistent effects include:

- Reduction in pain intensity
- Improved functional outcomes
- Decreased inflammation
- Enhanced tissue repair and recovery

The review emphasizes that treatment efficacy is highly dependent on wavelength selection, energy dose, and tissue targeting.

Conclusion:
Photobiomodulation therapy is a biologically plausible and clinically supported intervention for a wide range of musculoskeletal disorders. When properly administered, PBMT can reduce pain, improve function, and support tissue healing, making it a valuable adjunct in both conservative and postoperative orthopedic care.

Orthobiologic Synergy & Disease-Modifying Mechanistic Evidence

13. Will Hanney et al., 2022 – The Utility of Photobiomodulation as a Supplement to Regenerative Medicine. Discusses synergy with PRP, orthobiologics, tendon healing, regenerative rehabilitation, and biologic augmentation.

Abstract:

Background:
Regenerative medicine approaches—such as platelet-rich plasma (PRP), stem cell therapies, and other orthobiologics—are increasingly used to enhance tissue healing in musculoskeletal conditions. However, variability in patient response and biologic healing capacity has led to growing interest in adjunctive therapies that may optimize cellular activity and tissue repair. Photobiomodulation therapy (PBMT) has emerged as a potential synergistic modality due to its effects on mitochondrial activity, inflammation modulation, and tissue regeneration pathways.

Objective:
To review and evaluate the potential role of PBMT as an adjunct to regenerative medicine interventions, particularly in tendon healing, musculoskeletal injury repair, and rehabilitation optimization.

Methods:
This narrative review synthesizes preclinical and clinical literature examining the combined use of PBMT with regenerative therapies such as PRP and other biologics. The authors focus on mechanistic overlap, including:

- Cellular metabolism and ATP production

- Growth factor signaling enhancement
- Modulation of inflammatory cytokines
- Angiogenesis and collagen synthesis in tendon and soft tissue healing

Key Findings:

The review highlights emerging evidence suggesting that PBMT may enhance regenerative outcomes by:

- Improving cellular responsiveness to biologic injections (e.g., PRP)
- Accelerating tendon and soft tissue repair processes
- Reducing inflammation and oxidative stress in injured tissues
- Supporting earlier functional recovery in rehabilitation settings

While clinical data remain heterogeneous, preclinical studies consistently demonstrate synergistic effects between PBMT and biologic therapies.

Conclusion:

Photobiomodulation therapy shows strong theoretical and early experimental support as an adjunct to regenerative medicine. By enhancing cellular energy metabolism and modulating inflammatory and repair pathways, PBMT may improve the efficacy of orthobiologic treatments and accelerate musculoskeletal healing.

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14. NCT06122116 – Investigating Orthobiologics After PRP and Photobiomodulation for Knee Osteoarthritis. Compares PT alone, PT+PRP, PT+PBMT, and PT+PRP+PBMT.

Abstract:

Background:

Knee osteoarthritis is a progressive degenerative joint disease that leads to chronic pain, reduced mobility, and functional decline. Standard physical therapy (PT) remains a cornerstone of treatment, while orthobiologic interventions such as platelet-rich plasma (PRP) and emerging modalities like photobiomodulation therapy (PBMT) are increasingly used to enhance outcomes. However, comparative evidence on combined treatment strategies remains limited.

Objective:

To evaluate and compare the effectiveness of four treatment strategies in patients with knee osteoarthritis:

1. Physical therapy alone (PT)
2. PT + PRP
3. PT + PBMT
4. PT + PRP + PBMT

The study aims to determine whether adding orthobiologics and/or photobiomodulation provides incremental benefits in pain reduction, functional improvement, and overall knee health.

Methods:

This is a randomized, multi-arm clinical trial assessing patients with knee osteoarthritis assigned to one of the four intervention groups. Outcome measures include:

- Pain severity (e.g., VAS or similar validated scales)
- Functional status (e.g., WOMAC, KOOS)
- Physical performance and mobility metrics
- Patient-reported quality of life

Patients are followed over a defined treatment and recovery period to evaluate short- and intermediate-term outcomes.

Interventions:

- Standardized physical therapy protocol for all groups
- PRP injections administered according to study protocol
- PBMT administered using standardized dosing parameters
- Combination group receiving both PRP and PBMT in addition to PT

Outcome Focus:
The trial is designed to assess whether PBMT and PRP independently or synergistically enhance outcomes beyond physical therapy alone, and whether combined therapy yields additive or superior clinical improvement.

Conclusion (Study Rationale):
This study addresses a key gap in orthopedic rehabilitation research by directly comparing physical therapy alone versus multimodal regenerative and photobiomodulation-enhanced approaches. Results are expected to clarify the role of combined orthobiologic and PBMT strategies in optimizing outcomes for knee osteoarthritis patients.

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15. Zachary W. Sigman et al., 2026 – Assessment of Dose-Dependent Effects of 1064 nm PBMT on Human Tenocyte- and Bursa-Derived Cell Proliferation. Demonstrated dose-dependent tenocyte proliferation, increased metabolic activity, tissue-specific biologic response, and attenuated bursal-cell response.

Abstract:

Background:
Photobiomodulation therapy (PBMT) has demonstrated therapeutic effects in musculoskeletal tissues, yet cellular responses vary based on wavelength, dose, and tissue type. Tendons and bursae, which often coexist in overuse injuries, may respond differently to PBMT. Understanding dose-dependent and tissue-specific responses is critical for optimizing clinical application.

Objective:
To evaluate the dose-dependent effects of 1064 nm PBMT on human tenocyte proliferation, bursa-derived cell activity, and overall metabolic response in vitro.

Methods:

Human tenocyte and bursa-derived cell cultures were exposed to varying energy densities of 1064 nm PBMT. Outcomes assessed included:

- Cell proliferation rates
- Metabolic activity (e.g., mitochondrial function assays)
- Dose-response relationships across multiple energy levels
- Comparative tissue-specific responses between tendon and bursal cells

Results:

PBMT demonstrated a clear dose-dependent effect on cellular behavior. Key findings included:

- Tenocyte cultures: Increased proliferation and enhanced metabolic activity at specific therapeutic dose ranges
- Bursa-derived cells: Attenuated or less pronounced proliferative response compared to tenocytes, indicating tissue-specific sensitivity
- Evidence of a biphasic dose-response pattern consistent with photobiomodulation principles, where optimal dosing produced maximal biological benefit

Overall, results confirmed that PBMT effects are both dose-dependent and tissue-specific, with tendinous tissue showing a more robust regenerative response than bursal tissue under similar irradiation parameters.

Conclusion:

1064 nm photobiomodulation therapy induces distinct, dose-dependent biological responses in musculoskeletal cell types. Enhanced tenocyte proliferation and metabolic activation suggest a regenerative benefit for tendon tissue, while the attenuated response in bursal cells highlights the importance of tissue-specific dosing strategies for clinical application.

Core Take-Home Message:

The PBMT literature is evolving from symptom modulation toward biologic modulation. Human randomized trials support benefits in osteoarthritis, tendinopathy, spine pain, and postoperative recovery, while emerging translational and orthobiologic studies suggest PBMT may influence the musculoskeletal healing environment through effects on inflammation, mitochondrial activity, tissue metabolism, and regenerative rehabilitation.

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