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Thermal interventions in post-exercise recovery: a narrative review of cryotherapy, thermotherapy and athletic performance

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ABSTRACT

Background: Optimizing recovery after exercise is an important component of athletic performance, injury prevention, and training adaptation. Exercise-induced muscle damage (EIMD) and delayed onset muscle soreness (DOMS) are common after intense exercise. Cryotherapy and thermotherapy are widely used, although their effectiveness remains debated.

Aim: To summarize evidence on the effects of cryotherapy and thermotherapy on post-exercise recovery.

Materials and methods: A narrative review of studies from PubMed, Web of Science, and Google Scholar was conducted, focusing on muscle soreness, strength recovery, inflammation, and performance.

Results: Cryotherapy reduces pain and inflammation but may impair long-term adaptations. Thermotherapy improves blood flow, flexibility, and supports later recovery stages. Effectiveness depends on timing, duration, and exercise type. Cold is more beneficial immediately after exercise, while heat is more effective in later phases.

Conclusions: Both methods are useful and complementary. A phase-based approach combining cryotherapy and thermotherapy appears most effective. Individual factors should guide recovery strategies. Further high-quality studies are needed.

Keywords: cryotherapy, cold water immersion, thermotherapy, heat therapy, post-exercise recovery, muscle damage, DOMS, inflammation, athletic recovery, recovery strategies, physical performance.

Introduction

Post-exercise recovery can be defined as the restoration of an athlete's ability to meet or exceed their previous psychophysiological state or performance in a specific activity (1). It is a process essential for restoring physiological homeostasis, repairing muscle damage, and replenishing energy stores (2). Psychophysiological development occurs during non-training periods, making rest a fundamental element of building fitness (1). During the recovery process, muscle soreness is alleviated, general fatigue is reduced, and the body's tolerance for subsequent training loads is increased (3). Recovery is essential regardless of the athlete's level of performance. Its priorities may vary slightly depending on the intensity of competitions. Effective recovery directly enhances athletic performance (2). It allows the athlete to respond faster and more effectively to training, which translates into better results (1). Load management is crucial for achieving peak form and preventing overtraining (2). Failure to achieve full biological recovery carries the risk of serious consequences, including increased susceptibility to injuries and reduced exercise capacity, both in terms of training volume and intensity (1). The particular importance of recovery is evident in professional sports. A regular competition schedule forces athletes to maximize their potential (2). Under such conditions, the timeliness of recovery processes determines victory or defeat. Additionally, exercise-induced muscle damage, although essential for training adaptations, increases the physiological demand for effective recovery strategies (4). Recovery strategies are diverse, ranging from mechanical interventions to thermal modalities, although their effectiveness remains inconsistent across studies (5).

Materials and methods

A narrative literature review was conducted using the PubMed, Web of Science, and Google Scholar databases up to January 2021. Its aim is to present the current state of knowledge regarding the impact of cryotherapy and thermotherapy on post-exercise recovery, with particular emphasis on physiological mechanisms, clinical effects, and practical applications. Various combinations of keywords were used: cryotherapy, cold water immersion, thermotherapy, heat therapy, post-exercise recovery, muscle damage, DOMS, and inflammation, recovery strategies, physical performance. Priority was given to randomized controlled trials, systematic reviews, and meta-analyses evaluating recovery-related indicators, such as muscle soreness, strength recovery, inflammatory markers, and functional performance in physically active individuals.

Review of Evidence

Pathophysiology of DOMS and Muscle Damage

In the context of post-exercise recovery, it is crucial to understand the effects of applied training loads. Exercise-Induced Muscle Damage (EIMD) refers to physical microdamage to muscle fiber structures (sarcomeres) and connective tissue that occurs during training. This occurs primarily during eccentric contractions and following unfamiliar forms of activity (6,7). Delayed Onset Muscle Soreness (DOMS) in turn, is a direct result of the inflammatory processes following the onset of EIMD (7). Symptoms of EIMD include a temporary decline in muscle function (strength and range of motion), swelling, and an increase in muscle-specific markers in the blood, such as creatine kinase (CK) (7). DOMS is a type of ultrastructural injury in which symptoms (pain, stiffness) predominate over the actual degree of tissue damage (6,8). Unlike acute soreness, DOMS typically appears 24 hours after exercise, reaching peak intensity between 48 and 72 hours (6,8).

The pathophysiology of DOMS is complex and involves the interaction of multiple factors. The most important include: mechanical disruption of muscle structures (6), a delayed immune response to injury, increased enzyme release, and irritation of free nerve endings within the muscle (5, 6). The consequences are pain, tenderness, stiffness, and dysfunction of adjacent joints (5, 8). Importantly, muscle damage should not be considered solely detrimental, as it also represents a key stimulus for muscle adaptation and remodeling (4).

The Inflammatory Response in EIMD and DOMS

Intense physical exertion, exceeding the body's current adaptive capacity, initiates a cascade of pathophysiological events known as the acute phase response (APR) (9). The most critical aspect of this process is how muscle damage, oxidative stress, and inflammation feed into one another. EIMD results in increased permeability of cell membranes to intramuscular proteins. This leads to elevated levels of creatine kinase (CK), lactate dehydrogenase (LDH), and aminotransferases (AST and ALT) in the blood (9). Inflammation is regulated by a network of cytokines, intracellular signaling molecules. Exercise, particularly eccentric exercise, leads to significant fluctuations in these molecules, driving the inflammatory response (10). Initially, there is an increase in the concentration of pro-inflammatory cytokines (e.g., IL-6). Subsequently, anti-inflammatory molecules (e.g., IL-10, IL-1Ra) are released, aimed at restoring tissue homeostasis. Excessive production of pro-inflammatory cytokines (IL-1β, IL-6, TNF-α) is responsible for clinical symptoms such as muscle soreness, low mood, and loss of appetite (10). Intense physical exercise increases the production of reactive oxygen species (ROS) by up to tenfold (9, 11). Inflammatory cells, by releasing enzymes (proteases, collagenase) and additional ROS, exacerbate the damage. This phenomenon is referred to as secondary damage (11). When the body produces more free radicals than it can neutralize, oxidative stress occurs. This results in the degradation of proteins, lipids, and DNA in the muscles. This, in turn, exacerbates DOMS and impairs athletic performance (5, 11).

Cryotherapy

Mechanisms of action

Cryotherapy involves applying low temperatures to the skin's surface. Cold exposure activates thermosensory receptors such as TRPM8 and TRPA1, which initiate rapid neurovascular responses including vasoconstriction and subsequent inflammatory processes (12). This leads to reduced blood flow, decreased tissue swelling, and a reduction in inflammatory exudate and hematomas (13, 14, 15, 16). Cooling also affects cellular metabolism. Lowering the local temperature reduces tissue oxygen demand (9, 15) and may additionally trigger systemic responses, including increased catecholamine release, which contributes to analgesia and improved tolerance to post-exercise discomfort (17, 18, 19). This is crucial for limiting so-called secondary injury (15). Intense physical exertion can cause swelling and damage to the microcirculation, which limits the supply of oxygen to healthy tissues surrounding the injury. Lowering cellular metabolism in the area surrounding the injury has a protective effect. It puts these cells into a state of reduced activity. This allows them to survive the period of hypoxia and prevents them from dying (9, 15).

However, the effect of cryotherapy is not limited to tissue protection; it also has analgesic properties. This is explained, among other things, by slower transmission of impulses in sensory nerves (14, 19), the release of endogenous β-endorphins (1), and modulation of the cytokine profile, involving an increase in anti-inflammatory interleukins and a reduction in pro-inflammatory factors (19, 20).

Types of cryotherapy

In clinical and sports practice, we distinguish three main methods of applying cold:

Local cryotherapy: involves the use of ice packs, cooling gels, or crushed ice. More advanced methods include devices that allow for a continuous flow of cold water or cryopneumatic systems (13, 14, 16).

Cryocompression: local cooling combined with compression (special cuffs), which intensifies the anti-edema effect (13, 14, 16).

Cold Water Immersion (CWI): a popular method involving immersing the entire body or limbs in low-temperature water. It aims to accelerate the return to homeostasis (15, 16).

Whole-body cryotherapy (WBC): involves short-term (1–3 min) exposure to extremely low temperatures (from -110°C to -140°C) in special cryochambers (16, 20).

Evidence from clinical studies: DOMS, strength, and recovery

Studies indicate that the use of cryotherapy, particularly WBC and CWI methods, is effective in alleviating DOMS symptoms and reducing the subjective sensation of pain after intense exercise (15, 16, 17, 18, 20). Cryotherapy provides effective support for post-exercise recovery, primarily through rapid tissue cooling and suppression of the acute inflammatory response (4, 16, 17, 20, 21). However, caution is warranted, as excessively low temperatures or prolonged application times may paradoxically lead to delayed vasodilation and increased edema (14, 16, 19).

Thermotherapy

Mechanisms of Action

Thermotherapy, or heat treatment, is based on raising tissue temperature. This initiates a series of beneficial physiological processes. The key mechanism is vasodilation. Consequently, peripheral blood flow increases (22, 23, 24). Enhanced blood flow facilitates tissue regeneration. This results in increased oxygen and nutrient delivery to muscle tissues and fewer metabolic byproducts and substances that irritate pain receptors (23, 24, 25).

Heat exerts a muscle-relaxing effect. It reduces muscle tension and the excitability of peripheral nerves (22, 23). At the cellular level, heat shock proteins (HSP70) play a significant role. Their increased production under heat stress helps protect muscle cells from damage, prevents their aggregation, supports repair processes, and reduces the effects of oxidative stress and inflammation (24, 25, 26). However, it should be noted that a 1°C increase in temperature raises tissue metabolic demand by approximately 7%. This may partially limit the benefits of improved blood flow (25).

Forms of thermotherapy

In sports and rehabilitation practice, various forms of heat delivery are used.

Hot water immersion (HWI): full-body or limb baths, which are more effective than cold water at alleviating muscle pain following eccentric exercise (15).

Sauna (including IR): IR saunas are of particular importance, as their ability to penetrate heat deeper beneath the skin's surface allows them to more effectively affect blood vessels and nerves (23, 27).

Warm wraps and compresses: superficial heat sources (hot packs, towels, wax), easy to use at home (22, 23, 28).

Diathermy: the use of electromagnetic energy for deep tissue heating (22, 29).

Research Evidence: Recovery and Mobility

Clinical studies confirm that thermotherapy contributes to reducing muscle and joint stiffness and increasing their range of motion (22, 29). Injury initiates repair processes. This leads to the activation of satellite cells (muscle stem cells) and faster reconstruction of muscle fiber structures (15, 30). In a post-exercise context, immersion in warm water (HWI) is associated with a decrease in markers of muscle damage, such as creatine kinase (CK) and myoglobin (15, 30). Post-workout IR sauna sessions may improve performance test results and lower the pain threshold (23, 27). Despite these positive effects, experts often recommend caution during the acute phase of an injury. Here, heat can have the opposite effect, exacerbating swelling and inflammation, which can be detrimental (22, 29).

Comparison of Cryotherapy and Thermotherapy

Practical Implications for Athletes and Clinicians

The choice between cooling and heating in post-exercise recovery depends primarily on the therapeutic goal and the time elapsed since the end of exercise. Although both methods aim to restore homeostasis, they affect the body in opposite ways (Table 1)

Table 1: Summary of differences between cryotherapy and thermotherapy

Feature	Cryotherapy	Thermotherapy
Blood vessels	Constriction	Dilation
Tissue metabolism	Slowing (protection against hypoxia)	Acceleration (faster exchange of substances)
Anti-inflammatory effect	Strong - inhibits the formation of edema	Weak – may exacerbate acute inflammation
Effect on muscles	Anesthesia, reduction of pain	Relaxation, increased flexibility

Anti-inflammatory effect and impact on DOMS

Cryotherapy is commonly considered an effective strategy. By lowering tissue temperature, it effectively inhibits the activity of pro-inflammatory cytokines and cell-damaging enzymes. This method is recommended for managing microtraumas (EIMD), effectively reducing pain and swelling (15, 16, 17).

Thermotherapy, on the other hand, is more effective in the later stages of recovery. While cold inhibits inflammation, heat supports repair processes. By improving blood flow, thermotherapy accelerates the removal of waste products and delivers fresh building blocks for fiber repair. By providing a relaxing effect, heat effectively reduces delayed onset muscle soreness (DOMS) and the accompanying stiffness on the 2nd and 3rd days after exercise (15, 25).

Optimal Timing

Understanding the “time window” is key to effective recovery:

Immediate Phase (0–24 hours after training): Cryotherapy is most effective in this phase. Its purpose is to halt the cascade of secondary damage and relieve acute pain. Applying heat at this point could theoretically exacerbate internal bleeding and swelling (16).

Late Phase (48+ hours after training): this is the time for thermotherapy. Once the inflammation has subsided, heat improves circulation and relaxes tense tissues. Saunas and hot baths are effective ways to improve fascial elasticity and restore full range of motion (25).

Application in Sports

Contact and team sports (e.g., soccer, rugby, combat sports)**:** due to the high number of contusions and mechanical microtraumas, cryotherapy (CWI, WBC) remains a commonly used strategy. It helps athletes endure tournaments with a high frequency of matches.

Sports requiring high mobility (e.g., gymnastics, dance, yoga)**:** thermotherapy is more commonly used here. Heat improves tissue elasticity, which directly translates to better movement quality and a lower risk of strains during wide ranges of motion.

Endurance sports (e.g., cycling, long-distance running)**:** contrast therapy (alternating cold and heat) is often used here, which promotes rapid blood circulation and accelerates metabolism without the risk of excessive cooling or overheating of the body.

Discussion

An analysis of the literature shows that recovery is a complex process. This makes it difficult to definitively determine which method- cryotherapy or thermotherapy- is more effective (1, 10). Although both methods are widely used in professional and recreational sports, it is crucial to tailor them to the current phase of muscle damage (EIMD) (2, 3, 5, 6). The main point of contention in the literature remains the impact of cryotherapy on long-term training adaptation. The mechanism of vasoconstriction and reduced cellular metabolism, while beneficial in the acute phase (limiting secondary hypoxic injury) (11, 19), may suppress anabolic signals, thereby inhibiting muscle mass gain (10). In contrast, thermotherapy, through the activation of heat shock proteins (HSP70) and improved blood flow, appears to more favor tissue remodeling and angiogenesis (14, 21, 24). Therefore, it is a better solution at a later stage of recovery (9). Modern sports medicine leans toward a sequential model: cryotherapy as an “emergency” tool in the first 24 hours after exercise, followed by a transition to thermotherapy, which supports tissue repair and improves mobility (5). However, the interpretation of these results is subject to significant methodological limitations that must be taken into account. Due to the considerable heterogeneity of the data, extrapolating conclusions to specific populations is problematic. The available studies include elite athletes, recreational exercisers, and completely untrained individuals. Various intervention protocols are used, involving differences in temperature, duration, and frequency of treatments. This variability makes it difficult to establish uniform standards of care. An additional challenge is the lack of standardization resulting from the use of different methods to induce muscle damage. Resistance training versus endurance training results in different physiological responses in the body. Furthermore, subjective outcomes (DOMS) often do not correlate with objective markers (strength, creatine kinase, inflammation). Another limitation is the low statistical power of many studies, resulting from small sample sizes and short experiment durations. Therefore, despite the promising effects of both therapies, the conclusions should be interpreted with caution. Further high-quality, well-designed randomized controlled trials (RCTs) are necessary to establish optimal protocols and fully elucidate the effects of thermal treatments on post-exercise recovery (10, 13, 15). Additionally, placebo effects and subjective bias in reporting pain and fatigue may influence the perceived effectiveness of recovery interventions.

Conclusion

Cryotherapy and thermotherapy are two complementary strategies for post-exercise recovery, each exerting distinct physiological effects. Cryotherapy appears to be more effective in the acute phase, as it alleviates inflammatory responses and reduces pain perception. Thermotherapy may play a greater role in later stages by improving blood flow and supporting tissue repair processes. Current evidence suggests that a phase-specific approach, combining both methods depending on the timing and type of exercise-induced muscle damage, may yield the most beneficial outcomes. However, the heterogeneity of existing studies, including variations in protocols, populations, and outcome measures, limits the ability to establish standard recommendations. Future research should focus on well-designed randomized controlled trials to determine optimal treatment parameters and clarify the long-term effects of thermal interventions on training adaptation and performance.

Author Contributions

Conceptualization**:** MP
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The authors declare no conflict of interest.

Declaration on the Use of Artificial Intelligence
AI-assisted tools were used exclusively for linguistic refinement and structural editing of the manuscript. The authors take full responsibility for the scientific content, interpretation of the data, and final version of the manuscript

References

Naderi A, Rothschild JA, Santos HO, Hamidvand A, Koozehchian MS, Ghazzagh A, Berjisian E, Podlogar T. Nutritional Strategies to Improve Post-exercise Recovery and Subsequent Exercise Performance: A Narrative Review. Sports Med. 2025 Jul;55(7):1559-1577. https://doi.org/10.1007/s40279-025-02213-6. Epub 2025 Apr 12. PMID: 40221559; PMCID: PMC12297025.

Vatne E, Oliva-Lozano JM, Saenz C, Cost R, Hagen J. Post-Exercise Recovery Modalities in Male and Female Soccer Players of All Ages and Competitive Levels: A Systematic Review. Sports (Basel). 2025 Oct 2;13(10):343. https://doi.org/10.3390/sports13100343. PMID: 41150478; PMCID: PMC12567902.

Driller M, Leabeater A. Fundamentals or Icing on Top of the Cake? A Narrative Review of Recovery Strategies and Devices for Athletes. Sports (Basel). 2023 Nov 3;11(11):213. https://doi.org/10.3390/sports11110213. PMID: 37999430; PMCID: PMC10674277.

Rutkowska M, Bieńko M, Król T, Toborek M, Marchaj M, Korta K, et al. The Benefits of Ice Baths on Delayed Onset Muscle Soreness after high intensity training. J Educ Health Sport (Internet). 2024 May 14 (cited 2026 Apr. 13);68:49169. https://doi.org/10.12775/JEHS.2024.68.49169

Starzyk R, Śmiałek S, Florek J, Cholewa D, Guzik N, Jaklik D, et al. Effectiveness of recovery methods in reducing delayed onset muscle soreness (DOMS): A narrative review. Qual Sport (Internet). 2026 Jan. 3 (cited 2026 Apr. 13);49:66860. https://doi.org/10.12775/QS.2026.49.66860

Kancherla, Akhil Sai. "Delayed Onset Muscle Soreness (DOMS): An Update on Management." *Annals of Innovation in Medicine* 1.3 (2023). https://doi.org/10.59652/aim.v1i3.79

Xu F, Zeng J, Liu X, Lai J, Xu J. Exercise-Induced Muscle Damage and Protein Intake: A Bibliometric and Visual Analysis. Nutrients. 2022 Oct 14;14(20):4288. https://doi.org/10.3390/nu14204288. PMID: 36296973; PMCID: PMC9610071.

Di Lorenzo L, Forte AM, Agosti V, Forte F, Lanciano T, Pirraglia N, D'Avanzo C. Advances in Non-Pharmacological Strategies for DOMS: A Scoping and Critical Review of Recent Evidence. J Funct Morphol Kinesiol. 2025 Nov 20;10(4):452. https://doi.org/10.3390/jfmk10040452. PMID: 41283559; PMCID: PMC12641786.

Chaki B, Pal S, Chattopadhyay S, Bandyopadhyay A. Influence of puberty on high-intensity exercise-induced skeletal muscle damage and inflammatory response in sedentary boys. Sports Med Health Sci. 2024 Mar 7;7(2):116-123. https://doi.org/10.1016/j.smhs.2024.03.002. PMID: 39811409; PMCID: PMC11726034.

Docherty S, Harley R, McAuley JJ, Crowe LAN, Pedret C, Kirwan PD, Siebert S, Millar NL. The effect of exercise on cytokines: implications for musculoskeletal health: a narrative review. BMC Sports Sci Med Rehabil. 2022 Jan 6;14(1):5. https://doi.org/10.1186/s13102-022-00397-2. PMID: 34991697; PMCID: PMC8740100.

Fernández-Lázaro D, Arribalzaga S, Gutiérrez-Abejón E, Azarbayjani MA, Mielgo-Ayuso J, Roche E. Omega-3 Fatty Acid Supplementation on Post-Exercise Inflammation, Muscle Damage, Oxidative Response, and Sports Performance in Physically Healthy Adults—A Systematic Review of Randomized Controlled Trials. Nutrients. 2024 Jun 27;16(13):2044. https://doi.org/10.3390/nu16132044. PMID: 38999792; PMCID: PMC11243702.

Gozhenko A, Zukow W, Biryukov V, Vitiukov O. Acute Cold Respiratory Syndrome: A Narrative Review of Pathophysiological Mechanisms Beyond Viral Etiology. Pedag Psychol Sport (Internet). 2026 Mar. 13 (cited 2026 Apr. 13);31:69792. https://doi.org/10.12775/PPS.2026.31.69792

Lee Y, Shin YS, Kim HJ, An J. Effectiveness and methods of cryotherapy in reducing swelling after total knee arthroplasty: A systematic review of randomized controlled trials. Nurs Open. 2023 Sep;10(9):5989-5998. https://doi.org/10.1002/nop2.1906. Epub 2023 Jun 19. PMID: 37334865; PMCID: PMC10415999.

Liang Z, Ding Z, Wang D, Guo Y, Zhu L, Luo Z, Li L. Cryotherapy for Rehabilitation After Total Knee Arthroplasty: A Comprehensive Systematic Review and Meta-Analysis. Orthop Surg. 2024 Dec;16(12):2897-2915. https://doi.org/10.1111/os.14266. Epub 2024 Oct 14. PMID: 39402654; PMCID: PMC11608804.

Dablainville V, Mornas A, Normand-Gravier T, Al-Mulla M, Papakostas E, Olory B, Fermin TM, Zampeli F, Nader N, Alhammoud M, Bayne F, Sanchez AMJ, Cardinale M, Candau R, Bernardi H, Racinais S. Muscle regeneration is improved by hot water immersion but unchanged by cold following a simulated musculoskeletal injury in humans. J Physiol. 2025 Dec;603(23):7603-7625. https://doi.org/10.1113/jp287777. Epub 2025 May 28. PMID: 40437768; PMCID: PMC12666504.

Bakuła K, Nowicka IM, Turek PR, Dybała E. The Role of Cryotherapy in Sports Recovery: A Critical Review of Current Evidence. Qual Sport (Internet). 2026 Apr. 2 (cited 2026 Apr. 7);54:70230. https://doi.org/10.12775/QS.2026.54.70230

Stachyrak K, Gregułą A, Mazur B, Mika D, Kłos A, Turek K, et al. A Comprehensive Review on the Latest Insights into Cold Therapies and Their Impact on the Human Body, with a Focus on Neurophysiological Responses. J Educ Health Sport (Internet). 2024 Feb. 12 (cited 2026 Apr. 13);58:154-75. https://doi.org/10.12775/JEHS.2024.58.012

Pawlina M, Ziętara K, Raksa K, Nowakowska K, Lewkowicz M. Maximizing the efficiency of resistance training. J Educ Health Sport (Internet). 2022 May 10 (cited 2026 Apr. 13);12(7):16-23. https://doi.org/10.12775/JEHS.2022.12.07.002

Tokarczyk W, Demel K, Dziedzic M, Potoczek A, Talaska J, Kantor A, et al. Cryotherapy and Whole Body Cooling: A Critical Review of Physiological Impacts on Elite Athletes. Qual Sport (Internet). 2025 Mar. 18 (cited 2026 Apr. 13);39:59199. https://doi.org/10.12775/QS.2025.39.59199

He J, Zhang X, Ge Z, Shi J, Guo S, Chen J. Whole-body cryotherapy can reduce the inflammatory response in humans: a meta-analysis based on 11 randomized controlled trials. Sci Rep. 2025 Mar 5;15(1):7759. https://doi.org/10.1038/s41598-025-90396-3. PMID: 40044835; PMCID: PMC11882895.

Chen R, Ma X, Ma X, Cui C. The effects of hydrotherapy and cryotherapy on recovery from acute post-exercise induced muscle damage—a network meta-analysis. BMC Musculoskelet Disord. 2024 Sep 18;25(1):749. https://doi.org/10.1186/s12891-024-07315-2. PMID: 39294614; PMCID: PMC11409518.

Brosseau L, Yonge KA, Robinson V, Marchand S, Judd M, Wells G, Tugwell P. Thermotherapy for the treatment of osteoarthritis. Cochrane Database Syst Rev. 2003;2003(4):CD004522. https://doi.org/10.1002/14651858.cd004522. PMID: 14584019; PMCID: PMC6669258.

Ahokas EK, Ihalainen JK, Hanstock HG, Savolainen E, Kyröläinen H. A post-exercise infrared sauna session improves recovery of neuromuscular performance and muscle soreness after resistance exercise training. Biol Sport. 2023 Jul;40(3):681-689. https://doi.org/10.5114/biolsport.2023.119289. Epub 2022 Sep 15. PMID: 37398966; PMCID: PMC10286597.

Dębicki F, Grądalski Łukasz, Niemirka S, Janiak A, Dominiczak K, Kopaczyńska A, et al. The Impact of a Sauna on Post-Exercise Recovery. Qual Sport (Internet). 2025 Feb. 17 (cited 2026 Apr. 13);38:58208. https://doi.org/10.12775/QS.2025.38.58208

Rousse Y, Sautillet B, Costalat G, Brocherie F, Millet GP. Isolated and Combined Effects of Cold, Heat, and Hypoxia Therapies on Muscle Recovery Following Exercise-Induced Muscle Damage. Sports Med. Nov 2025;55(11):2721-2751. https://doi.org/10.1007/s40279-025-02300-8. Epub 2025 Sep 22. PMID: 40983804; PMCID: PMC12559053.

Mikami T, Yamauchi H. Preconditioning with whole-body or regional hyperthermia attenuates exercise-induced muscle damage in rodents. Physiol Res. 2022 Mar 25;71(1):125-134. https://doi.org/10.33549/physiolres.934569. Epub 2021 Sep 10. PMID: 34505524; PMCID: PMC8997678.

Łagowski R, Kosęda J, Fordymacki J. The Sauna and health: How regular sauna sessions affect the body’s health. Qual Sport (Internet). 2024 Dec. 8 (cited 2026 Apr. 13);35:56289. https://doi.org/10.12775/QS.2024.35.56289

Welch V, Brosseau L, Shea B, McGowan J, Wells G, Tugwell P. Thermotherapy for treating rheumatoid arthritis. Cochrane Database Syst Rev. 2000;2002(4):CD002826. doi: 10.1002/14651858.CD002826. Update in: Cochrane Database Syst Rev. 2001;(2):CD002826. https://doi.org/10.1002/14651858.cd002826. PMID: 11034770; PMCID: PMC6991938.

Bin C, Cimin S, Li N, Wang L, Chen D. Thermotherapy for shoulder pain: A protocol for systematic review. Medicine (Baltimore). 2022 Jan 21;101(3):e28446. https://doi.org/10.1097/md.0000000000028446. PMID: 35060498; PMCID: PMC8772670.

Matusiak F, Brzoza K. The Impact of Sauna Bathing on Cardiovascular Homeostasis: From Molecular Mechanism to Clinical Benefits. Qual Sport (Internet). 2026 Jan. 7 (cited 2026 Apr. 13);49:67491. https://doi.org/10.12775/QS.2026.49.67491