RESEARCH PAPER

Occupational Therapy Based Post-Surgical Rehabilitation in Lower Limb Orthopaedic Conditions: A Case Series

Prof. (Dr.) Surendra Kumar Meena Ph.D [1]*, Dr Soumyashree Samantaray[2], Dr. Simanta Buragohain[3]

[1*]Dean, Faculty of Physiotherapy and Occupational Therapy, Ph.D, MOT (Hand Therapy), BOT, SOTI (USA), PGDHA, Vivekananda Global University, Jaipur.
[2]PG Scholar, Department Physiotherapy and Occupational Therapy, Vivekananda Global University, Jaipur, Rajasthan
[3]Assistant Professor, Department Physiotherapy and Occupational Therapy MOT (Paediatrics), Ph. D Scholar, Vivekananda Global University, Jaipur.

***Corresponding Author:** Prof. (Dr.) Surendra Kumar Meena Ph. D, MOT (Hand Therapy), BOT, SOTI (USA), PGDHA,
Dean & Professor, Faculty of Physiotherapy and Occupational Therapy, Vivekananda Global University, Jaipur., Jaipur Sector 36, Sisyawas, NRI Road, Jagatpura, Jaipur – 303 012, Rajasthan, India

ABSTRACT

Background: Post-operative recovery following lower limb orthopaedic surgeries such as Total Knee Arthroplasty (TKA), Anterior Cruciate Ligament (ACL) Reconstruction, Posterior Cruciate Ligament (PCL) Reconstruction, and corrective osteotomies is frequently associated with pain, swelling, joint stiffness, reduced range of motion (ROM), muscle weakness, and impaired functional mobility. Early and structured rehabilitation plays a crucial role in restoring mobility and functional independence.

Objective: To evaluate the effectiveness of an occupational therapy-based rehabilitation protocol integrating conventional therapeutic exercises, Photobiomodulation Therapy (PBM), and cryotherapy in improving post-surgical functional outcomes in patients with lower limb orthopaedic conditions.

Methodology: This prospective case series was conducted in the Department of Occupational Therapy at Apex Superspecialty Hospital, Varanasi. A total of 30 post-operative patients (18 males and 12 females) aged between 18 and 55 years were included. Diagnoses included osteoarthritis knee, ACL injuries, PCL injuries, varus and valgus deformities, and distal femoral shaft fractures. Surgical interventions included ACL reconstruction (n=8), Total Knee Arthroplasty (n=13), osteotomy (n=9), and PCL reconstruction. Patients underwent a structured rehabilitation program consisting of conventional therapeutic exercises, PBM therapy, and cryotherapy for 1 hour per session, 6 days per week, for 3 weeks.

Results: At baseline, patients demonstrated severe pain (VAS score: 8), restricted knee ROM (0°–45° flexion), Oxford Knee Score (OKS) of 20, stiffness, and dependence on walker-assisted ambulation. Following the 3-week rehabilitation program, significant clinical improvement was observed. VAS scores improved to 2–3, OKS improved to 40, and patients achieved independent walking, stair climbing, and commode transfers. Improvements in knee mobility and reduction in joint stiffness were also observed.

Conclusion:A structured occupational therapy-based rehabilitation protocol integrating conventional therapeutic exercises with PBM and cryotherapy demonstrated significant improvement in pain reduction, mobility, and functional independence in post-surgical orthopaedic patients. The findings support the incorporation of multimodal rehabilitation strategies in post-operative orthopaedic care to facilitate enhanced recovery and improved quality of life.

Keywords: Knee Surgery, Photobiomodulation Therapy, Cryotherapy, Occupational Therapy, Rehabilitation, Functional Recovery.

How to cite this article: Meena SK, Samantaray S, Buragohain S. Occupational Therapy Based Post-Surgical Rehabilitation in Lower Limb Orthopaedic Conditions: A Case Series. Int J Drug Deliv Technol. 2026;16(49s): 798-804. DOI: 10.25258/ijddt.16.49s.86

INTRODUCTION

The knee joint is a major weight-bearing articulation essential for locomotion, balance, postural control, and performance of activities of daily living. Due to its complex anatomical structure and biomechanical demands, the knee is highly vulnerable to traumatic injuries, degenerative disorders, sports-related pathologies, and post-surgical functional impairments. Orthopaedic conditions affecting the knee contribute significantly to disability, reduced productivity, decreased quality of life, and long-term functional dependence worldwide.

Globally, the prevalence of knee-related disorders has increased substantially over the past two decades due to aging populations, obesity, sedentary lifestyles, increased sports participation, road traffic accidents, and occupational stress. Osteoarthritis of the knee remains one of the leading causes of disability among

*Author for Correspondence: Prof. (Dr.) Surendra Kumar Meena Ph.D

older adults, while ligamentous injuries such as ACL and PCL tears are increasingly prevalent among younger athletic populations. In developing countries such as India, the burden of knee injuries and post-operative disability continues to rise due to increasing rates of degenerative joint disease, sports injuries, and trauma.

Surgical intervention has become a common treatment modality for severe knee pathology. Procedures such as Total Knee Arthroplasty (TKA), ligament reconstruction, corrective osteotomy, fracture fixation, and meniscal repair aim to restore structural integrity and improve joint function. However, surgery alone does not guarantee optimal recovery. Many patients continue to experience pain, edema, stiffness, muscle weakness, reduced range of motion, impaired gait, poor balance, and functional limitations following surgery.

Post-operative rehabilitation therefore plays a crucial role in restoring physical function and reintegration into daily activities. Rehabilitation aims to reduce pain and inflammation, restore joint mobility, improve muscle strength, retrain balance and coordination, enhance gait performance, and improve participation in social and occupational roles.

Occupational therapy is an integral component of post-operative rehabilitation. Occupational therapists focus not only on physical recovery but also on restoring independence in activities of daily living, transfers, mobility, self-care, and community participation. Functional rehabilitation strategies help patients regain confidence and improve quality of life following surgery.

Conventional rehabilitation approaches typically involve strengthening exercises, stretching, gait training, balance exercises, neuromuscular re-education, and functional task-oriented interventions. In recent years, adjunctive modalities such as Photobiomodulation Therapy (PBM) and cryotherapy have gained increasing importance due to their ability to accelerate tissue healing and reduce post-operative symptoms.

Photobiomodulation Therapy, also known as low-level laser therapy, utilizes specific wavelengths of red and near-infrared light to stimulate cellular metabolism and tissue repair. PBM has been reported to reduce inflammation, improve circulation, enhance ATP production, reduce pain, and facilitate neuromuscular recovery. Similarly, cryotherapy has demonstrated beneficial effects in reducing edema, inflammation, pain, and muscle spasm following orthopaedic surgery.

Although several studies have independently examined the effects of PBM and cryotherapy, limited evidence exists regarding their combined integration within occupational therapy-based rehabilitation protocols following lower limb orthopaedic surgery. This case series therefore aims to evaluate the clinical and functional outcomes of a comprehensive rehabilitation program integrating conventional therapeutic exercises, PBM, and cryotherapy in post-surgical orthopaedic patients.

Anatomy and Functional Importance of the Knee Joint

The knee joint is the largest synovial joint in the human body and functions primarily as a modified hinge joint. It consists of the tibiofemoral and patellofemoral articulations and allows flexion, extension, rotational movements, and shock absorption during movement.

Bones Involved

- Femur
- Tibia
- Patella
- Fibula

Ligamentous Structures

The primary stabilizing ligaments of the knee include:

- Anterior Cruciate Ligament (ACL)
- Posterior Cruciate Ligament (PCL)
- Medial Collateral Ligament (MCL)
- Lateral Collateral Ligament (LCL)

Menisci

The medial and lateral menisci function as shock absorbers, load distributors, and joint stabilizers.

Muscular Support

The major muscle groups influencing knee stability and mobility include:

- Quadriceps femoris
- Hamstrings
- Gastrocnemius
- Popliteus
- Tensor fascia lata and iliotibial band

Biomechanics of the Knee Joint

The biomechanics of the knee are highly complex. During activities such as walking, stair climbing, running, and squatting, the knee experiences forces several times greater than body weight. The screw-home mechanism contributes to terminal knee stability, while coordinated muscular activation ensures smooth movement and joint protection.

Abnormal biomechanics, muscle weakness, poor neuromuscular control, and ligamentous instability may predispose individuals to injury and post-operative dysfunction.

Epidemiology of Knee Disorders and Surgeries

Knee osteoarthritis affects millions of individuals worldwide and remains one of the leading causes of disability among older adults. Studies have demonstrated increasing prevalence rates due to rising obesity, sedentary lifestyles, and increased life expectancy.

Sports-related knee injuries, particularly ACL tears, are common among adolescents and young adults. Female athletes have been shown to possess higher risks of non-contact ACL injuries due to anatomical and hormonal factors.

In India, sports injuries, road traffic accidents, and degenerative joint disease significantly contribute to the burden of orthopaedic disability. Despite advances in

surgical management, many patients continue to experience prolonged recovery periods and functional limitations due to inadequate rehabilitation services.

Post-Operative Functional Limitations

Patients undergoing lower limb orthopaedic surgeries frequently experience:

- Pain and edema
- Reduced joint mobility
- Quadriceps weakness
- Impaired gait
- Balance deficits
- Fear of movement
- Functional dependence
- Difficulty in stair climbing and transfers

Without structured rehabilitation, these impairments may lead to delayed recovery, reduced participation, and poor long-term outcomes.

Rationale of the Study

Although conventional rehabilitation remains the cornerstone of post-operative management, adjunctive modalities such as PBM and cryotherapy may significantly improve rehabilitation efficiency and functional outcomes. Integrating these modalities within occupational therapy-based rehabilitation protocols may enhance recovery by simultaneously addressing pain, inflammation, tissue healing, and functional independence.

The present study was therefore undertaken to evaluate the effectiveness of a multimodal rehabilitation protocol integrating PBM, cryotherapy, and conventional therapeutic exercises in post-surgical orthopaedic patients.

The knee joint is one of the largest and most complex synovial joints in the human body and plays a vital role in weight-bearing, mobility, balance, and functional activities such as walking, stair climbing, squatting, and running. Due to its biomechanical complexity and constant exposure to high loading forces, the knee is highly susceptible to traumatic injuries, degenerative changes, and post-surgical functional impairments.

Lower limb orthopaedic conditions such as osteoarthritis, ligament injuries, meniscal injuries, and deformities frequently require surgical intervention including Total Knee Arthroplasty (TKA), ligament reconstruction, osteotomy, and fracture fixation procedures. Although surgical intervention aims to restore structural integrity and reduce pain, patients commonly experience post-operative complications including joint stiffness, reduced range of motion, pain, muscle weakness, edema, gait disturbances, and difficulty performing activities of daily living.

Effective rehabilitation is therefore essential to optimize functional recovery and improve quality of life. Conventional rehabilitation protocols commonly include therapeutic exercises, gait training, strengthening, flexibility exercises, and balance training. In recent years, adjunctive modalities such as Photobiomodulation Therapy (PBM) and cryotherapy have gained increasing clinical attention due to their potential benefits in reducing inflammation, controlling pain, promoting tissue healing, and accelerating recovery.

Photobiomodulation Therapy utilizes red and near-infrared light wavelengths to stimulate cellular activity and mitochondrial function, thereby enhancing tissue repair, reducing inflammation, and improving circulation. Cryotherapy, on the other hand, utilizes localized cooling to reduce pain, edema, muscle spasm, and inflammatory responses.

Despite increasing clinical use of these modalities, limited literature exists regarding their combined integration within occupational therapy-based post-surgical rehabilitation protocols in lower limb orthopaedic conditions. This case series aims to evaluate the functional outcomes of a comprehensive rehabilitation program combining conventional therapeutic exercises, PBM, and cryotherapy in post-operative orthopaedic patients.

METHODOLOGY

Study Design

This study was designed as a prospective case series.

Study Setting

The study was conducted in the Department of Occupational Therapy at Apex Superspecialty Hospital, Varanasi.

Participants

A total of 30 post-operative patients were included in the study, comprising 18 males and 12 females aged between 18 and 55 years.

Clinical Diagnoses

- Osteoarthritis knee
- Anterior Cruciate Ligament (ACL) injuries
- Posterior Cruciate Ligament (PCL) injuries
- Varus deformity
- Valgus deformity
- Distal femoral shaft fractures

Surgical Procedures

- ACL Reconstruction (n=8)
- Total Knee Arthroplasty (n=13)
- Osteotomy (n=9)
- PCL Reconstruction

Inclusion Criteria

- Age between 18–55 years
- Normal cognitive function
- Stable vital signs
- No severe comorbidities
- Absence of open wounds and external fixators
- Ability to participate in regular rehabilitation sessions

Exclusion Criteria

- Patients unable to attend regular therapeutic sessions
- Presence of unstable medical conditions
- Severe neurological or cognitive impairment

Initial Clinical Assessment

Patients were referred to the Occupational Rehabilitation Department approximately 6–8 weeks post-operatively with complaints of:

- Pain

- Joint stiffness
- Reduced range of motion
- Difficulty in walking and transfers

Baseline Findings

- Visual Analog Scale (VAS): 8/10
- Oxford Knee Score (OKS): 20
- Knee flexion ROM: 0°–45°
- Walker-assisted ambulation
- Difficulty in stair climbing and commode transfers

Intervention Protocol

The rehabilitation program was conducted for 3 weeks.

Frequency and Duration

- 1-hour therapy sessions
- 6 days per week
- Outpatient basis

Rehabilitation Components

1. Conventional Therapeutic Exercises

- Guided resistive exercises
- Quadriceps and hamstring strengthening
- TheraBand exercises
- Swiss ball exercises
- Balance and coordination training
- Gait training
- Functional mobility exercises
- Transfer training

2. Photobiomodulation Therapy (PBM)

THOR Photobiomodulation Therapy was administered as part of the rehabilitation protocol. PBM utilizes red and near-infrared wavelengths to stimulate mitochondrial activity, increase ATP synthesis, improve circulation, and reduce inflammatory mediators.

Mechanism of Action of PBM

- Increased cellular metabolism and ATP production
- Enhanced tissue healing and regeneration
- Reduction of inflammatory cytokines
- Improved microcirculation
- Pain modulation and nerve repair

3. Cryotherapy

Zimmer cryotherapy was used to provide localized cold air therapy for pain and inflammation management.

Mechanism of Action of Cryotherapy

- Reduction in tissue temperature
- Vasoconstriction and edema reduction
- Decreased nerve conduction velocity
- Reduction in pain and muscle spasm
- Improved tolerance to rehabilitation exercises

RESULTS

Following completion of the 3-week rehabilitation protocol, significant functional and clinical improvements were observed in the study population.

Clinical Outcomes

Outcome Measure	Baseline	Post Rehabilitation
Visual Analog Scale (VAS)	8/10	2–3/10
Oxford Knee Score (OKS)	20	40
Knee Flexion ROM	0°–45°	Significant Improvement
Ambulation	Walker-assisted	Independent Walking
Stair Climbing	Difficult	Independent
Commode Transfers	Dependent	Independent

Functional Improvements

- Reduction in joint stiffness
- Improved gait pattern
- Enhanced balance and mobility
- Improved lower limb strength
- Better tolerance to functional activities
- Increased independence in activities of daily living

DISCUSSION

The present case series evaluated the effectiveness of a comprehensive occupational therapy-based rehabilitation protocol integrating conventional therapeutic exercises, Photobiomodulation Therapy (PBM), and cryotherapy in patients undergoing lower limb orthopaedic surgeries. Significant improvements were observed in pain reduction, mobility, gait performance, joint range of motion, and functional independence following the 3-week rehabilitation program.

Post-operative rehabilitation is widely recognized as a critical determinant of functional outcome following orthopaedic surgery. Although surgical intervention addresses structural pathology, rehabilitation facilitates restoration of neuromuscular control, muscular strength, mobility, endurance, and participation in activities of daily living.

The reduction in Visual Analog Scale (VAS) scores from 8/10 to 2–3/10 observed in this study indicates substantial pain relief following the integrated rehabilitation protocol. Pain management is a major challenge in post-operative orthopaedic rehabilitation, as persistent pain can limit participation in exercise therapy and delay functional recovery.

The observed improvement in Oxford Knee Scores further suggests enhanced functional capacity and independence following intervention. Patients demonstrated improved gait, independent ambulation, stair climbing ability, and transfer performance, indicating successful restoration of lower limb function.

Role of Conventional Therapeutic Exercises

Conventional rehabilitation exercises formed the foundation of the rehabilitation program. Strengthening exercises targeting the quadriceps, hamstrings, and

surrounding stabilizing musculature are essential for restoring knee joint stability and functional mobility. Balance and proprioceptive exercises contribute to neuromuscular re-education and prevention of re-injury.

TheraBand exercises and Swiss ball activities facilitated progressive strengthening, core stability, and dynamic balance training. Functional mobility training and gait retraining further improved confidence and independence during ambulation.

Role of Photobiomodulation Therapy

Photobiomodulation Therapy has gained increasing attention in rehabilitation medicine due to its biological effects on cellular metabolism and tissue healing. PBM works primarily through absorption of light energy by cytochrome c oxidase within mitochondria, leading to enhanced ATP production and improved cellular metabolism.

The anti-inflammatory effects of PBM are particularly relevant in post-operative rehabilitation. PBM has been shown to reduce pro-inflammatory cytokines such as TNF-alpha and IL-1 beta while enhancing anti-inflammatory mediators. These effects may contribute to reduced edema, pain, and tissue irritation.

In addition, PBM promotes angiogenesis, collagen synthesis, and nerve regeneration, thereby facilitating tissue repair and functional recovery. The improved tolerance to therapeutic exercise observed in the present study may partially be attributed to the analgesic and anti-inflammatory effects of PBM.

Previous studies have similarly demonstrated beneficial effects of PBM in orthopaedic rehabilitation. Grangeon-Chapon et al. reported reduced post-operative pain following total knee arthroplasty with PBM intervention. Ozturk et al. demonstrated improvements in edema reduction and early functional outcomes following PBM therapy.

Role of Cryotherapy

Cryotherapy is a well-established modality in musculoskeletal rehabilitation and sports medicine. Localized cooling reduces tissue temperature, causing vasoconstriction and reduction of inflammatory responses. Cryotherapy also decreases nerve conduction velocity, thereby reducing pain perception.

Zimmer cryotherapy provided rapid skin cooling and improved patient comfort during rehabilitation sessions. Reduced pain and muscle spasm likely contributed to improved participation in exercise therapy and early mobilization.

The reduction in swelling and inflammation achieved through cryotherapy may further enhance joint mobility and functional recovery. Meta-analyses have demonstrated beneficial effects of cryotherapy in reducing pain and improving early rehabilitation outcomes following knee surgery.

Occupational Therapy Perspective

Occupational therapy plays an important role in facilitating functional independence following surgery. Unlike purely exercise-based rehabilitation approaches, occupational therapy emphasizes meaningful functional activity and participation.

In the present study, occupational therapy interventions focused on:

- Functional mobility training
- Transfer training
- Activities of daily living
- Gait retraining
- Balance and coordination
- Endurance building
- Community reintegration

These interventions likely contributed to the significant improvements observed in walking, stair climbing, and commode transfers.

Clinical Significance

The findings of this case series demonstrate that integration of PBM and cryotherapy within conventional rehabilitation protocols may accelerate recovery and improve patient outcomes following orthopaedic surgery.

The multimodal rehabilitation approach addressed multiple aspects of post-operative dysfunction simultaneously, including:

- Pain
- Inflammation
- Muscle weakness
- Joint stiffness
- Reduced mobility
- Functional dependence

Early improvement in mobility and independence may further reduce long-term disability, improve quality of life, and potentially decrease healthcare burden.

Comparison with Existing Literature

The findings of the present study are consistent with previous literature supporting the use of PBM and cryotherapy in orthopaedic rehabilitation. Several randomized controlled trials and systematic reviews have demonstrated improvements in pain, edema reduction, tissue healing, and functional mobility following these interventions.

However, limited literature exists regarding the combined integration of PBM, cryotherapy, and occupational therapy-based rehabilitation in post-surgical orthopaedic populations. Therefore, the present case series contributes clinically relevant evidence supporting integrated multimodal rehabilitation strategies.

Future Scope

Future research should focus on:

- Larger randomized controlled trials
- Standardized PBM dosing protocols
- Long-term follow-up studies
- Comparative effectiveness research
- Functional and quality-of-life outcome measures
- Cost-effectiveness analysis

Further investigation may help establish evidence-based guidelines for integrating PBM and cryotherapy within orthopaedic rehabilitation programs.

Post-operative orthopaedic rehabilitation is essential for restoring mobility, reducing disability, and improving functional independence following lower limb surgeries. The present case series demonstrated significant improvement in pain, mobility, and functional outcomes following a comprehensive rehabilitation protocol integrating conventional therapeutic exercises, Photobiomodulation Therapy, and cryotherapy.

The reduction in VAS scores and improvement in Oxford Knee Scores observed in this study are consistent with previous literature demonstrating the beneficial effects of PBM and cryotherapy in post-surgical rehabilitation. PBM has been shown to stimulate mitochondrial activity, increase ATP synthesis, enhance tissue healing, and reduce inflammatory cytokines. These mechanisms contribute to pain reduction and improved tissue recovery.

Cryotherapy has long been utilized in rehabilitation to decrease edema, inflammation, and pain by reducing tissue temperature and slowing nerve conduction velocity. In the present study, cryotherapy likely contributed to improved pain tolerance, enabling patients to participate more effectively in therapeutic exercises and functional mobility training.

The integration of occupational therapy interventions further enhanced functional recovery by emphasizing gait training, transfer training, strengthening, balance exercises, and activities of daily living. Patients demonstrated substantial improvements in independent ambulation, stair climbing, and commode transfers following rehabilitation.

The findings of this case series support the use of multimodal rehabilitation strategies in post-operative orthopaedic care. Combining conventional exercise-based rehabilitation with PBM and cryotherapy may accelerate functional recovery and improve overall quality of life in post-surgical patients.

LIMITATIONS

The present study had several limitations:

- Small sample size
- Absence of a control group
- Short duration of follow-up
- Heterogeneous surgical population
- Lack of long-term outcome assessment

Future studies with larger sample sizes and randomized controlled trial designs are recommended to further validate the effectiveness of integrated rehabilitation protocols utilizing PBM and cryotherapy.

CONCLUSION

This case series highlights the effectiveness of a structured occupational therapy-based rehabilitation program integrating conventional therapeutic exercises, Photobiomodulation Therapy, and cryotherapy in patients undergoing lower limb orthopaedic surgeries.

Significant improvements were observed in pain reduction, mobility, range of motion, gait performance, and functional independence following the 3-week intervention protocol. The combined use of PBM and cryotherapy served as valuable adjuncts in facilitating tissue healing, reducing inflammation, and improving rehabilitation outcomes.

The findings support the incorporation of multimodal rehabilitation approaches within post-operative orthopaedic care to promote faster recovery, restore functional independence, and enhance quality of life.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Considerations

All participants provided informed consent prior to participation in the study. The rehabilitation interventions were conducted in accordance with institutional clinical rehabilitation protocols and ethical standards.

REFERENCES

1. Grangeon-Chapon C, Domenech J, Fauvernier M, Gineste C, Perrey S. Effects of photobiomodulation therapy on postoperative pain and recovery after total knee arthroplasty: a pilot randomized controlled trial. Lasers Med Sci. 2023;38(2):703–710.
2. Ozturk M, Eksioglu E, Erden N, et al. Photobiomodulation therapy improves early functional outcomes and reduces edema after total knee arthroplasty: A randomized controlled trial. Lasers Med Sci. 2024;39(3):655–663.
3. Ilfeld BM, Trescot AM, Enneking FK, et al. Wearable photobiomodulation device for pain control and rehabilitation after total knee arthroplasty: A feasibility case series. Integr Clin Med. 2024;7(1):012.
4. Moura RS, Nunes CP, Sales CCL, et al. Proposal of a protocol of rehabilitation and photomodulation laser in the treatment of patients in the post-surgical partial meniscectomy: A case report. Clin Med Invest. 2018;3(1):1–5.
5. Gao W, Yang X, Shen J, Zhang J. Efficacy of cryotherapy after total knee arthroplasty: A meta-analysis of 31 randomized controlled trials. BMC Musculoskelet Disord. 2024;25(1):54.
6. Pichonnaz C, Bassin JP, Currat D, Jolles BM, Duc C. Effectiveness of continuous cold and compression therapy for knee conditions: a systematic review and meta-analysis. Phys Ther Sport. 2016;21:11–21.
7. Lanferdini FJ, da Silva DP, Kolberg C, et al. Effects of photobiomodulation therapy versus cryotherapy on exercise-induced muscle damage: A systematic review and meta-analysis. Lasers Med Sci. 2022;37(1):89–102.
8. de Andrade ALM, Bossini PS, Parizotto NA. Effects of low-level laser therapy on the postoperative healing process: A literature review. Lasers Med Sci. 2017;32(4):1157–1166.
9. Arnaut LR, Ferlito JV, de Oliveira Gonçalves M, et al. High-intensity photobiomodulation therapy associated with therapeutic exercises in knee

osteoarthritis: Protocol for a randomized clinical trial. Medicine (Baltimore). 2024;103(22):e38450.
10. Shelbourne KD, Nitz P. Accelerated rehabilitation after anterior cruciate ligament reconstruction. Am J Sports Med. 1990;18(3):292–299.
11. Wilk KE, Reinold MM, Andrews JR. Rehabilitation following articular cartilage procedures in the knee. J Orthop Sports Phys Ther. 2006;36(10):774–794.
12. Risberg MA, Holm I. The long-term effect of 2 postoperative rehabilitation programs after anterior cruciate ligament reconstruction. Am J Sports Med. 2009;37(10):1958–1966.
13. Moffet H, Collet JP, Shapiro SH, et al. Effectiveness of intensive rehabilitation on functional ability and quality of life after first total knee arthroplasty. Arch Phys Med Rehabil. 2004;85(4):546–556.
14. Artz N, Elvers KT, Lowe CM, et al. Effectiveness of physiotherapy exercise following total knee replacement: systematic review and meta-analysis. BMC Musculoskelet Disord. 2015;16:15.
15. Bade MJ, Stevens-Lapsley JE. Early high-intensity rehabilitation following total knee arthroplasty improves outcomes. Arthritis Care Res. 2011;63(9):1238–1245.
16. Brosseau L, Yonge KA, Welch V, et al. Thermotherapy for treatment of osteoarthritis. Cochrane Database Syst Rev. 2003;(4):CD004522.
17. Leal-Junior ECP, Lopes-Martins RAB, Bjordal JM. Clinical and scientific recommendations for the use of photobiomodulation therapy in exercise performance enhancement and post-exercise recovery. Lasers Med Sci. 2019;34(1):1–11.
18. Page P. Current concepts in muscle stretching for exercise and rehabilitation. Int J Sports Phys Ther. 2012;7(1):109–119.
19. Kisner C, Colby LA, Borstad J. Therapeutic Exercise: Foundations and Techniques. 7th ed. Philadelphia: F.A. Davis Company; 2018.
20. Magee DJ. Orthopedic Physical Assessment. 7th ed. Elsevier; 2021.
21. Neumann DA. Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation. 3rd ed. Elsevier; 2017.
22. Norkin CC, White DJ. Measurement of Joint Motion: A Guide to Goniometry. 5th ed. F.A. Davis; 2016.
23. Prentice WE. Rehabilitation Techniques for Sports Medicine and Athletic Training. 7th ed. McGraw Hill; 2020.
24. Cameron MH. Physical Agents in Rehabilitation: From Research to Practice. 5th ed. Elsevier; 2017.
25. Michlovitz SL, Bellew JW, Nolan TP. Modalities for Therapeutic Intervention. 6th ed. F.A. Davis; 2018.