

Cryotherapy And Sport Massage In Volleyball Athlete Recovery: An Evidence-Based Review

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Authors' contribution:

A. Conception and design of the study; **B.** Acquisition of data; **C.** Analysis and interpretation of data; **D.** Manuscript preparation; **E.** Obtaining funding

Received: 2025-11-25

Accepted: 2025-11-30

Published: 2025-12-21

ABSTRACT

Volleyball is a high-intensity sport characterized by repetitive jumping, spiking, blocking, and rapid directional changes that frequently lead to muscle fatigue, exercise-induced muscle damage, inflammation, and delayed onset muscle soreness (DOMS). Effective recovery strategies are therefore essential to maintain athlete performance and reduce injury risk. This study aimed to analyze and compare the effectiveness of cryotherapy and sport massage in the recovery of volleyball athletes through an evidence-based review approach. The review followed evidence-based practice principles and PRISMA guidelines by examining scientific literature published between 2015 and 2025 from Scopus, PubMed, Web of Science, ScienceDirect, Google Scholar, and SINTA-indexed journals. A total of 127 articles were initially identified, and 24 studies met the inclusion criteria for final analysis. The findings indicated that cryotherapy demonstrated superior physiological recovery effects, with 88% of studies reporting reductions in DOMS, 79% showing decreased inflammatory markers, and 54% identifying improvements in neuromuscular recovery and jump performance. Meanwhile, sport massage showed stronger effects on subjective recovery, with 75% of studies reporting improved perceived recovery and fatigue reduction, while 58% demonstrated enhanced flexibility and reduced muscle stiffness. The evidence suggests that cryotherapy is more effective for acute physiological restoration, whereas sport massage contributes substantially to psychological recovery and movement quality. Therefore, combining both modalities may provide a comprehensive recovery strategy for optimizing volleyball athlete performance and readiness during training and competition.

Keywords : Cryotherapy; Sport Massage; Recovery; Volleyball Athletes; Evidence-Based Review

INTRODUCTION

Volleyball is recognized as a high-intensity intermittent sport that requires repeated explosive actions, including jumping, spiking, blocking, diving, and rapid changes of direction. According to the physiological demands theory of team sports, repeated high-intensity movements place considerable neuromuscular and metabolic stress on athletes, resulting in accumulated fatigue and performance decline (Sheppard et al., 2017; Gabbett, 2016). During training and competition, volleyball athletes experience substantial eccentric muscle contractions, particularly during landing and deceleration phases. The Exercise-Induced Muscle Damage (EIMD) theory explains that repetitive eccentric contractions produce microtrauma in muscle fibers, leading to inflammation, delayed onset muscle

soreness (DOMS), and temporary reductions in muscular performance (Hyldahl & Hubal, 2014; Peake et al., 2017). Furthermore, the General Adaptation Syndrome proposed by Selye suggests that inadequate recovery following physical stress may result in maladaptation, overreaching, or increased injury risk (Kellmann et al., 2018). Therefore, recovery management has become a critical component of contemporary volleyball conditioning programs (Bishop et al., 2018).

The physiological recovery theory states that recovery interventions aim to restore homeostasis, replenish energy stores, accelerate tissue repair, and prepare athletes for subsequent physical demands (Dupuy et al., 2018). Among the various recovery modalities available, cryotherapy and sport massage have gained widespread acceptance in both elite and recreational sports settings. Cryotherapy, particularly cold-water immersion (CWI), is based on the thermoregulatory and vascular response theory, whereby cold exposure induces vasoconstriction, decreases tissue temperature, reduces metabolic activity, and suppresses inflammatory processes (Ihsan et al., 2016). The inflammatory modulation theory further suggests that lowering tissue temperature may attenuate the production of inflammatory cytokines and reduce secondary muscle damage following strenuous exercise (Hohenauer et al., 2018). Conversely, sport massage is grounded in the mechanical and circulatory stimulation theory, which proposes that manual manipulation of soft tissues enhances blood circulation, facilitates lymphatic drainage, reduces muscle stiffness, and promotes relaxation (Davis et al., 2020). In addition, the psychophysiological recovery model indicates that massage may reduce perceived fatigue, anxiety, and psychological stress, thereby contributing to overall recovery quality (Weerapong et al., 2015).

Despite their widespread application, evidence regarding the effectiveness of cryotherapy and sport massage remains inconsistent. According to the Recovery-Stress Balance Model, recovery interventions may produce different outcomes depending on exercise intensity, timing of application, individual characteristics, and training status (Kellmann et al., 2018). Several studies have reported that cryotherapy effectively reduces DOMS, inflammation, and muscle damage markers such as creatine kinase (CK) and interleukin-6 (IL-6) (Machado et al., 2016; Rose et al., 2017). However, the adaptation interference hypothesis suggests that excessive suppression of inflammatory responses through frequent cryotherapy use may attenuate long-term muscular adaptations and protein synthesis (Roberts et al., 2015). Similarly, sport massage has been shown to improve flexibility, subjective recovery, and muscle relaxation, yet its effects on objective performance indicators such as sprint speed, maximal strength, and explosive power remain relatively small (Davis et al., 2020; Poppendieck et al., 2016). These conflicting findings create uncertainty among coaches and sports therapists regarding the most effective recovery strategy for volleyball athletes.

Over the past decade, considerable scientific attention has focused on post-exercise recovery interventions. According to the post-exercise recovery framework proposed by Dupuy et al. (2018), cryotherapy has emerged as one of the most investigated recovery modalities due to its potential to reduce inflammation, edema, and muscle soreness. Recent systematic reviews have demonstrated that cold-water immersion significantly decreases DOMS within 24–48 hours following strenuous exercise and enhances neuromuscular recovery (Machado et al., 2016; Hohenauer et al., 2018). Moreover, the physiological cooling theory explains that cryotherapy can reduce inflammatory biomarkers such as IL-6, CK, and C-reactive protein (CRP), thereby accelerating tissue recovery processes (Rose et al., 2017).

A recent network meta-analysis further demonstrated that cryotherapy effectiveness is highly dependent on treatment timing and modality. Cold-water immersion appears

particularly effective during the first 24 hours post-exercise, whereas whole-body cryotherapy may produce superior recovery outcomes after 48–72 hours (Poppendieck et al., 2016). These findings are especially relevant for volleyball athletes, who frequently perform repeated explosive actions requiring rapid recovery between training sessions and competitions. Parallel to cryotherapy research, sport massage has also received considerable scientific attention. The mechanotransduction theory suggests that massage-induced mechanical stimuli can influence cellular signaling pathways involved in tissue repair and inflammation regulation (Crane et al., 2017). Massage techniques such as effleurage, petrissage, friction, vibration, and tapotement have been reported to increase local circulation, stimulate lymphatic flow, and reduce muscle stiffness (Davis et al., 2020). A comprehensive meta-analysis involving more than 1,000 participants found that sport massage significantly improves flexibility and reduces DOMS, although effects on strength, endurance, sprint performance, and jump height are generally limited (Poppendieck et al., 2016).

Furthermore, the psychobiological model of recovery emphasizes that recovery is not solely physiological but also psychological. Sport massage has consistently demonstrated beneficial effects on perceived fatigue, stress reduction, mood enhancement, and relaxation (Weerapong et al., 2015). These psychological benefits may be particularly advantageous for volleyball athletes who often participate in congested competition schedules requiring rapid mental and physical recovery. Although the literature supports the effectiveness of both cryotherapy and sport massage, important knowledge gaps remain. Most previous investigations have focused on general athletic populations such as soccer players, runners, cyclists, rugby players, and resistance-trained individuals (Dupuy et al., 2018). Comparatively few studies specifically examine volleyball athletes, despite the unique physiological demands of repeated jumping, landing, and overhead movements. Furthermore, most reviews evaluate cryotherapy and massage independently rather than conducting direct comparisons between the two modalities. Consequently, evidence-based guidance for selecting the most appropriate recovery strategy in volleyball remains limited. Additionally, many studies prioritize physiological outcomes such as inflammation and muscle soreness while neglecting volleyball-specific performance variables including jump height, agility, explosive power, and match readiness.

Therefore, this evidence-based review aims to synthesize contemporary findings regarding cryotherapy and sport massage in volleyball athlete recovery. The novelty of this review lies in its comparative analysis of two widely used recovery modalities through physiological, performance, and practical perspectives while integrating evidence from both international Scopus-indexed journals and Indonesian SINTA-indexed publications. Such integration is expected to provide stronger scientific guidance for coaches, physiotherapists, and sports scientists in designing effective volleyball recovery programs.

METHODS

This study employed an evidence-based review design to systematically synthesize and critically evaluate scientific evidence regarding the effectiveness of cryotherapy and sport massage in the recovery of volleyball athletes. An evidence-based review is considered an appropriate methodological approach for integrating findings from multiple studies to provide comprehensive recommendations for sports practitioners, coaches, physiotherapists, and researchers (Higgins et al., 2023). This approach is grounded in the principles of Evidence-Based Practice (EBP), which emphasize the integration of the best

available scientific evidence with professional expertise and practical application in sports performance and recovery settings (Bishop et al., 2018). The review process was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, which has been widely adopted in sports science and rehabilitation research to ensure methodological transparency, reproducibility, and rigor (Page et al., 2021). Literature searches were performed across several international and national databases, including Scopus, Web of Science, PubMed, ScienceDirect, Google Scholar, and SINTA-indexed journals. These databases were selected because they provide extensive coverage of sports medicine, exercise physiology, physiotherapy, and recovery-related studies (Hohenauer et al., 2018).

The search strategy utilized combinations of keywords and Boolean operators, including "cryotherapy," "cold-water immersion," "whole-body cryotherapy," "sport massage," "recovery," "volleyball athlete," "muscle soreness," "exercise-induced muscle damage," and "athletic performance." Studies published between 2015 and 2025 were included to ensure the incorporation of the most recent scientific evidence. According to evidence synthesis theory, restricting the review to contemporary literature enhances the relevance and applicability of findings to current sports science practice (Dupuy et al., 2018). The inclusion criteria comprised: (1) original research articles, systematic reviews, and meta-analyses; (2) studies published in peer-reviewed journals indexed in Scopus or SINTA; (3) investigations examining cryotherapy and/or sport massage as recovery interventions; (4) studies involving athletes or physically active individuals; and (5) articles written in English or Indonesian. Meanwhile, studies lacking full-text access, conference abstracts, opinion papers, and non-peer-reviewed publications were excluded. This selection process follows methodological recommendations suggesting that high-quality evidence should primarily originate from peer-reviewed scientific literature (Kellmann et al., 2018).

Data extraction was conducted systematically by recording information regarding authors, publication year, study design, participant characteristics, intervention protocols, outcome measures, and key findings. Particular attention was given to physiological outcomes, including delayed onset muscle soreness (DOMS), creatine kinase (CK), inflammatory biomarkers, perceived recovery, and fatigue, as well as performance-related indicators such as jump height, power output, agility, and neuromuscular function (Machado et al., 2016; Davis et al., 2020). The analysis employed a narrative synthesis approach, which is recommended when studies exhibit methodological heterogeneity in intervention protocols, participant characteristics, and outcome measures (Popay et al., 2018). Findings were categorized into three major themes: physiological recovery mechanisms, performance recovery outcomes, and practical applications in volleyball. Through this approach, the review aimed to provide a comprehensive comparison of cryotherapy and sport massage while identifying strengths, limitations, and evidence-based recommendations for volleyball recovery programs.

RESULTS AND DISCUSSION

Result

A total of 127 articles were initially identified from Scopus, PubMed, Web of Science, ScienceDirect, Google Scholar, and SINTA databases. After removing duplicates and screening titles, abstracts, and full texts, 24 studies met the inclusion criteria and were included in the final review. The selected studies consisted of 14 investigations examining cryotherapy interventions, 7 studies evaluating sport massage, and 3 studies assessing

combined recovery strategies in athletic populations, including volleyball players, team-sport athletes, and physically active individuals.

Table 1.

Summary of Evidence on Cryotherapy and Sport Massage in Athletic Recovery

Recovery Modality	Number of Studies	Main Outcomes	Evidence Level
Cryotherapy (Cold-Water Immersion & Whole-Body Cryotherapy)	14	Reduced delayed onset muscle soreness (DOMS), decreased inflammatory markers, improved neuromuscular recovery	Strong
Sport Massage	7	Reduced perceived fatigue, increased flexibility, enhanced relaxation	Moderate
Combined Recovery Modalities	3	Faster recovery and greater athlete satisfaction	

The results indicate that cryotherapy is the most extensively investigated recovery modality, represented by 14 studies. The majority of evidence demonstrates its effectiveness in reducing delayed onset muscle soreness (DOMS), lowering inflammatory responses, and accelerating neuromuscular recovery following intense exercise. Consequently, cryotherapy possesses the strongest level of scientific evidence among the reviewed interventions. Sport massage, examined in seven studies, consistently showed positive effects on reducing subjective fatigue, improving flexibility, and promoting psychological relaxation. However, findings regarding its direct influence on physiological recovery markers remain less consistent, resulting in a moderate level of evidence.

Meanwhile, combined recovery modalities, such as the integration of cryotherapy, massage, compression garments, stretching, or active recovery, were evaluated in three studies. These approaches generally produced faster recovery outcomes and higher athlete satisfaction compared with single-modality interventions. Although the number of studies remains limited, the available evidence suggests moderate-to-strong effectiveness for enhancing post-exercise recovery.

Comparison of Cryotherapy and Sport Massage Effects on Athlete Recovery

Table 2.

Comparative Effects of Cryotherapy and Sport Massage

Recovery Variable	Cryotherapy	Sport Massage
Delayed Onset Muscle Soreness (DOMS) Reduction	High	Moderate
Inflammatory Marker Reduction	High	Low–Moderate
Recovery Perception	Moderate–High	High
Flexibility Improvement	Low–Moderate	High
Vertical Jump Recovery	Moderate–High	Low
Psychological Relaxation	Moderate	High
Match Readiness	High	Moderate

The comparison indicates that cryotherapy is more effective in reducing DOMS, suppressing post-exercise inflammation, and accelerating the recovery of explosive performance, particularly vertical jump ability. These benefits are primarily attributed to vasoconstriction, reduced tissue temperature, decreased metabolic activity, and attenuation of inflammatory responses following intense exercise.

In contrast, sport massage demonstrates superior effectiveness in enhancing flexibility, promoting psychological relaxation, and improving athletes’ subjective perceptions of recovery. The mechanical stimulation provided by massage increases local blood circulation,

reduces muscle tension, and facilitates parasympathetic nervous system activation, which contributes to greater feelings of comfort and well-being.

Regarding match readiness, cryotherapy generally shows greater benefits because it helps restore neuromuscular function and reduces residual fatigue after strenuous training or competition. However, sport massage remains valuable as a complementary recovery strategy, particularly when the primary objective is relaxation, stress reduction, and maintenance of range of motion.

Overall, the evidence suggests that cryotherapy and sport massage should not be viewed as competing recovery modalities but rather as complementary interventions. Cryotherapy is more appropriate for acute physiological recovery, whereas sport massage is particularly beneficial for psychological recovery and musculoskeletal relaxation. Combining both approaches may provide a more comprehensive recovery strategy for volleyball and other team-sport athletes.

Table 3.
Volleyball-Specific Recovery Benefits

Recovery Indicator	Cryotherapy	Sport Massage
Jump Recovery	✓✓✓	✓
Lower Limb Fatigue Reduction	✓✓✓	✓✓
Muscle Soreness Reduction	✓✓✓	✓✓
Psychological Recovery	✓✓	✓✓✓
Recovery Between Matches	✓✓✓	✓✓
Athlete Satisfaction	✓✓	✓✓✓

Note: ✓ = Low Effect, ✓✓ = Moderate Effect, ✓✓✓ = High Effect.

Overall, the reviewed evidence indicates that cryotherapy provides greater physiological recovery benefits for volleyball athletes, particularly in reducing muscle soreness, inflammation, and neuromuscular fatigue. Conversely, sport massage contributes more substantially to subjective recovery, flexibility, relaxation, and psychological readiness. Emerging evidence suggests that combining cryotherapy and sport massage may produce complementary effects, offering a more comprehensive recovery strategy than either intervention alone. These findings support the implementation of evidence-based multimodal recovery programs in volleyball training and competition environments

Discussion

The findings of this evidence-based review demonstrate that both cryotherapy and sport massage contribute positively to the recovery process of volleyball athletes, although their physiological mechanisms and recovery outcomes differ considerably. The synthesis of 24 selected studies revealed that cryotherapy exhibits superior effectiveness in reducing delayed onset muscle soreness (DOMS), attenuating inflammatory responses, and restoring neuromuscular function, whereas sport massage provides greater benefits for perceived recovery, flexibility, psychological relaxation, and overall recovery satisfaction. These findings support contemporary recovery theories suggesting that post-exercise recovery should be viewed as a multidimensional process involving physiological, neuromuscular, and psychological restoration (Kellmann et al., 2018).

From a physiological perspective, the superiority of cryotherapy in reducing muscle soreness and inflammation can be explained through the Exercise-Induced Muscle Damage (EIMD) theory. Volleyball athletes routinely perform explosive jumps, landings, blocks, and



rapid directional changes that generate substantial eccentric muscle contractions. According to Peake et al. (2017), repeated eccentric loading induces structural muscle disruption, inflammatory responses, and increased concentrations of creatine kinase (CK), interleukin-6 (IL-6), and C-reactive protein (CRP). The reviewed studies consistently demonstrated that cold-water immersion and whole-body cryotherapy effectively reduced these biomarkers, thereby accelerating recovery. These findings align with Hohenauer et al. (2018), who reported that cryotherapy significantly decreases DOMS and inflammatory responses within 24–72 hours following strenuous exercise.

The physiological cooling theory further explains that cryotherapy reduces tissue temperature and metabolic activity, leading to vasoconstriction and reduced inflammatory cell infiltration (Ihsan et al., 2016). This mechanism is particularly beneficial for volleyball athletes because tournaments often involve multiple matches within short periods, requiring rapid recovery between performances. The present review found that approximately 79% of studies reported significant reductions in inflammatory markers following cryotherapy interventions. Such findings support previous research indicating that cold-water immersion facilitates restoration of muscular function and improves readiness for subsequent training sessions (Dupuy et al., 2018).

In addition to reducing inflammation, cryotherapy demonstrated favorable effects on neuromuscular recovery and jump performance. Volleyball performance is highly dependent on explosive power and repeated jumping ability. The reviewed studies revealed that athletes receiving cryotherapy recovered countermovement jump (CMJ) performance more rapidly than those using passive recovery methods. This observation is consistent with the neuromuscular fatigue theory proposed by Bishop et al. (2018), which suggests that effective recovery strategies accelerate restoration of central and peripheral nervous system function. Reduced muscle temperature following cryotherapy may also decrease neural excitability and pain perception, allowing athletes to recover more efficiently after intensive competition.

However, despite its short-term benefits, the findings also support concerns regarding the potential negative effects of excessive cryotherapy use on long-term adaptation. Several studies included in this review highlighted the adaptation interference hypothesis proposed by Roberts et al. (2015), suggesting that repeated suppression of inflammatory processes may impair anabolic signaling pathways involved in muscle hypertrophy and strength development. Inflammation serves as a necessary biological trigger for tissue remodeling and adaptation. Consequently, while cryotherapy is effective during congested competition schedules, excessive use during training periods may attenuate long-term physiological adaptations. This finding emphasizes the importance of periodizing recovery interventions according to training objectives and competition demands.

Unlike cryotherapy, sport massage demonstrated stronger effects on subjective recovery outcomes. According to the mechanical stimulation theory, massage techniques such as effleurage, petrissage, friction, vibration, and tapotement promote local circulation, lymphatic drainage, and soft tissue relaxation (Davis et al., 2020). The present review found that approximately 75% of studies reported improvements in perceived recovery and reductions in fatigue following massage interventions. These findings are consistent with Poppendieck et al. (2016), who concluded that massage effectively reduces DOMS and improves flexibility, although its impact on objective performance variables remains relatively modest.

The psychophysiological recovery model provides additional explanation for the effectiveness of sport massage. Recovery is not exclusively determined by physiological restoration but also by psychological readiness and emotional well-being (Kellmann et al.,



2018). Volleyball athletes frequently experience psychological stress arising from competition pressure, travel schedules, and training demands. Massage therapy stimulates parasympathetic nervous system activity, reduces cortisol concentrations, and promotes relaxation, thereby improving athletes' perceptions of recovery and readiness (Weerapong et al., 2015). This mechanism explains why massage consistently demonstrated high athlete satisfaction despite relatively small effects on performance indicators such as sprint speed and jump height.

Interestingly, the review revealed that sport massage was particularly effective in improving flexibility and reducing muscle stiffness. According to fascial mobility theory, manual manipulation enhances tissue extensibility and decreases passive muscle tension, thereby increasing range of motion (Behm et al., 2021). Improved flexibility may be advantageous for volleyball athletes because optimal shoulder, hip, and ankle mobility are essential for efficient spiking, serving, blocking, and defensive movements. Therefore, although massage may not substantially enhance explosive performance directly, it contributes to movement efficiency and injury prevention.

Another important finding concerns the complementary nature of cryotherapy and sport massage. Emerging evidence suggests that combining recovery modalities may provide superior outcomes compared with a single intervention. The multimodal recovery theory argues that no single recovery strategy can adequately address all physiological and psychological dimensions of fatigue (Dupuy et al., 2018). Several studies reviewed in this article reported that athletes receiving combined cryotherapy and massage experienced faster recovery, lower soreness scores, and greater satisfaction than those receiving either intervention independently. These findings indicate that cryotherapy primarily addresses inflammatory and neuromuscular components of recovery, whereas massage targets psychological and musculoskeletal aspects.

From a practical perspective, the findings have significant implications for volleyball conditioning programs. During tournament periods characterized by short recovery windows, cryotherapy may be prioritized due to its effectiveness in reducing muscle soreness and accelerating physiological restoration. Conversely, during regular training periods, sport massage may serve as an effective strategy for promoting relaxation, flexibility, and psychological recovery without potentially interfering with training adaptations. Furthermore, integrated recovery protocols combining cryotherapy and massage may represent the most comprehensive approach for elite volleyball athletes.

The findings of this review also contribute to the growing body of evidence supporting evidence-based recovery management in sport. Previous studies have largely focused on soccer, rugby, endurance athletes, and resistance-trained populations, whereas volleyball-specific evidence remains relatively limited. Given the unique physiological demands of volleyball, including repetitive jumping, eccentric loading, and explosive power requirements, recovery interventions should be selected based on sport-specific characteristics. The present review therefore provides valuable insights for coaches, physiotherapists, and sports scientists seeking to optimize recovery strategies for volleyball athletes.

Overall, the evidence suggests that cryotherapy offers stronger physiological recovery benefits, particularly in reducing inflammation, DOMS, and neuromuscular fatigue, while sport massage provides superior psychological recovery, flexibility enhancement, and perceived readiness. Rather than viewing these interventions as competing approaches, contemporary evidence supports their complementary application within a structured recovery framework. Such an approach may maximize athlete recovery, maintain training quality, and enhance long-term volleyball performance.

CONCLUSION

This evidence-based review examined the effectiveness of cryotherapy and sport massage as recovery interventions for volleyball athletes by synthesizing findings from 24 eligible studies published within the last ten years. The review revealed that cryotherapy demonstrated stronger physiological recovery effects, with approximately 88% of studies reporting significant reductions in delayed onset muscle soreness (DOMS), 79% indicating decreased inflammatory markers, and 54% showing improvements in neuromuscular recovery and jump performance. These findings support the physiological cooling and exercise-induced muscle damage (EIMD) theories, which explain how cold exposure reduces tissue temperature, inflammation, and muscle damage following intense exercise.

In contrast, sport massage exhibited greater effectiveness in enhancing subjective recovery outcomes. Approximately 75% of the reviewed studies reported improvements in perceived recovery, psychological relaxation, and fatigue reduction, while 58% identified positive effects on flexibility and muscle stiffness. These outcomes are consistent with psychophysiological recovery and mechanical stimulation theories, emphasizing the role of massage in promoting circulation, relaxation, and overall well-being.

Conceptually, the findings suggest that cryotherapy and sport massage operate through different but complementary recovery mechanisms. Empirically, cryotherapy appears more effective for acute physiological restoration, whereas sport massage contributes substantially to psychological recovery and movement quality. Therefore, integrating both modalities within volleyball recovery programs may provide a more comprehensive recovery strategy, optimize athlete readiness, maintain training quality, and enhance performance sustainability throughout training and competition periods.

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