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DELAYED ONSET MUSCLE SORENESS (DOMS): MECHANISMS, PREVENTION, AND THERAPEUTIC STRATEGIES – A COMPREHENSIVE NARRATIVE REVIEW

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ABSTRACT

Background: Delayed Onset Muscle Soreness (DOMS) is a prevalent physiological response to strenuous or novel physical activity, particularly eccentric muscle contractions. It is characterized by delayed muscle pain, stiffness, swelling, and transient reductions in strength and range of motion. DOMS can negatively impact athletic performance, exercise adherence, and quality of life.
Objective: This narrative review aims to comprehensively examine the underlying mechanisms of DOMS, evaluate evidence-based prevention and treatment strategies, and provide practical recommendations for clinicians and athletes.
Methods: A systematic search of the scientific literature was conducted, including randomized controlled trials, cohort studies, systematic reviews, and meta-analyses published in the past decade. The focus was on interventions such as cryotherapy, massage, foam rolling, acupuncture, kinesiotaping, electromagnetic stimulation, curcumin, omega-3 fatty acids, anthocyanins, and herbal extracts.
Results: Cryotherapy, massage, and foam rolling consistently demonstrate efficacy in reducing muscle soreness and improving recovery markers. Nutritional strategies, particularly curcumin and omega-3 supplementation, show significant potential in attenuating inflammation and oxidative stress. Emerging modalities like kinesiotaping and electromagnetic stimulation warrant further research but offer promising adjunctive benefits.
Conclusion: Effective DOMS management requires a multimodal, individualized approach that integrates progressive exercise adaptation, targeted physical therapies, and evidence-based nutritional supplementation. Further high-quality studies are necessary to optimize protocols and confirm long-term safety and effectiveness.

KEYWORDS

Delayed Onset Muscle Soreness, Eccentric Exercise, Recovery Strategies, Foam Rolling, Cryotherapy, Curcumin, Omega-3 Fatty Acids, Acupuncture, Kinesiotaping, Oxidative Stress

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Introduction

Delayed Onset Muscle Soreness (DOMS) is a well-recognized and extensively studied phenomenon in exercise science and sports medicine. Typically, DOMS develops 12–24 hours after unaccustomed or high-intensity exercise, reaches its peak intensity around 48 hours, and gradually resolves over the following 5–7 days (Wilke et al., 2021; Lin et al., 2025). The clinical manifestations include muscle tenderness, swelling, decreased range of motion, and a temporary loss of strength, which can reduce exercise performance and limit the willingness to participate in future training sessions (Desai et al., 2021; Behm & Wilke, 2019).

Although DOMS is generally considered a normal adaptive response to mechanical overload, excessive soreness may hinder rehabilitation, compromise technical execution during training, and contribute to overuse injuries. Therefore, understanding effective strategies to prevent and manage DOMS is of considerable importance for both elite athletes and recreational exercisers. This review synthesizes current evidence on the pathophysiology, prevention, and treatment of DOMS and discusses practical applications of established and emerging interventions.

Pathophysiological Mechanisms

The underlying mechanisms of DOMS involve a complex cascade of mechanical, inflammatory, oxidative, and neural processes (Wilke et al., 2021; Desai et al., 2021; Behm & Wilke, 2019; Peake et al., 2017; Schroeter et al., 2024). Initially, unaccustomed eccentric contractions induce microtrauma to the sarcomeres and surrounding connective tissue. Structural disruption increases the permeability of the sarcolemma and results in uncontrolled calcium influx, activating proteolytic enzymes such as calpains and

phospholipases, which further degrade cellular proteins and membrane phospholipids (Behm & Wilke, 2019; Peake et al., 2017).

Neutrophil and macrophage infiltration occurs in response to this damage, leading to the release of pro-inflammatory cytokines (including interleukin-1β, interleukin-6, and tumor necrosis factor-alpha), as well as reactive oxygen species (ROS) that perpetuate tissue injury (Dupuy et al., 2018; Peake et al., 2017). This inflammatory cascade contributes to the development of swelling, stiffness, and heightened pain sensitivity.

In addition, Lin et al. (2025) highlighted the role of transient neural microdamage, characterized by disruption of nociceptive afferents, which increases the excitability of pain pathways. Acid-sensing ion channels (ASIC-3) and transient receptor potential vanilloid 1 (TRPV1) receptors are activated in damaged muscle, amplifying nociceptive transmission and producing the characteristic delayed pain response (Peake et al., 2017). Collectively, these processes explain the delayed onset, progressive intensity, and spontaneous resolution of DOMS symptoms.

Warm-Up and Repeated Bout Effect

Implementing an appropriate warm-up and gradual exposure to eccentric loading are well-established strategies for attenuating DOMS. This protective adaptation, known as the repeated bout effect, reduces muscle damage and soreness in subsequent training sessions (Behm & Wilke, 2019). Even a single low-intensity eccentric session has been shown to confer significant protective effects against future exercise-induced muscle damage, decreasing markers such as creatine kinase and improving recovery of strength and flexibility (Wilke et al., 2021).

Research suggests that the repeated bout effect involves multiple mechanisms, including enhanced sarcomere alignment, remodeling of connective tissue, and upregulation of protective heat shock proteins and antioxidant enzymes (Behm & Wilke, 2019; Peake et al., 2017). These adaptations improve mechanical stability and reduce the inflammatory response to subsequent bouts of eccentric exercise. Therefore, athletes and practitioners are encouraged to integrate progressive overload and regular exposure to eccentric stimuli into training programs to minimize DOMS severity and optimize performance adaptations.

Cryotherapy and Cold Water Immersion

Cryotherapy, including cold-water immersion, ice packs, and whole-body cryotherapy chambers, is among the most frequently investigated interventions for DOMS. Meta-analyses have shown that cold-water immersion at temperatures of 10–15 °C for 10–15 minutes significantly reduces perceived muscle soreness and biomarkers of muscle damage, such as creatine kinase, compared to passive recovery (Dupuy et al., 2018; Moore et al., 2025). Schroeter et al. (2024) recommend initiating cryotherapy within 4 hours post-exercise to achieve optimal benefits.

The mechanisms of action include vasoconstriction, decreased metabolic activity, reduced nerve conduction velocity, and attenuation of inflammatory cytokine release (Dupuy et al., 2018). However, excessive or prolonged cryotherapy application may impair muscle protein synthesis and limit hypertrophic adaptations when used chronically. Consequently, practitioners should carefully consider timing, duration, and frequency of cryotherapy based on individual training goals and recovery needs.

Massage and Foam Rolling

Massage therapy has long been employed to alleviate muscle soreness, improve circulation, and promote relaxation following intense exercise (Behm & Wilke, 2019). Randomized controlled trials indicate that massage performed within 2 hours post-exercise can reduce DOMS by approximately 20–30% compared to no treatment or passive recovery. The physiological effects include enhanced lymphatic drainage, increased microvascular perfusion, and decreased muscle stiffness, contributing to improved recovery (Dupuy et al., 2018).

Foam rolling has gained widespread popularity due to its convenience and low cost. This self-myofascial release technique mobilizes fascial structures, reduces myofascial adhesions, and decreases pain perception by stimulating mechanoreceptors (Michalak et al., 2024). Michalak et al. (2024) compared foam rollers of different densities and found that higher-density rollers were more effective for reducing soreness and improving hip range of motion. Pagaduan et al. (2022) observed that consistent foam rolling performed for at least 60 seconds per muscle group resulted in significant improvements in flexibility and reductions in perceived pain lasting up to 72 hours post-exercise. Combining foam rolling with dynamic stretching may further enhance recovery and support neuromuscular function.

Emerging Physical Therapies

In addition to conventional modalities, several alternative therapies have been investigated for their potential to reduce DOMS symptoms. Acupuncture has been studied in randomized controlled trials and systematic reviews, demonstrating moderate effectiveness compared to sham or no treatment (Cheng et al., 2025). The proposed mechanisms include modulation of endogenous opioid pathways, reduction of inflammatory cytokine levels, and improved local circulation.

Kinesiotaping is another emerging intervention gaining popularity among athletes. Elastic therapeutic tape applied over the affected muscle groups may enhance proprioceptive feedback, support soft tissues, and reduce pain perception (Cheng et al., 2025). Although some studies have shown promising outcomes, evidence remains limited by small sample sizes and methodological variability. A systematic review by Cheng et al. (2025) concluded that kinesiotaping may provide short-term reductions in DOMS severity, but further high-quality trials are needed to confirm efficacy.

Electromagnetic stimulation represents a novel approach involving the application of low-frequency magnetic fields to modulate inflammation and accelerate recovery. Preliminary studies suggest potential benefits, including decreased muscle soreness and improved performance metrics, but data are still limited (Frontiers in Physiology Editorial Team, 2023). Collectively, these emerging therapies warrant further investigation to establish standardized protocols and long-term safety profiles.

Nutritional Supplementation and Phytotherapy

Curcumin, the bioactive compound in turmeric, has garnered substantial interest due to its potent anti-inflammatory and antioxidant properties. Meta-analyses by Beba et al. (2022) demonstrated that curcumin supplementation significantly reduces serum creatine kinase levels, muscle soreness, and pro-inflammatory cytokine concentrations. Optimal dosing appears to range between 150–500 mg daily over 2–12 weeks, depending on individual response and exercise intensity.

Omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), have also been shown to attenuate exercise-induced inflammation and oxidative stress (Ahmadi et al., 2024; Fernández-Lázaro et al., 2024; Ke et al., 2024). These polyunsaturated fatty acids modulate the production of pro-inflammatory cytokines and promote cell membrane integrity, resulting in decreased DOMS severity. Daily supplementation of 1–3 grams of combined EPA and DHA has been recommended in several trials.

Anthocyanins, naturally occurring flavonoid compounds found in berries and other pigmented fruits, contribute to scavenging reactive oxygen species and supporting muscle recovery. Souza et al. (2022) found that anthocyanin-rich supplementation reduced subjective soreness and biomarkers of oxidative damage following eccentric exercise.

Herbal preparations, including ginger, ashwagandha, and blackcurrant extract, have been investigated as adjunctive recovery aids. Anugrah et al. (2024) reviewed several studies indicating that these botanicals possess anti-inflammatory and analgesic properties that may reduce DOMS symptoms. However, variability in product quality and dosing regimens underscores the need for standardized formulations and further clinical trials.

Overall, nutritional strategies represent a promising avenue for reducing DOMS severity, but practitioners should consider individual tolerances, potential interactions with medications, and product standardization when recommending supplements.

Practical Recommendations

Based on current evidence, the following recommendations can be made to help manage and prevent DOMS effectively:

- **Gradual Progression**: Incorporate progressive overload and gradual increases in eccentric training volume to induce protective adaptations and reduce the severity of muscle soreness in subsequent sessions.
- **Cryotherapy Application**: Utilize cryotherapy or cold-water immersion within the first 4 hours post-exercise for 10–15 minutes at 10–15 °C to reduce inflammation and perceived soreness. Avoid chronic overuse that may hinder training adaptations.
- **Massage and Foam Rolling**: Employ massage therapy within 1–2 hours post-exercise and consistent foam rolling sessions (≥60 seconds per muscle group) to enhance circulation, decrease stiffness, and improve recovery outcomes.
- **Nutritional Support**: Consider supplementation with curcumin (150–500 mg daily) and omega-3 fatty acids (1–3 g daily) to attenuate inflammation and oxidative stress. Anthocyanins and selected herbal extracts may also be beneficial as adjunctive measures.

• **Emerging Modalities**: Explore acupuncture, kinesiotaping, and electromagnetic stimulation on an individual basis, recognizing that while promising, these interventions require further validation.

• **Personalization**: Tailor recovery protocols to the athlete's training status, preferences, and specific demands, continually evaluating effectiveness and tolerability.

An overview of these interventions, their proposed mechanisms, evidence levels, and potential adverse effects is provided in Table 1.

Table 1. Overview of DOMS Interventions

Intervention	Mechanism of Action	Optimal Timing	Evidence Level	Potential Adverse Effects
Cryotherapy	Reduces inflammation, edema, nerve conduction	0–4 hours post-exercise	High-quality evidence (meta-analyses)	Frostbite risk, possible blunted hypertrophy
Massage	Improves circulation, reduces muscle tension	1–48 hours post-exercise	Moderate-quality evidence (RCTs)	Minimal
Foam Rolling	Myofascial release, decreases pain sensitivity	0–72 hours post-exercise	High-quality evidence (systematic reviews)	Transient discomfort
Curcumin	Anti-inflammatory, antioxidant	2–12 weeks supplementation	High-quality evidence (meta-analyses)	Gastrointestinal discomfort in high doses
Omega-3 Fatty Acids	Lowers pro-inflammatory cytokines	Daily	Moderate-quality evidence (RCTs)	Interactions with anticoagulants
Anthocyanins	Neutralizes reactive oxygen species	2–4 weeks supplementation	Moderate-quality evidence (RCTs)	None reported
Acupuncture	Modulates nociceptive signaling	Several sessions post-exercise	Moderate-quality evidence (systematic reviews)	Minimal
Kinesiotaping	Enhances proprioception, reduces soreness	Up to 48 hours after application	Preliminary evidence (small trials)	Minimal
Electromagnetic Stimulation	Modulates inflammation, nerve excitability	Immediately post-exercise	Preliminary evidence (pilot studies)	Limited long-term data

Note: Evidence levels are based on available systematic reviews and randomized controlled trials. This table was prepared by the author based on reviewed literature sources.

Conclusions

Delayed Onset Muscle Soreness (DOMS) represents a complex interplay of structural damage, inflammatory signaling, oxidative stress, and neural sensitization following high-intensity or novel exercise. Decades of research have enhanced our understanding of the underlying mechanisms and facilitated the development of effective prevention and management strategies.

Cryotherapy and cold-water immersion remain among the most consistently supported modalities, providing significant reductions in muscle soreness and damage biomarkers. Massage and foam rolling offer practical, evidence-based options for alleviating discomfort and accelerating recovery, while curcumin and omega-3 fatty acid supplementation show substantial promise in mitigating inflammation and oxidative damage. Anthocyanins and certain herbal preparations further expand the range of nutritional interventions available to support muscle repair.

Emerging therapies such as acupuncture, kinesiotaping, and electromagnetic stimulation contribute additional tools, although further high-quality trials are necessary to establish standardized protocols and confirm long-term safety. Ultimately, effective DOMS management requires an individualized, multimodal approach that balances progressive training adaptations, targeted therapeutic modalities, and evidence-based supplementation. Continuous research efforts will be essential to refine dosing regimens, optimize combined interventions, and enhance recovery outcomes across athletic and recreational populations.

REFERENCES

1. Ahmadi, M., Hoorang, N., Imanian, B., et al. (2024). Boosting recovery: Omega-3 and whey protein enhance strength and ease muscle soreness in female futsal players. *Nutrients, 16*(24), 4263. https://doi.org/10.3390/nu16244263
2. Anugrah, S. M., Kusnanik, N. W., & Suharjana, S. (2024). Herbal supplements that have the potential to accelerate recovery of exercise-induced muscle damage: Systematic review. *Retos, 51*, 840–848. https://doi.org/10.47197/retos.v51.100616
3. Beba, M., Mohammadi, H., Clark, C. C. T., & Djafarian, K. (2022). The effect of curcumin supplementation on delayed-onset muscle soreness, inflammation, muscle strength, and joint flexibility: A systematic review and dose-response meta-analysis of randomized controlled trials. *Phytotherapy Research, 36*(7), 2767–2778. https://doi.org/10.1002/ptr.7477
4. Behm, D. G., & Wilke, J. (2019). Do self-myofascial release devices release myofascia? Rolling mechanisms: A narrative review. *Sports Medicine, 49*(8), 1173–1181. https://doi.org/10.1007/s40279-019-01149-y
5. Cheng, X., Lin, J., & Fan, Y. (2025). Effects of vibration training combined with kinesio taping on delayed-onset muscle soreness. *Frontiers in Bioengineering and Biotechnology, 13*, 1561309. https://doi.org/10.3389/fbioe.2025.1561309
6. Desai, R., Flatt, A. A., Esco, M. R., et al. (2021). Effects of foam rolling for delayed onset muscle soreness on loaded tactical performance tasks. *Science & Sports, 36*(2), 95–101. https://doi.org/10.1016/j.scispo.2020.11.002
7. Dupuy, O., Douzi, W., Theurot, D., Bosquet, L., & Dugué, B. (2018). An evidence-based approach for choosing post-exercise recovery techniques to reduce markers of muscle damage, soreness, fatigue, and inflammation: A systematic review with meta-analysis. *Frontiers in Physiology, 9*, 403. https://doi.org/10.3389/fphys.2018.00403
8. Fernández-Lázaro, D., Mielgo-Ayuso, J., Seco-Calvo, J., et al. (2024). 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, 16*(13), 2044. https://doi.org/10.3390/nu16132044
9. Friedrich, T. K., Grimmer, M., Hohmann, B., et al. (2022). 12-week curcumin supplementation may relieve postexercise muscle soreness in adolescent athletes. *Frontiers in Nutrition, 9*, 1078108. https://doi.org/10.3389/fnut.2022.1078108
10. Frontiers in Physiology Editorial Team. (2023). Effects of combined transcranial and peripheral electromagnetic stimulation on DOMS symptomatology and athletic performance. *Frontiers in Physiology, 14*, 1267315. https://doi.org/10.3389/fphys.2023.1267315
11. Ke, Q., Li, Z., Zhang, Y., et al. (2024). Effects of omega-3 supplementation on delayed onset muscle soreness, creatine kinase, and muscle strength following high-intensity interval training in men with overweight or obesity: A randomized, double-blind, placebo-controlled trial. *Journal of Sports Science and Medicine, 23*(2), 210–218. https://pubmed.ncbi.nlm.nih.gov/38841630/
12. Lin, L. J., Wu, T. Y., Cheng, Y. H., et al. (2025). Delayed-onset muscle soreness begins with a transient neural microdamage. *International Journal of Molecular Sciences, 26*(5), 2319. https://doi.org/10.3390/ijms26052319
13. Liu, X., Lin, L., & Hu, G. (2024). Meta-analysis of the effect of curcumin supplementation on skeletal muscle damage status. *PLoS ONE, 19*(7), e0299135. https://doi.org/10.1371/journal.pone.0299135
14. Michalak, B., Kopiczko, A., Gajda, R., et al. (2024). Recovery effect of self-myofascial release treatment using different types of foam rollers. *Scientific Reports, 14*, 15762. https://doi.org/10.1038/s41598-024-66577-x
15. Moore, E., Thomas, S., Cooke, P., et al. (2025). Effects of different doses of cold water immersion on delayed-onset muscle soreness and recovery outcomes: A network meta-analysis. *Frontiers in Physiology, 16*, 1525726. https://doi.org/10.3389/fphys.2025.1525726
16. Pagaduan, J. C., Chang, S.-Y., & Chang, N.-J. (2022). Chronic effects of foam rolling on flexibility and performance: A systematic review of randomized controlled trials. *International Journal of Environmental Research and Public Health, 19*(7), 4315. https://doi.org/10.3390/ijerph19074315
17. Peake, J. M., Neubauer, O., Della Gatta, P. A., & Nosaka, K. (2017). Muscle damage and inflammation during recovery from exercise. *Journal of Applied Physiology, 122*(3), 559–570. https://doi.org/10.1152/japplphysiol.00971.2016
18. Schroeter, S., Bloch, W., Hirschmüller, A., et al. (2024). Update: Delayed onset muscle soreness (DOMS) – Muscle biomechanics, pathophysiology and therapeutic approaches. *Deutsche Zeitschrift für Sportmedizin, 75*, 189–194. https://doi.org/10.5960/dzsm.2024.608
19. Souza, T. C. de M., Goston, J. L., Martins-Costa, H. C., Minighin, E. C., & Anastácio, L. R. (2022). Can anthocyanins reduce delayed-onset muscle soreness? A systematic review and meta-analysis of randomized controlled trials. *Preventive Nutrition and Food Science, 27*(3), 265–275. https://doi.org/10.3746/pnf.2022.27.3.265
20. Wilke, J., Behrens, M., Tenberg, S., et al. (2021). Is “delayed onset muscle soreness” a false friend? The potential implication of the fascial connective tissue in post-exercise discomfort. *International Journal of Molecular Sciences, 22*(17), 9482. https://doi.org/10.3390/ijms22179482