



Review Article

Online ISSN (3219-2789)

Post-Exercise Recovery Interventions in Competitive Athletes: A Systematic Review of Physiological and Performance Outcomes

Jeki Haryanto¹ , Dally Rahman^{2*} , Mohamad Nizam Nazarudin³ , Japhet Ndayisenga⁴ ,
Jon Mikel Picebea Arburu⁵ , Eval Edmizal¹

¹Coaching Department, Faculty of Sport Science, Universitas Negeri Padang, Padang City, Indonesia; ²Department of Medical-Surgical and Emergency Nursing, Faculty of Nursing, Universitas Andalas, Indonesia; ³Faculty of Education, Universiti Kebangsaan Malaysia, Selangor, Malaysia; ⁴Faculty of Physical education and Sports, University of Burundi, Bujumbura, Burundi; ⁵Society, Sports and Physical Exercise Research Group (GIKAFIT), Physical Education and Sport Department, Faculty of Education and Sport, University of the Basque Country (EHU), 01007 Vitoria-Gasteiz, Spain

Received: 9 July 2026; Revised: 1 October 2026; Accepted: 8 October 2026

Abstract

Background: Congested competitive calendars compress recovery between high-intensity efforts, making resolution of muscle damage, inflammation, and neuromuscular fatigue a determinant of performance and injury risk. Existing syntheses appraise modality families in isolation. **Objective:** To review post-exercise recovery interventions in competitive athletes across four domains (cryotherapy, manual therapy and compression, combined protocols, and nutritional strategies) for muscle damage markers, perceptual fatigue, and performance restoration. **Methods:** Following PRISMA 2020, Scopus was searched on 12 July 2026 (updated 10 September) for English-language studies published 2022-2026. Of 702 records, 687 were screened after deduplication, 47 were assessed in full text, and 25 were included. Quality was appraised with MMAT 2018 and AMSTAR 2. Heterogeneity precluded meta-analysis; thematic synthesis was used. **Results:** Cryotherapy, mostly cold-water immersion, was associated with reduced creatine kinase and soreness and improved neuromuscular and perceived recovery, moderated by exposure dose; network meta-analytic evidence favored 10-15°C for 10-15 min. Foam rolling and massage reduced perceived soreness; compression evidence was limited. Combined protocols outperformed single-modality comparators in all six direct comparisons, marginally in one. Nutrition was examined only within combined protocols or surveys (5 of 25 studies), and no study isolated hydration. Evidence came mainly from male team-sport athletes. **Conclusions:** Multimodal strategies appear more favorable than single-modality approaches, but without pooled estimates, these comparisons remain provisional. Priorities are sex-stratified trials, a standardized core outcome set, season-long designs, and validation of sensor-guided prescription.

Keywords: Athlete recovery; Evidence synthesis; Post-exercise recovery; Recovery strategies; Sports performance; Systematic review.

تدخلات التعافي بعد التمرين لدى الرياضيين التنافسيين: مراجعة منهجية للنتائج الفسيولوجية والأداء

الخلاصة

الخلفية: تضغط التقويمات التنافسية المزدحمة التعافي بين الجهود عالية الشدة، مما يجعل تلف العضلات والالتهاب والإرهاق العصبي العضلي عاملاً محدداً للأداء ومخاطر الإصابة. تقوم التراكيب الحالية بتقييم مجموعة الأساليب بشكل منفصل. **الهدف:** مراجعة تدخلات التعافي بعد التمرين لدى الرياضيين التنافسيين عبر أربعة مجالات (العلاج بالتبريد، العلاج اليدوي والضغط، البروتوكولات المدمجة، والاستراتيجيات الغذائية) للبحث عن علامات تلف العضلات، والإرهاق الإدراكي، واستعادة الأداء. **الطرائق:** بعد PRISMA 2020، تم البحث في Scopus في 12 يوليو 2026 (تم التحديث في 10 سبتمبر) عن دراسات باللغة الإنجليزية نشرت في الفترة 2022-2026. من بين 702 سجل، تم فحص 687 بعد إزالة التكرار، و47 تم تقييمها بالنص الكامل، و25 مدرجة مدرجة. تم تقييم الجودة باستخدام اختبار MMAT 2018 وAMSTAR 2. منع التباينات التحليل التلوي؛ تم استخدام التركيب الموضوعي. **النتائج:** ارتبط العلاج بالتبريد، الغمر في الماء البارد، بانخفاض في الكيناز كرياتين والألم وتحسن التعافي العصبي العضلي والمدرّك، مع تعديل جرعة التعرض؛ وفضلت الأدلة التحليلية الشبكية 10-15°C لمدة 10-15 دقيقة. قلة التدايلك باستخدام الرغوة والتدايلك من الألم المدرّك؛ وكانت أدلة الضغط محدودة. تفوقت البروتوكولات المدمجة على المقارنات ذات النمط الواحد في جميع المقارنات المباشرة الست، بفارق ضئيل في واحدة. تم فحص التغذية فقط ضمن بروتوكولات أو مسوحات مشتركة (5 من 25 دراسة)، ولم تهمل أي دراسة عن الترطيب. جاءت الأدلة بشكل رئيسي من رياضيين ذكور في الرياضات الجماعية. **الاستنتاجات:** تبدو الاستراتيجيات متعددة الوسائط أكثر ملائمة من الأساليب ذات النمط الواحد، لكن بدون تقديرات مجمعة تظل هذه المقارنات مؤقتة. الأولويات هي التجارب المصنفة حسب الجنس، مجموعة النتائج الأساسية الموحدة، التصميم على مدار الموسم، والتحقق من صحة الوصفات الموجهة بالمستشعرات.

*Corresponding author: Dally Rahman. Department of Medical-Surgical and Emergency Nursing, Faculty of Nursing, Universitas Andalas, Indonesia; Email: dallyrahman@nrs.unand.ac.id

Article citation: Haryanto J, Rahman D, Nazarudin Nizam MN, Arburu JMP, Edmizal E. Post-Exercise Recovery Interventions in Competitive Athletes: A Systematic Review of Physiological and Performance Outcomes. *Al-Rafidain J Med Sci.* 2026;11(2):178-189. doi: <https://doi.org/10.54133/ajms.v11i2.3245>

© 2026 The Author(s). Published by Al-Rafidain University. This is an open access journal issued under the CC BY-NC-SA 4.0 license (<https://creativecommons.org/licenses/by-nc-sa/4.0/>).



INTRODUCTION

Athletic performance depends on recovery between training sessions and competition [1,2]. High-intensity intermittent exercise, repeated sprinting, eccentric loading, and psychophysiological stress generate systemic perturbations that must be resolved to restore homeostasis [3,4], and congested fixtures leave team-sport athletes' minimal recovery between

matches [5-8]. Identifying which interventions best attenuate exercise-induced muscle damage and restore functional capacity is therefore a priority in sport medicine and exercise physiology [9,10]. Recovery encompasses glycogen restoration, resolution of inflammation, repair of ultrastructural muscle damage, clearance of lactate and reactive oxygen species, and restored neuromuscular excitability [3,11], most commonly indexed by serum creatine

kinase (CK), interleukin-6 (IL-6), C-reactive protein (CRP), blood lactate, and perceived soreness [12,13]. Inadequate recovery may produce cumulative fatigue, performance decrement, and elevated injury risk [14,15]. The evidence base comprises four intervention families. First, cryotherapy and hydrotherapy—cold-water immersion (CWI), whole- and partial-body cryotherapy, and contrast-water therapy, of which CWI is most investigated, with evidence for attenuated delayed-onset muscle soreness (DOMS) and inflammatory markers [16-18]. Second, mechanical and manual modalities—sports massage, foam rolling, and compression garments—are associated with improved lactate clearance, altered pain perception, and enhanced peripheral circulation [19-24]. Third, nutritional strategies addressing substrate and fluid status, such as carbohydrate-protein co-ingestion, antioxidant-rich beverages, and structured rehydration [25-28]. Fourth, sleep regulation and emerging technologies such as photobiomodulation, pneumatic compression, vibration, and metabolomic profiling [29-36]. These families are typically studied in isolation but applied in combination. Recent syntheses do not provide a comprehensive cross-modal account. Batista *et al.* [18] meta-analyzed CWI parameters but, examining one modality, could not address whether CWI should replace or accompany manual or nutritional strategies. Liu and Ma [37] and Yu *et al.* [38] ranked cryotherapy variants by network meta-analysis while excluding nutritional and manual arms, producing hierarchies internal to one family. Liu *et al.* [10] broadened the comparison but restricted inclusion to elite soccer, leaving transfer to combat, aquatic, or endurance contexts unresolved. Across these reviews, sport type, competitive level, sex, and training status are rarely stratified, limiting generalizability [39,40], and combined versus single-modality protocols—the configurations practitioners actually deploy—have received little systematic evaluation [41,42]. Within a 48- to 72-hour turnaround, practitioners must choose among modalities competing for the same window, and without cross-modal evidence, these decisions rest on preference and local availability rather than comparative efficacy [7,43]. A synthesis holding these interventions and their combinations within one appraisal framework is therefore required. This review consolidates evidence from 2022-2026 and appraises cryotherapy, manual therapy and compression, combined protocols, and nutritional strategies together rather than serially, stratifying by sport category so that the boundaries of each recommendation are visible. Formulated research questions include RQ1: To what extent do cryotherapy-based interventions reduce biochemical markers of muscle damage and restore physical performance in competitive athletes, and under what dosing parameters? RQ2: To what extent do manual therapy and compression-based modalities reduce delayed-onset muscle soreness and support neuromuscular recovery in competitive athletes, and through what mechanisms? RQ3: To what extent do combined multimodal protocols produce superior recovery outcomes compared with single-modality

interventions in competitive athletes, and in which competitive contexts? RQ4: To what extent do nutritional and hydration strategies contribute to physiological and performance recovery when applied alongside physical recovery modalities?

METHODS

Study design and framework

This review uses a systematic literature review (SLR) design, which minimizes selection bias through explicit inclusion and exclusion criteria and enables reproducible evidence aggregation. Reporting followed the PRISMA 2020 statement [44]; because PRISMA governs reporting completeness rather than the internal validity of included studies, methodological quality was appraised separately (see Quality assessment). The protocol was not registered in PROSPERO, which we acknowledge as a limitation.

Search strategy

The Boolean search string applied in Scopus was constructed using field codes TITLE-ABS-KEY: (("post-competition recovery" OR "post-match recovery" OR "post-exercise recovery" OR "athletic recovery" OR "sport recovery" OR "recovery intervention*" OR "recovery strategy*" OR "recovery protocol*" OR "recovery method*" OR "recovery treatment*" AND (athlete* OR player* OR sport* OR "elite athlete*" OR "competitive athlete*") AND ("cold water immersion" OR "CWI" OR cryotherapy OR massage OR "foam rolling" OR "active recovery" OR stretching OR "compression garment*" OR "contrast water therapy" OR "sleep intervention*" OR hydration OR nutrition OR protein OR carbohydrate* OR "sports drink*" OR "tart cherry juice" OR "beetroot juice" OR omega- 3) AND (fatigue OR "sport performance") OR performance OR recovery OR "muscle soreness" OR DOMS OR "muscle damage" OR "neuromuscular function" OR "physical performance" OR "physiological recovery" OR "perceptual recovery" OR "heart rate variability" OR HRV OR lactate OR "creatine kinase"))).

Information sources and rationale for database selection

Scopus was searched on 12 July 2026 and re-run on 10 September 2026, returning 702 records in total spanning 2022-2026; all bibliographic metadata derive from the exported Scopus dataset. Scopus was chosen as the sole source because it applies one curated indexing policy across the sports medicine, exercise physiology, and sports nutrition literature, supplies structured, exportable metadata enabling a reproducible screening trial, and is weighted toward Q1 Scimago-ranked journals. This constrains sensitivity: Scopus indexes fewer sport-specific serials than SPORTDiscus and does not fully overlap with MEDLINE. To estimate the magnitude, we ran a verification search of PubMed and SPORTDiscus

using the same Boolean concepts: 22 of our 25 included studies were retrievable from at least one additional database, and 3 potentially eligible records fell outside our Scopus-only strategy. Multi-database searching is recommended for subsequent work.

Eligibility criteria

Studies were eligible if they enrolled competitive athletes or physically active adults in sport-specific training, evaluated one or more post-exercise or post-match recovery interventions, and reported physiological, biochemical, perceptual, or performance recovery outcomes. Eligible designs were randomized controlled trials, crossover or

within-subject trials, prospective cohort studies, surveys of applied recovery practice, and systematic reviews or network meta-analyses. The 2022-2026 window begins after the 2021 release of PRISMA 2020, holding included syntheses to contemporary reporting standards and capturing the resumption of competitive calendars at pre-pandemic or greater density after the 2020-2021 disruption, making fixture congestion—a central concern here—an operative condition in the included studies. A scoping check of 2018-2021 records confirmed that the principal modality families were already represented in the 2022-2026 window, so no entire class of intervention is likely omitted. Full criteria are summarized in Table 1.

Table 1: Inclusion and exclusion criteria

Criterion	Inclusion	Exclusion
Language	English only	Non-English publications
Document type	Article, Review, Crossover study, Survey	Conference paper, Book chapter, Editorial, Letter
Publication period	2022-2026	Before 2022
Subject area	Sport medicine, Exercise physiology, Sports science, Nutrition in sport	Unrelated disciplines (veterinary, clinical surgery)
Accessibility	Full-text retrievable	Abstract-only; inaccessible full text
Population	Competitive athletes, physically active adults in sport-specific training	Sedentary populations, clinical patients, non-sport contexts
Intervention	Post-exercise or post-match recovery interventions	Interventions not related to post-exercise recovery
Outcome	Physiological, biochemical, or performance recovery outcomes	Outcomes unrelated to recovery

Study selection process

Records were exported from Scopus to Mendeley for deduplication and screened in Rayyan. Two reviewers independently screened all titles and abstracts and assessed full texts against the eligibility criteria; disagreements were resolved by discussion, with a third reviewer adjudicating. Cohen's κ was 0.84 in title and abstract screening and 0.83 at full-text assessment. Selection followed the four PRISMA 2020 stages (Figure 1).

ineligible document type. Of 50 reports sought, 3 could not be obtained, leaving 47 assessed in full text. Twenty-two were excluded: 4 for methodological incompatibility (insufficient outcome data or no comparison condition), 16 as out of scope (intervention not post-exercise or an ineligible population), and 2 for inaccessible full text. Twenty-five studies entered the synthesis.

Quality assessment

The Mixed Methods Appraisal Tool (MMAT, 2018) [45] was applied to the 23 primary studies, its design-specific criteria accommodating randomized, crossover, non-randomized, and quantitative descriptive designs within one framework; the two network meta-analyses were appraised with AMSTAR 2 [46]. Two reviewers appraised each study independently, resolving discrepancies by discussion. Following MMAT guidance, no study was excluded based on appraisal score; quality is reported per study and used interpretively, with lower-quality findings weighted accordingly. Of the 23 primary studies, one met four or five MMAT criteria, six met three, and 16 met two or fewer (Table 2).

Data extraction procedure

Two reviewers independently extracted data using a piloted template capturing first author and year, country, study design, sample characteristics (sport, competitive level, sex, sample size), intervention type and dose, comparator, outcome measures, and findings on recovery efficacy. Extracted data are summarized in Table 3.

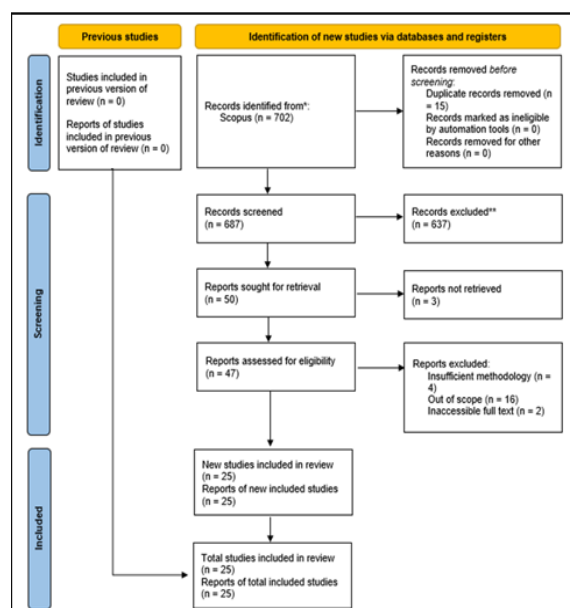


Figure 1: PRISMA 2020 Flow Diagram of Study Selection.

Identification retrieved 702 records; removing 15 duplicates left 687. Title and abstract screening excluded 637 for insufficient topical relevance or

Table 2: Methodological quality of the 25 included studies appraised with the Mixed Methods Appraisal Tool (MMAT, 2018) and AMSTAR 2

No	Study [ref], year	Design (n)	Tool	C1	C2	C3	C4	C5	Overall rating	Main limitation
1	Ningsih et al. [19], 2025	RCT (n not verified)	MMAT-2	CT	CT	CT	CT	Y	Unclear	Randomization, baseline, attrition and blinding not verifiable
2	Pereira et al. [9], 2025	RCT, parallel (n=18 analyzed of 30)	MMAT-2	Y	N	N	Y	Y	Moderate	40% attrition; arms imbalanced by sex; participants unblinded
3	Bouchiba et al. [16], 2022	Randomized crossover (n=12)	MMAT-2	CT	Y	Y	CT	Y	Moderate	Small n; randomization and assessor blinding unreported
4	Espi-López et al. [57], 2023	RCT, parallel (n=47)	MMAT-2	CT	CT	CT	CT	Y	Unclear	Unequal arms; concealment and blinding to be confirmed
5	Baseri et al. [48], 2022	Crossover, randomization not reported (n=24)	MMAT-3	Y	Y	CT	CT	Y	Moderate	Order/carry-over and confounding not addressed
6	Janusiak et al. [52], 2025	RCT, parallel (n=20)	MMAT-2	CT	CT	CT	CT	Y	Unclear	About 5 per arm; procedures not verifiable
7	Janusiak et al. [51], 2026	Randomized crossover (n=20)	MMAT-2	CT	N	Y	CT	Y	Low	Baseline differences between conditions (ANCOVA needed)
8	Sedano & Maroto-Izquierdo [54], 2025	RCT, parallel (n=22)	MMAT-2	CT	CT	CT	CT	Y	Unclear	No passive control; randomization not verifiable
9	Aben et al. [53], 2023	Randomized crossover (n=10)	MMAT-2	CT	Y	CT	CT	CT	Unclear	Nutrition and sleep-advice adherence not controlled
10	Skein et al. [49], 2025	Randomized crossover (n=10)	MMAT-2	Y	Y	CT	CT	Y	Moderate	Recreational athletes; blinding not reported
11	Braun-Trocchio et al. [1], 2022	Online survey (n=264)	MMAT-4	Y	N	CT	CT	Y	Low	Self-selected sample; response rate not reported
12	Martínez-Rodríguez et al. [60], 2025	Randomized crossover (n=11)	MMAT-2	CT	Y	Y	CT	Y	Moderate	Small n; blinding not reported
13	Pernigoni et al. [7], 2022	Online survey (n=107)	MMAT-4	Y	CT	CT	CT	Y	Unclear	Convenience sampling; instrument validation unclear
14	Barrenetxea-García et al. [59], 2025	RCT, parallel (n=27 of 34)	MMAT-2	CT	CT	N	CT	CT	Low	79% completion; 7-week adherence not verifiable
15	Boguszewski et al. [58], 2024	RCT, parallel (n=81)	MMAT-2	CT	CT	CT	N	CT	Low	Unequal arms (33/48); self-reported VAS by unblinded participants
16	Nogueira Martins et al. [30], 2026	Randomized blinded crossover (registered)	MMAT-2	Y	Y	CT	Y	Y	High	Completeness of outcome data to be confirmed
17	Boobani et al. [61], 2026	Pilot RCT (n=15)	MMAT-2	CT	CT	Y	CT	CT	Unclear	5 per arm; authors describe results as exploratory
18	Barrenetxea-García et al. [62], 2024	Online survey (n=307)	MMAT-4	Y	CT	CT	CT	Y	Unclear	Open recruitment; response rate not calculable
19	Benincasa et al. [22], 2025	Within-subject comparison (n=14)	MMAT-3	CT	Y	CT	CT	Y	Unclear	Intra-session re-oxygenation, not post-exercise recovery
20	Trybulski et al. [56], 2025	RCT, parallel (n=48)	MMAT-2	CT	CT	CT	CT	Y	Unclear	Randomization and blinding to be confirmed
21	Trybulski et al. [55], 2025	RCT, single-blind (n=36)	MMAT-2	CT	CT	CT	CT	Y	Unclear	Blinded party to be confirmed
22	Liu et al. [10], 2026	Network meta-analysis (23 RCTs)	AMSTAR 2	Critical items - 2: Y; 4: PY; 7: NV; 9: Y; 11: Y; 13: NV; 15: NV					Moderate*	Combined-modality arms excluded by design
23	Yu et al. [38], 2026	Network meta-analysis (RCTs)	AMSTAR 2	Critical items - 2: Y; 4: PY; 7: NV; 9: Y; 11: Y; 13: NV; 15: NV					Moderate*	Publication window 2014-2025; sex imbalance (~85% male)
24	Malone et al. [50], 2022	Prospective cohort, two seasons (n=16)	MMAT-3	Y	Y	CT	Y	CT	Moderate	Exposure groups formed post hoc; no passive control
25	Li et al. [43], 2025	Online survey (n=163)	MMAT-4	Y	CT	CT	CT	Y	Unclear	Coach subsample small; response rate not reported

Data analysis and synthesis

Thematic synthesis followed the three-stage method of Thomas and Harden [47]. First, the Results and Discussion sections of each study were coded line by line, the coding unit being any statement relating a recovery intervention to an outcome; one reviewer coded and a second independently verified a 30% random subsample. Second, codes were grouped into descriptive themes by iterative comparison until both reviewers agreed that every code was accommodated. Third, descriptive themes were developed into four analytical themes corresponding to the four research questions. Within each theme, findings were stratified by sport category (team, combat, aquatic, and endurance) to make the boundaries of each conclusion explicit.

Rationale for narrative rather than meta-analytic synthesis

Meta-analysis was considered but judged inappropriate for three reasons. Outcome metrics were

incommensurable: recovery was indexed by serum CK, IL-6, countermovement jump height, sprint time, pressure pain threshold, or visual analog soreness scales; none were reported by enough studies to support pooling. Dosing varied substantially within modality (immersion at 5-15°C for 3-15 min, applied from immediately to two hours post-exercise), so any pooled estimate would average physiologically distinct protocols. Several studies omitted the dispersion statistics needed for effect sizes, and selective pooling would have introduced its own bias. Thematic synthesis was therefore adopted, and comparative statements describe directions of effect rather than quantified differences.

RESULTS

The 25 included studies were published between 2022 and 2026, with volume increasing from 2025 onward (2022: n= 5; 2023: n= 2; 2024: n= 2; 2025: n= 11; 2026: n= 5). The most represented countries were Spain (n= 5), Poland (n= 5), Brazil (n= 2), China (n= 2), and the United Kingdom (n= 2). Randomized

controlled trials (n= 10) were the most prevalent design, followed by randomized crossover trials (n= 6), surveys (n= 4), network meta-analyses (n= 2),

crossover or within-subject studies without reported randomization (n= 2), and one prospective cohort study. Table 3 summarizes the included studies.

Table 3: Summary studies included

Author(s) & Year	Title	Country	Method	Key Findings
Ningsih <i>et al.</i> [19], 2025	Sport massage vs cupping: blood oxygen and lactic acid.	Indonesia	RCT	Sport massage and cupping both improved blood oxygen and lactate; no significant difference between interventions
Pereira <i>et al.</i> [9], 2025	Effectiveness of CWI vs massage in reducing DOMS after CrossFit.	Brazil	RCT	Cold-water immersion and massage similarly reduced DOMS; combined approach provided marginal additional benefit
Bouchiba <i>et al.</i> [16], 2022	CWI improves recovery of central and peripheral fatigue in soccer.	Tunisia	Randomized crossover	CWI significantly attenuated central and peripheral neuromuscular fatigue post simulated match
Espi-López <i>et al.</i> [57], 2023	Foam rolling vs manual therapy in post-exercise recovery.	Spain	RCT	Both interventions reduced soreness; manual therapy showed greater short-term pain relief
Baseri <i>et al.</i> [48], 2022	Active and CWI recovery strategies after small-sided soccer.	Iran	Crossover	CWI outperformed active recovery in restoring perceived well-being and physical readiness within 24 h
Janusiak <i>et al.</i> [52], 2025	Efficacy of recovery strategies on pain pressure thresholds in basketball.	Poland	RCT	Combined recovery (CWI + massage) improved pain pressure thresholds more than single-modality approaches
Janusiak <i>et al.</i> [51], 2026	Effects of CWI, contrast-water therapy, and active recovery on biomarkers.	Poland	Randomized crossover	Contrast-water therapy reduced CK and IL-6 most effectively compared to CWI and active recovery
Sedano & Maroto-Izquierdo [54], 2025	Effectiveness of neuromuscular recovery strategies in elite youth female football.	Spain	RCT	Compression garments combined with cold-water immersion demonstrated superior neuromuscular recovery
Aben <i>et al.</i> [53], 2023	Multimodal recovery strategy after high-intensity rugby league training.	United Kingdom	Randomized crossover	Multimodal protocol (CWI + nutrition + sleep) significantly restored performance markers vs passive recovery
Skein <i>et al.</i> [49], 2025	Cold-water recovery between rugby sevens bouts in the heat.	Australia	Randomized crossover	CWI between match bouts in hot conditions attenuated thermal strain and improved repeated sprint output
Braun-Trocchio <i>et al.</i> [1], 2022	Recovery strategies in endurance athletes: Survey.	USA	Survey	Nutrition and sleep were the most commonly used and perceived as most effective recovery tools
Martínez-Rodríguez <i>et al.</i> [60], 2025	Impact of recovery strategies on karate athletes.	Spain	Randomized crossover	Active recovery combined with nutritional supplementation produced superior biochemical and performance recovery
Pernigoni <i>et al.</i> [7], 2022	Application of recovery strategies in basketball: worldwide survey.	Global	Survey	Cold-water immersion and massage were the top-ranked recovery methods globally among basketball practitioners
Barrenetxea-García <i>et al.</i> [59], 2025	Foam rolling impact on oxidative stress and performance in water polo.	Spain	RCT	Foam rolling reduced oxidative stress markers and maintained performance across congested match periods
Boguszewski <i>et al.</i> [58], 2024	Effects of foam rolling applied to DOMS of quadriceps after Tabata.	Poland	RCT	Foam rolling reduced DOMS intensity significantly compared to passive rest at 24 and 48 h post-training
Nogueira Martins <i>et al.</i> [30], 2026	Photobiomodulation therapy vs other recovery strategies in CrossFit.	Brazil	Randomized crossover	Photobiomodulation therapy reduced CK and muscle soreness comparably to CWI with anti-inflammatory benefits
Boobani <i>et al.</i> [61], 2026	Two-week recovery strategies in martial arts athletes.	Latvia	Pilot RCT	Structured multi-week recovery protocols improved performance readiness and reduced systemic fatigue indicators
Barrenetxea-García <i>et al.</i> [62], 2024	Post-exercise recovery strategies survey in water polo.	Spain	Survey	Coaches and athletes primarily rely on passive recovery and nutrition; awareness of advanced modalities was limited
Benincasa <i>et al.</i> [22], 2025	Effects of compression garments on muscle oxygen saturation recovery.	Italy	Within-subject	Compression garments enhanced oxygen saturation recovery in upper limbs, suggesting beneficial circulatory effects
Trybulski <i>et al.</i> [56], 2025	Acute effects of pneumatic and cold compression on recovery in combat sports.	Poland	RCT	Pneumatic compression combined with cryotherapy accelerated biomechanical and functional recovery in MMA athletes
Trybulski <i>et al.</i> [55], 2025	Sports massage and BFR with cold therapy in MMA athletes.	Poland	RCT	Combined sports massage and BFR with cold therapy significantly reduced recovery time in MMA athletes post-fatigue
Liu <i>et al.</i> [10], 2026	Efficacy of post-exercise recovery strategies for elite soccer: NMA.	China	NMA	Far-infrared therapy was most effective for CMJ, intermittent negative pressure therapy for CK and portable cold compression for muscle soreness; no intervention improved 20-m sprint; combined strategies were excluded
Yu <i>et al.</i> [38], 2026	CWI protocol optimization: systematic review and NMA	China	NMA	Optimal CWI protocol varied by exercise type; 10-15 min at 10-15 °C was most effective for team-sport recovery
Malone <i>et al.</i> [50], 2022	Whole-body cryotherapy post-match recovery in elite soccer	United Kingdom	Cohort	WBC exposure duration differentially influenced post-match CK and muscle soreness in elite Premier League soccer players
Li <i>et al.</i> [43], 2025	Recovery in endurance sports: survey of coaches and athletes	Netherlands	Survey	Nutrition, sleep, and cold immersion formed the dominant recovery triad among elite endurance coaches and athletes

Findings for RQ1: Cryotherapy-Based Recovery Interventions

Cryotherapy was the most studied modality: 12 of the 23 primary studies included CWI, whole-body cryotherapy (WBC), or another cold-based condition, alone or within a combined protocol. Bouchiba *et al.* [16] showed that CWI attenuated both central and peripheral neuromuscular fatigue after simulated soccer match play, indicating effects beyond peripheral anti-inflammatory mechanisms. Baseri *et al.* [48] found CWI outperformed active recovery in restoring perceived well-being and physical readiness within 24 h of small-sided soccer games, and Pereira

et al. [9] found CWI and massage reduced DOMS to a similar extent after a CrossFit workout. Skein *et al.* [49] found that CWI between rugby sevens bouts in hot conditions attenuated thermal strain and improved repeated sprint output. Dose and modality influenced these effects. Malone *et al.* [50] found that WBC exposure duration differentially influenced post-match CK and muscle soreness in elite Premier League soccer players. Janusiak *et al.* [51] found contrast-water therapy reduced CK and IL-6 more effectively than CWI or active recovery, although baseline differences between conditions limit this comparison (Table 2). Nogueira Martins *et al.* [30] found photobiomodulation reduced CK and muscle

soreness comparably to CWI. At the synthesis level, Yu *et al.* [38] found that the optimal CWI protocol varied by exercise type, with 10-15 min at 10-15°C most effective for team-sport recovery, whereas Liu *et al.* [10] ranked far-infrared therapy, intermittent negative pressure therapy, and cold compression above CWI for jump height, CK, and soreness, respectively, in elite soccer. The cryotherapy evidence is concentrated in team sport: eight of the 12 primary studies enrolled soccer, basketball, or rugby players [16,48-54], two enrolled combat-sport athletes [55,56], and two CrossFit athletes [9,30]. The 10-15°C, 10-15 min recommendation, therefore, rests principally on repeated high-intensity running contexts and should be extrapolated cautiously to disciplines with different damage profiles.

Findings for RQ2: Manual Therapy and Compression-Based Recovery

Nine included studies that examined manual therapy or compression, three only within combined protocols [52,54,55] (see RQ3). Espí-López *et al.* [57] found foam rolling and manual therapy both reduced soreness and improved range of motion at 48 h, with manual therapy showing greater short-term pain relief. Boguszewski *et al.* [58] reported reduced DOMS intensity after foam rolling versus passive rest at 24 and 48 h post-Tabata. Barrenetxea-Garcia *et al.* [59] found foam rolling reduced oxidative stress markers and maintained performance across congested match periods in water polo players, the only aquatic intervention sample in this review. For massage, Ningsih *et al.* [19] found sports massage and cupping both improved blood oxygen and lactate without significant difference between interventions, and Pereira *et al.* [9] found massage reduced DOMS comparably to CWI. Compression evidence within the included set is limited. Benincasa *et al.* [22] found that compression garments enhanced upper-limb oxygen saturation recovery, suggesting beneficial circulatory effects, although the outcome reflected intra-session re-oxygenation (Table 2); Sedano and Maroto-Izquierdo [54] examined compression only in combination with CWI. No included study tested the mechanism through which manual therapy or compression acts.

Findings for RQ3: Combined and Multimodal Recovery Protocols

Six included studies compared combined protocols directly with single-modality comparators [9,52,54-56,60]; all six favored the combined condition, although in Pereira *et al.* [9] the additional benefit was marginal. Janusiak *et al.* [52] found that combined CWI and massage improved pressure pain thresholds more than single-modality approaches, and Sedano and Maroto-Izquierdo [54] found that compression garments combined with CWI produced superior neuromuscular recovery in elite youth female football players. Trybulski *et al.* [56] found that pneumatic compression combined with cryotherapy accelerated biomechanical and functional recovery in MMA

athletes beyond cryotherapy alone, and the same group [55] found that sports massage and blood flow restriction combined with cold therapy reduced recovery time in MMA athletes beyond any single component. Martínez-Rodríguez *et al.* [60] found that active recovery combined with nutritional supplementation produced superior biochemical and performance recovery to either component alone in karate athletes. Two further studies support this direction without a single-modality comparator. Aben *et al.* [53] found that a multimodal protocol combining CWI, nutrition, and sleep restored performance markers more fully than passive recovery, although the design cannot isolate each component. Boobani *et al.* [61] reported that structured multi-week recovery protocols improved performance readiness and reduced systemic fatigue indicators in martial arts athletes, results the authors describe as exploratory. At the synthesis level, Liu *et al.* [10] excluded combined strategies from their network and called for multi-arm trials to validate them. Because the combined conditions differ substantially in composition, dose, and timing, consistency of direction does not identify an optimal combination; it supports only the narrower claim that layering modalities with distinct mechanisms tends to outperform intensifying a single mechanism. Implementation lags the evidence. In the four included surveys, CWI and massage were the top-ranked methods among basketball practitioners [7]; nutrition and sleep were the most used and most valued tools among endurance athletes [1]; water polo players and coaches relied mainly on passive recovery and nutrition, with limited awareness of advanced modalities [62]; and nutrition, sleep, and cold immersion formed the dominant triad among elite endurance coaches and athletes, with formal recovery periodization rare [43]. Practitioners therefore relied on a few preferred modalities rather than an individualized combined plan.

Findings for RQ4: Nutritional Strategies as Recovery Adjuncts

Nutritional strategies appeared in five of the 25 included studies: as components of combined protocols in two trials [53,60] and as reported practice in three surveys [1,43,62]. No included study evaluated a nutritional or hydration intervention in isolation. Within combined protocols, active recovery with nutritional supplementation produced superior biochemical and performance recovery in karate athletes [60], and a multimodal protocol including nutrition restored performance markers more fully than passive recovery in rugby league players [53]; neither design isolates the nutritional contribution. Surveys identified nutrition as the most used recovery tool in endurance sport [1,43] and water polo [62]. The included evidence therefore shows nutrition to be widely used and compatible with favorable outcomes in combined protocols but cannot establish its independent or dose-dependent effect.

DISCUSSION

Synthesis of principal findings

Four findings emerge. Cryotherapy, particularly CWI, was the most studied modality and was associated with reduced CK and soreness and improved neuromuscular and perceived recovery, with benefit depending on exposure dose; in the one trial measuring IL-6, contrast-water therapy outperformed CWI. Manual therapy, particularly foam rolling and massage, reliably improved perceived soreness, but compression evidence was limited, and no included study tested the mechanism. Combined protocols outperformed single-modality comparators in all six direct comparisons, but the combinations were too varied to identify an optimal configuration. Nutrition was examined only within combined protocols and surveys, and hydration was excluded, so their independent contributions cannot be estimated from this evidence.

Mechanistic interpretation

The pattern across themes coheres better mechanistically than as a ranking of modalities. Cryotherapy acts through vasoconstriction, reduced tissue temperature, and attenuated inflammatory signaling; manual therapy through afferent modulation of nociception and, for foam rolling, altered motoneuron excitability; compression through venous return and interstitial pressure; and nutrition through substrate availability and redox balance. Because these pathways do not overlap, layering interventions that act on different pathways plausibly yields additive benefit [63], which may explain the advantage of combined protocols under RQ3. The hormetic stress-adaptation model qualifies this reading: the exercise-induced perturbation is not only damage to resolve but also the signal driving adaptation. Reactive oxygen species and inflammatory mediators from strenuous exercise act upstream of mitochondrial biogenesis and hypertrophic remodeling, so suppressing them may favor rapid competition readiness but attenuate adaptation when applied indiscriminately during accumulation phases [64-66]. Recovery should therefore be periodized against the training goal—a proposition the included literature supports in principle but has not been tested prospectively.

Comparison with previous syntheses and evidence outside the included set

Our conclusion that CWI benefit is protocol-dependent aligns with Batista *et al.* [18], who found that immersion parameters moderate the effect on soreness, and with the dose range identified by the included network meta-analysis of Yu *et al.* [38]. Studies outside the included set point the same way: CWI after simulated match-play reduced serum CK at 24 and 48 h versus passive recovery [67]; whole- and partial-body cryotherapy compared with CWI produced mixed findings [68,69]; the interval between

exercise and application and thermal acclimatization status moderated outcomes [70,71]; and percussive massage with CWI improved neuromuscular properties and reduced soreness in young soccer players [72], consistent with protocol-specific prescription [73]. A U-shaped dose-response for carbohydrate-protein supplementation on rowing performance [74] suggests that dose-dependency is a general principle rather than a cryotherapy-specific artifact. Liu *et al.* [10] excluded combined strategies from their network and identified them as a priority for multi-arm trials; the included trials begin to address this gap, particularly in combat sports [55,56,60]; outside the included set, a combined strategy better sustained performance across a congested basketball period during Ramadan, when nutritional and hydration timing is constrained [42]. Surveys in tennis [75] and of carbohydrate knowledge in soccer [76] suggest that knowledge, education, and accessibility barriers also limit the uptake of combined protocols. We partially disagree with Liu and Ma [37], who favored CWI for team sports and body cryotherapy for individual sports based on limited comparisons; the included studies do not clearly differentiate between types of cryotherapies. The null findings of Gustafsson *et al.* [77], a trial outside the included set, for cold- and hot-water immersion versus placebo in national-level soccer players across a season warrant analysis. Four features distinguish that trial. Its season-long design averaged the intervention across matches of varying demand, whereas positive findings typically follow a single high-damage bout; repeated in-season cold- or hot-water immersion likewise had no effect on body composition or performance in academy rugby players [78]. Participants were national-level rather than elite, with smaller match loads and less scope for detectable benefit. A credible placebo removed expectation effects. Outcomes were assessed weekly rather than at 24 and 48 h, when cryotherapy effects on CK are largest. Cryotherapy benefit, therefore, appears acute and context-dependent, and season-long averaging may be the wrong resolution for detecting it. Evidence outside the included set is consistent for manual therapy and compression and adds mechanistic detail. Foam rolling reduced CK in elite volleyball athletes [79], and its acute effects on performance and perceived fatigue have been examined in young football players [80]; sports massage benefited pain perception, recovery, and psychological well-being [81-83], and classic and lymphatic massage reduced DOMS in the rectus abdominis [84] and quadriceps femoris [85] versus passive rest. Nunes *et al.* [86] found post-massage pain reduction was not mediated by muscle stiffness or intramuscular fluid content, implicating centrally mediated mechanisms; this single study concerns massage and does not extend to compression, which acts through venous return and interstitial pressure. Compression garments improved proprioception and muscular efficacy after exercise-induced fatigue [87], moderate-pressure compression pants improved anaerobic performance and physiological recovery [23], compression socks produced acute recovery benefits between bouts [24],

and a user-centered compression sleeve showed preliminary efficacy for hamstring soreness in female NCAA athletes [88]. Nutrition is a growing focus of recovery research [89], but its evidence lies largely outside the included set. Carbohydrate-protein co-ingestion immediately post-exercise is consistently identified as a priority for glycogen resynthesis and attenuation of the cortisol response [4,27,90,91], and nutritional intervention improved post-competition recovery indices when combined with structured training [92]. Antioxidant-rich beverages attenuated exercise-induced oxidative stress [25,93-95]: short-term beetroot juice enhanced strength, reduced fatigue, and promoted biomarker recovery in a randomized double-blind crossover trial [25]; pomegranate juice reduced CK in collegiate volleyball players [96]; and cherry juice and chocolate milk supported football performance and recovery when consumed per recommended protocols [95]. Hydration management also influenced recovery [97-100]: training type differentially affected hydration status and performance [99], ad libitum hydration during ultra-trail events was associated with muscle and liver damage markers and electrolyte imbalance [97], and alkaline water with L-glutamine enhanced salivary alpha-amylase activity and testosterone in boxing athletes [98]. These studies provide context for, not evidence within, this synthesis.

Sources of heterogeneity

Five sources of heterogeneity limit cross-study precision. Immersion dose ranged from 5 to 15°C and 3 to 15 min. Timing ranged from immediately to two hours post-exercise, a window across which the inflammatory response changes substantially. Training status spanned from recreational to elite international levels, with correspondingly different baseline damage profiles. Samples were skewed heavily male, and the few enrolling female athletes did not standardize their menstrual cycle phase. Outcome instruments differed even for shared constructs, with soreness indexed by the visual analog scale, pressure pain threshold, or algometry.

Practical implications

The evidence supports context-specific prescription. The configurations below are starting points supported by evidence for their components, not validated composite protocols. For congested team-sport fixtures (≤ 72 h turnaround): CWI at 10-15°C for 10-15 min immediately post-exercise [38]; carbohydrate-protein co-ingestion within 1-3 h (≈ 1.0 - 1.2 g/kg/h carbohydrate with 0.3 g/kg protein over 4 h) [74,90]; and next-day sports massage (15-20 min) or foam rolling, with overnight compression garments [24,57,58], to restore sprint and jump capacity before the next fixture. In combat sport with acute weight-making: staged rehydration with electrolyte replacement before any cold exposure [97,98], then structured refeeding with cryotherapy deferred until euhydration; the next day, pneumatic compression with cryotherapy [56] or massage with blood flow

restriction [55]. In endurance events with high substrate depletion, extrapolating from evidence outside the included set: prioritize carbohydrate replacement over cold exposure [4,27], adding a nitrate- or polyphenol-rich beverage if oxidative stress is the target [25,96]; next day, active recovery with compression, avoiding routine cryotherapy during adaptation phases [66], so glycogen is resynthesized without blunting the adaptive signal. The doses cited are those tested in primary studies, not pooled optima, and no included trial evaluated these configurations as composites. Survey evidence [7,43,62] shows that practitioners rely on a few preferred modalities, so implementation planning belongs in protocol design.

Research gaps

Four gaps are consequential. First, sex-stratified research is nearly absent, so recommendations from male samples are applied to female athletes without evidence; because the menstrual cycle phase may influence recovery [39,40], the direction of any sex difference cannot be assumed. Second, the absence of a standardized core outcome set prevents pooling and cross-modal comparison. Third, habitual recovery use is untested long-term: under the hormetic model, routine post-training cryotherapy could attenuate adaptation across a season while improving acute readiness, a trade-off resolvable only by season-long randomized designs with adaptation outcomes. Fourth, wearable biosensors and multi-omics profiling attract enthusiasm but little prospective validation [101,102]; no included study tested whether sensor-guided prescription outperforms a fixed protocol.

Answers to the research questions

In direct response: cryotherapy, most consistently CWI, appears to be the best-supported single modality for reducing muscle damage markers and restoring neuromuscular and perceived recovery, contingent on dose, with the 10-15°C, 10-15 min range derived mainly from team-sport evidence (RQ1). Foam rolling and massage reliably reduce perceived soreness, whereas included evidence for compression is limited and its mechanism untested (RQ2). Combined protocols outperformed single-modality comparators in all six direct comparisons, half of them in combat sport, although no optimal composition can yet be specified (RQ3). Nutrition was only studied in combined protocols and surveys, so its independent and dose-dependent effects, as well as those of hydration, cannot be determined from the evidence (RQ4).

Strengths

This review has three methodological strengths. It is, to our knowledge, the first to appraise cryotherapy, manual therapy and compression, combined protocols, and nutritional strategies within a single eligibility and appraisal framework, permitting cross-modal comparison that single-family reviews cannot support. Screening, extraction, and quality appraisal

were conducted independently in duplicate, with inter-rater agreement reported. Finally, stratifying the synthesis by sport category clearly indicates the specific population to which each conclusion applies, rather than leaving the applicable population implied.

Study Limitations

Six limitations qualify these findings. The search was Scopus-only; verification in PubMed and SPORTDiscus retrieved 22 of 25 included studies but identified 3 potentially eligible records outside our strategy, so selection bias is possible. English-language inclusion may have omitted relevant work. The protocol was not prospectively registered, so methodological deviations cannot be verified independently. Heterogeneity in outcome metrics, dosing, and assessment timing precluded meta-analysis; comparative statements therefore describe direction, not magnitude, and remain provisional. Samples skewed toward male athletes and team and combat sports, leaving transferability to female athletes and to endurance, racket, and aquatic disciplines uncertain, and no included study isolated a nutritional or hydration intervention. Finally, methodological quality varied: most trials lacked assessor blinding, and few reported a priori power calculations, so several synthesized findings rest on limited internal validity.

Future Prospects

Future research should prioritize four directions: sex-stratified randomized controlled trials recording menstrual cycle phase and contraceptive use; a standardized core outcome set pairing unified biomarker panels (CK, IL-6, CRP) with validated perceptual and performance indices to enable meta-analysis; season-long designs quantifying the hormetic trade-off between acute readiness and adaptation; and prospective validation of sensor-guided prescription, using wearable biosensors and multi-omics profiling, against fixed protocols.

Conclusion

Multimodal recovery appears to outperform single-modality approaches, with benefit depending more on dose and timing than on the intervention chosen. Cryotherapy, typically CWI at 10–15 °C for 10–15 min, remains the best-supported single intervention for attenuating muscle damage and restoring performance, although the evidence derives mainly from team sports. Foam rolling and massage reduce soreness, whereas included evidence for compression is limited; nutrition contributed to favorable outcomes only within combined protocols. CK responded to cryotherapy, perceived soreness to manual therapy and cold, and performance most consistently to combined modalities acting on different mechanisms. Because heterogeneity precluded pooling, these findings indicate direction only. Coaches should sequence complementary interventions periodized to training goals, since suppressing inflammation may

favor competition readiness over adaptation, and clinicians should dose and time recovery with pharmacological precision. Future research should prioritize sex-stratified trials, a standardized core outcome set, season-long designs, and validation of sensor-guided methods against fixed prescriptions. Recovery should be deliberate, not habitual.

Conflict of interests

The authors declared no conflict of interest.

Funding source

The authors did not receive any source of funds.

Data sharing statement

All data analyzed in this review are derived from publicly available published studies.

REFERENCES

- Braun-Trocchio R, Graybeal AJ, Kreutzer A, Warfield E, Renteria J, Harrison K, et al. Recovery strategies in endurance athletes. *J Funct Morphol Kinesiol*. 2022;7(1):22. doi: 10.3390/jfmk7010022.
- George P, Vasiliki M, Ioannis I, Christina K, Christos K. Athletic recovery in modern football: from physiology to applied practice. *Int J Hum Mov Sports Sci*. 2025;13(4):784–792. doi: 10.13189/saj.2025.130414.
- Liu X, Liu J. Research progress on exercise fatigue from the perspective of fatigue biomarkers. *PeerJ*. 2026;14:e20424. doi: 10.7717/peerj.20424.
- Mohr M, Vigh-Larsen JF, Krstrup P. Muscle glycogen in elite soccer - a perspective on the implication for performance, fatigue, and recovery. *Front Sports Act Living*. 2022;4:876534. doi: 10.3389/fspor.2022.876534.
- Soler-López A, Gómez-Carmona CD, Moreno-Villanueva A, Gutiérrez AM, Pino-Ortega J. Effects of congested matches and training schedules on salivary markers in elite futsal players. *Appl Sci*. 2024;14(12):4968. doi: 10.3390/app14124968.
- Mihailescu L, Chiriac PB, Mihailescu LE, Manolachi V, Potop V. Determining the capacity for effort and recovery of the elite soccer players specialized in different playing positions. *PeerJ*. 2023;11:e15477. doi: 10.7717/peerj.15477.
- Pernigoni M, Conte D, Calleja-González J, Boccia G, Romagnoli M, Ferioli D. The application of recovery strategies in basketball: A worldwide survey. *Front Physiol*. 2022;13:887507. doi: 10.3389/fphys.2022.887507.
- Vachon A, Berryman N, Mujika I, Paquet JB, Sauvet F, Bosquet L. Impact of tapering and proactive recovery on young elite rugby union players' repeated high intensity effort ability. *Biol Sport*. 2022;39(3):735–743. doi: 10.5114/BIOLOSPORT.2022.109453.
- Pereira GS, Paulino GE, De Almeida THMF, Siqueira CMR, Torres Da Silva JR, Da Silva ML, et al. Effectiveness of cold-water immersion vs. massage in reducing delayed-onset muscle soreness and enhancing recovery following CrossFit® Murph Workout: Randomized trial. *PLoS One*. 2025;20(8):e0329892. doi: 10.1371/journal.pone.0329892.
- Liu J, Li Q, Han Y. Efficacy of post-exercise recovery strategies for elite soccer players: a network meta-analysis. *Front Physiol*. 2026;17:1760392. doi: 10.3389/fphys.2026.1760392.
- Maculewicz E, Mastalerz A, Garbacz A, Mróz A, Stastny P, Petr M, et al. The interactions between monocarboxylate transporter genes MCT1, MCT2, and MCT4 and the kinetics of blood lactate production and removal after high-intensity efforts in elite males. *BMC Genomics*. 2025;26(1):133. doi: 10.1186/s12864-025-11307-4.
- Fenni Y, Ikiouane M, Kettab K, Remini H, Zaabar S. Post-match changes in biomarkers and fatigue-related physical performance parameters in adult amateur soccer players. *BMC*

- Sports Sci Med Rehabil.* 2026;18(1):226. doi: 10.1186/s13102-026-01642-8.
13. Slimani M, Ghouili H, Dhahbi W, Farhani Z, Ben Aissa M, Souaifi M, et al. Position-specific biomarker responses to match vs. VAMEVAL test modalities in elite female soccer players. *Cogent Soc Sci.* 2025;11(1):2447399. doi: 10.1080/23311886.2024.2447399.
 14. Kreher JB, Stepanek J, Amrine R, Reddy S. Overtraining syndrome (OTS) in three endurance athletes and roads to recovery. *BMJ Case Rep.* 2025;18(7):e265066. doi: 10.1136/bcr-2025-265066.
 15. Belinchón-deMiguel P, Ramos-Campo DJ, Clemente-Suárez VJ. Physiological, biomechanical, and thermographic responses in male athletes during an ultra-endurance race. *Appl Sci.* 2024;14(15):6511. doi: 10.3390/app14156511.
 16. Bouchiba M, Bragazzi NL, Zarzissi S, Turki M, Zghal F, Grati MA, et al. Cold water immersion improves the recovery of both central and peripheral fatigue following simulated soccer match-play. *Front Physiol.* 2022;13:860709. doi: 10.3389/fphys.2022.860709.
 17. Zhang W, Ren S, Zheng X. Effect of 3 min whole-body and lower limb cold water immersion on subsequent performance of agility, sprint, and intermittent endurance exercise. *Front Physiol.* 2022;13:981773. doi: 10.3389/fphys.2022.981773.
 18. Batista NP, de Carvalho FA, Machado AF, Micheletti JK, Pastre CM. What parameters influence the effect of cold-water immersion on muscle soreness? An updated systematic review and meta-analysis. *Clin J Sport Med.* 2023;33(1):13-25. doi: 10.1097/JSM.0000000000001081.
 19. Ningsih YF, Kristiyandaru A, Nurhayati F, Nurpratiwi R, Aimkosa R, Winarno ME, et al. Sport massage vs cupping: which one is more effective in improving blood oxygen level and reducing lactic acid? *Polish J Physiother.* 2025;2025(1):48-56. doi: 10.56984/8ZG007DAVFB.
 20. Rusdiawan A, Widodo A, Lani A, Özman C, Putra AY, Susanto N, et al. The impact of ice compression and massage techniques on lactate removal and interleukin-6 concentrations during halftime recovery in intermittent sports. *Physical Educ Theory Methodol.* 2025;25(5):1033-1041. doi: 10.17309/tmfv.2025.5.01.
 21. Mahendra WD. The effect of sports massage therapy on fitness recovery of female soccer athletes. *Rehabil Recreat.* 2025;19(1):139-146. doi: 10.32782/2522-1795.2025.19.1.13.
 22. Benincasa MT, Coiro F, Coppola S, Serra E, Celentano E, Costa C, et al. Effects of compression garments on muscle oxygen saturation recovery in the upper limbs using near-infrared spectroscopy. *J Funct Morphol Kinesiol.* 2025;10(3):317. doi: 10.3390/jfmk10030317.
 23. Li Q, Che K, Yu W, Song W, Zhou Y. Effects of compression pants with different pressure levels on anaerobic performance and post-exercise physiological recovery. *Sensors (Basel).* 2025;25(15):4875. doi: 10.3390/s25154875.
 24. Leabeater A, Clarke A, James L, Huynh M, Driller M. Evaluating the acute effect of compression socks for recovery between exercise bouts. *J Hum Sport Exerc.* 2023;18(4):820-832. doi: 10.14198/jhse.2023.184.07.
 25. Salem A, Ammar A, Kerkeni M, Boujelbane MA, Uyar AM, Köbel LM, et al. Short-term beetroot juice supplementation enhances strength, reduces fatigue, and promotes recovery in physically active individuals. *Nutrients.* 2025;17(10):1720. doi: 10.3390/nu17101720.
 26. Ferrara L, D'Angelo S. Post-exercise fatigue, lactate, and natural nutritional strategy. *J Phys Educ Sport.* 2023;23(9):2274-2283. doi: 10.7752/jpes.2023.09261.
 27. Dhiman C, Kapri BC. Optimizing athletic performance and post-exercise recovery: The significance of carbohydrates and nutrition. *Monten J Sports Sci Med.* 2023;19(2):49-56. doi: 10.26773/mjssm.230907.
 28. Ramírez-Munera M, Arcusa R, López-Román FJ, Ávila-Gandía V, Pérez-Piñero S, Muñoz-Carrillo JC, et al. Impact of chronic nitrate and citrulline malate supplementation on performance and recovery in Spanish professional female soccer players. *Nutrients.* 2025;17(14):2381. doi: 10.3390/nu17142381.
 29. Kim YS, Kwak JJ, Park HG, Lee WL, Lee KJ. Vibration-based recovery interventions improve perceived fatigue, blood lactate clearance, and isokinetic muscle function following exercise-induced fatigue in amateur swimmers. *Appl Sci.* 2026;16(9):4245. doi: 10.3390/app16094245.
 30. Nogueira Martins PHG, Tomazoni SS, Monteiro Machado CDS, Pereira AL, Pinto HD, Aguiar Lino MM, et al. A randomised crossover trial comparing photobiomodulation therapy with other recovery strategies in CrossFit athletes. *PLoS One.* 2026;21(5):e0349880. doi: 10.1371/journal.pone.0349880.
 31. Trybalski R, Kuźdzał A, Bichowska-Pawęska M, Vovkanych A, Kawczyński A, Biolik G, et al. Immediate effect of cryo-compression therapy on biomechanical properties and perfusion of forearm muscles in mixed martial arts fighters. *J Clin Med.* 2024;13(4):1177. doi: 10.3390/jcm13041177.
 32. Leduc C, Weaving D, Owen C, Ramirez-Lopez C, Chantler S, Aloulou A, et al. The effect of acute sleep extension vs active recovery on post exercise recovery kinetics in rugby union players. *PLoS One.* 2022;17(8):e0273026. doi: 10.1371/journal.pone.0273026.
 33. Douzi W, Bon D, Dupuy O, Beuzen F, Dugué B. 1H NMR urinary metabolomic analysis in recreational athletes: Impact of physical exercise, high intensity interval training and whole body cryostimulation. *Comput Struct Biotechnol J.* 2025;27:1913-1926. doi: 10.1016/j.csbj.2025.05.007.
 34. dos Santos SN, Ananias GEO, da Rocha ER Jr, Carmo AC, Bento EDS, de Aquino TM, et al. NMR-based metabolomics reveals position-specific signatures associated with physical demands in professional soccer players. *Biomedicines.* 2025;13(11):2583. doi: 10.3390/biomedicines13112583.
 35. Yang J, Xiong Y, Piao J, Leung M, Liu G, Zhu M, et al. Wearable fluidic fabric with excellent heat transfer performance for sports recovery. *Adv Sci (Weinh).* 2025;12(8):2411691. doi: 10.1002/advs.202411691.
 36. Wrześniewski K, Pałka T, Blecharz J. The influence of vibratory massage after physical exertion on selected psychological processes. *Front Psychol.* 2024;15:1380282. doi: 10.3389/fpsyg.2024.1380282.
 37. Liu S, Ma Y. Effects of cold water immersion vs body cryotherapy on delayed onset muscle soreness and jump performance: A systematic review and meta-analysis. *Medicine (Baltimore).* 2026;105(4):e46781. doi: 10.1097/MD.00000000000046781.
 38. Yu T, Liu Y, Ding C, Wang S, Wan Y, Fei X, et al. Cold water immersion protocol optimization across exercise modalities: a systematic review and network meta-analysis. *BMC Sports Sci Med Rehabil.* 2026;18(1):216. doi: 10.1186/s13102-026-01653-5.
 39. Silva AF, Trybalski R, Trybek G, Moska W, Aidar FJ, González-Fernández FT. Impact of the menstrual cycle on physical recovery after small-sided games: A crossover study in women's soccer players. *J Sports Sci Med.* 2025;24(3):532-542. doi: 10.52082/jssm.2025.532.
 40. Benito PJ, Alfaro-Magallanes VM, Rael B, Castro EA, Romero-Parra N, Rojo-Tirado MA, et al. Effect of menstrual cycle phase on the recovery process of high-intensity interval exercise. *Int J Environ Res Public Health.* 2023;20(4):3266. doi: 10.3390/ijerph20043266.
 41. Marín-Galindo A, Perez-Bey A, Escudier-Vázquez JM, Velázquez-Díaz D, Calleja-González J, Vaz-Pardal C, et al. Acute effects of nutritional and physical recovery strategies on exercise performance, muscle damage, and fatigue in elite basketball players. *Life (Basel).* 2026;16(2):275. doi: 10.3390/life16020275.
 42. Brini S, Yagin FH, Gonzalez JC, Badicu G, Teles SDG, Gonzalez JR, et al. The effects of a combined recovery strategy during a match-congested period crossing Ramadan among professional male basketball players. *J Mens Health.* 2025;21(3):11-23. doi: 10.22514/jomh.2025.032.
 43. Li S, Kempe M, Lemmink KAPM. Recovery strategies in endurance sports: A survey in coaches and athletes. *Int J Sports Physiol Perform.* 2025;20(1):120-130. doi: 10.1123/ijsp.2024-0032.
 44. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ.* 2021;372:n71. doi: 10.1136/bmj.n71.
 45. Hong QN, Fàbregues S, Bartlett G, Boardman F, Cargo M, Dagenais P, et al. The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Educ Inf.* 2018;34(4):285-291. doi: 10.3233/EFI-180221.
 46. Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, et al. AMSTAR 2: a critical appraisal tool for systematic

- reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ*. 2017;358:j4008. doi: 10.1136/bmj.j4008.
47. Thomas J, Harden A. Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Med Res Methodol*. 2008;8:45. doi: 10.1186/1471-2288-8-45.
 48. Baseri MK, Reisi J, Bagheri R, Clemente FM. Effects of active and cold-water immersion recovery strategies on perceived well-being and physical readiness after small-sided soccer games. *Hum Mov*. 2022;23(3):120-129. doi: 10.5114/hm.2022.107979.
 49. Skein M, Hunter J, Carney A. Cold-water recovery between bouts of simulated rugby sevens matches in the heat. *J Therm Biol*. 2025;134:104333. doi: 10.1016/j.jtherbio.2025.104333.
 50. Malone JJ, Hodges D, Roberts C, Sinclair JK, Page RM, Allan R. Effect of alterations in whole-body cryotherapy (WBC) exposure on post-match recovery markers in elite Premier League soccer players. *Biol Sport*. 2022;39(1):31-36. doi: 10.5114/BIOLOSPORT.2021.102931.
 51. Janusiak M, González-Fernández FT, Leão C, Smoter M, Kisilewicz A, Klich S, et al. Effects of cold-water, contrast-water therapy, and active recovery on blood biomarkers and pain in basketball players. *Biomed Hum Kinet*. 2026;18(1):148-162. doi: 10.2478/bhk-2026-0018.
 52. Janusiak M, Silva RM, González Fernández FT, Smoter M, Kisilewicz A, Klich S. Efficacy of recovery strategies on pain pressure thresholds in basketball players. *Retos*. 2025;65:569-578. doi: 10.47197/retos.v65.110201.
 53. Aben HGJ, Hills SP, Higgins D, Cooke CB, Davis D, Jones B, et al. The efficacy of a multimodal recovery strategy implemented after a high-intensity rugby league training session. *J Strength Cond Res*. 2023;37(8):1634-1642. doi: 10.1519/JSC.0000000000004450.
 54. Sedano S, Maroto-Izquierdo S. Effectiveness of different neuromuscular recovery strategies in elite youth female football players. *Sports (Basel)*. 2025;13(2):36. doi: 10.3390/sports13020036.
 55. Trybulski R, Rocznik R, Olaniszyn G, Svyshch Y, Vovkanych A, Wilk M. Sports massage and blood flow restriction combined with cold therapy accelerate muscle recovery after fatigue in mixed martial arts athletes. *J Funct Morphol Kinesiol*. 2025;10(2):194. doi: 10.3390/jfink10020194.
 56. Trybulski R, Klich S, Valera-Calero JA, Kawczyński A, Fernández-de-Las-Peñas C, Kuźdzał A. Effect of pneumatic and cold compression on muscle performance and recovery in combat sports athletes. *Sci Rep*. 2025;15(1):44993. doi: 10.1038/s41598-025-29014-1.
 57. Espi-López GV, Ruescas-Nicolau MA, Castellet-García M, Suso-Martí L, Cuenca-Martínez F, Marques-Sule E. Effectiveness of foam rolling vs. manual therapy in postexercise recovery interventions for athletes: A randomized controlled trial. *J Strength Cond Res*. 2023;37(6):e361-e368. doi: 10.1519/JSC.0000000000004383.
 58. Boguszewski D, Krawczyk A, Dębek M, Adamczyk JG. The effects of foam rolling applied to delayed-onset muscle soreness of the quadriceps femoris after Tabata training. *Biomed Hum Kinet*. 2024;16(1):203-209. doi: 10.2478/bhk-2024-0021.
 59. Barrenetxea-García J, Busto N, Calleja-González J, Villarreal ESD, Perazzetti A, Nuell S, et al. The impact of foam rolling recovery tool on oxidative stress biomarkers and performance in water polo players. *J Exerc Rehabil*. 2025;21(3):140-150. doi: 10.12965/jer.2550170.085.
 60. Martínez-Rodríguez A, López-Plaza D, Nadal-Nicolás Y, Sánchez-Sánchez J, Leyva-Vela B, Cuestas-Calero BJ, et al. Impact of recovery strategies on physiological and performance parameters in karate athletes: a randomized crossover study. *Sport Sci Health*. 2025;21(4):2993-3005. doi: 10.1007/s11332-025-01509-4.
 61. Boobani B, Grants J, Saulite S, Jakubovskis G, Zusa A, Bernans E, et al. Two-week recovery strategies to enhance performance readiness in martial arts athletes: A pilot study. *Sports (Basel)*. 2026;14(2):46. doi: 10.3390/sports14020046.
 62. Barrenetxea-García J, Perazzetti A, Nuell S, Mielgo-Ayuso J, de Villarreal ES, Calleja-González J. Perceptions and use of recovery strategies in water polo players and coaches: a worldwide survey. *J Exerc Rehabil*. 2024;20(3):112-123. doi: 10.12965/jer.2448214.107.
 63. Millour G, Lepers R, Coste A, Hausswirth C. Effects of combining cold exposure and compression on muscle recovery: a randomized crossover study. *Front Physiol*. 2025;16:1598075. doi: 10.3389/fphys.2025.1598075.
 64. Sarikaya M, Öge B, Embiyaoglu NM, Selçuk M, Çınar V, Öner S, et al. The acute effects of simulated hypoxic training at different altitudes on oxidative stress and muscle damage in elite long-distance runners. *PeerJ*. 2025;13(5):e19338. doi:10.7717/peerj.19338.
 65. Isola V, Hulmi JJ, Mbay T, Kyröläinen H, Häkkinen K, Ahola V, et al. Changes in hormonal profiles during competition preparation in physique athletes. *Eur J Appl Physiol*. 2025;125(2):393-408. doi: 10.1007/s00421-024-05606-z.
 66. Horgan BG, West NP, Tee N, Halson SL, Drinkwater EJ, Chapman DW, et al. Effect of repeated post-resistance exercise cold or hot water immersion on in-season inflammatory responses in academy rugby players. *Eur J Appl Physiol*. 2024;124(9):2615-2628. doi: 10.1007/s00421-024-05424-3.
 67. Alexander J, Carling C, Rhodes D. Utilisation of performance markers to establish the effectiveness of cold-water immersion as a recovery modality in elite football. *Biol Sport*. 2022;39(1):19-29. doi: 10.5114/BIOLOSPORT.2021.103570.
 68. Haq A, Ribbans WJ, Hohenauer E, Baross AW. The comparative effect of different timings of whole body cryotherapy treatment with cold water immersion for post-exercise recovery. *Front Sports Act Living*. 2022;4:940516. doi: 10.3389/fspor.2022.940516.
 69. Naylor AS, Edwards BJ, Robertson CM. Effects of treatment dosage of whole-body cryotherapy upon post-match recovery of endocrine and biochemical markers in elite rugby league players. *Health Sci Rep*. 2023;6(4):e1227. doi: 10.1002/hsr2.1227.
 70. Zhou Z, Su Y, Wu Y, Qin F, Zheng X. The effects of cold water immersion and partial body cryotherapy on subsequent exercise performance and thermoregulatory responses in hot conditions. *J Therm Biol*. 2024;123:103926. doi: 10.1016/j.jtherbio.2024.103926.
 71. Panyakham A, Pariwat P. Effect of cold water immersion during half time on body recovery in soccer player. *J Phys Educ Sport*. 2022;22(3):749-756. doi: 10.7752/jpes.2022.03094.
 72. Buoite Stella A, Dragonetti AM, Fontanot S, Sabot R, Martini M, Galmonte A, et al. The acute effects of cold water immersion and percussive massage therapy on neuromuscular properties and muscle soreness after exercise in young male soccer players. *Sports (Basel)*. 2024;12(6):167. doi: 10.3390/sports12060167.
 73. Feng C, Chen P, Zhang W, Luo B, Du G, Liao T, et al. An evidence-based approach to selecting post-exercise cryostimulation techniques for improving exercise performance and fatigue recovery. *Heliyon*. 2024;10(11):e32196. doi: 10.1016/j.heliyon.2024.e32196.
 74. Wang X, Wu H. A U-shaped dose-response of carbohydrate-protein supplementation on rowing performance. *Front Nutr*. 2025;12:1651457. doi: 10.3389/fnut.2025.1651457.
 75. Viboh V, Kokić IS, Novak D. The use of recovery methods in professional and recreational tennis players. *Coll Antropol*. 2023;47(1):31-37. doi: 10.5671/ca.47.1.4.
 76. Hannon MP, Carter JL, North M, Cole M, Morton JP. Fuel-90: validation of a questionnaire to assess players' knowledge of carbohydrate guidelines for soccer. *Sport Sci Health*. 2025;21(3):1953-1964. doi: 10.1007/s11332-025-01424-8.
 77. Gustafsson J, Montiel-Rojas D, Romare MGA, Johansson E, Folkesson M, Pernigoni M, et al. Cold- and hot-water immersion are not more effective than placebo for the recovery of physical performance and training adaptations in national level soccer players. *Eur J Appl Physiol*. 2025;125(11):3179-3194. doi: 10.1007/s00421-025-05835-w.
 78. Horgan BG, Halson SL, Drinkwater EJ, West NP, Tee N, Alcock RD, et al. No effect of repeated post-resistance exercise cold or hot water immersion on in-season body composition and performance responses in academy rugby players. *Eur J Appl Physiol*. 2023;123(2):351-359. doi: 10.1007/s00421-022-05075-2.
 79. Zhang X, Li X, Wu Z, Li X, Zhang G. Deciphering recovery paradigms: Foam rolling's impact on DOMS and lactate dynamics in elite volleyball athletes. *Heliyon*. 2024;10(7):e29180. doi: 10.1016/j.heliyon.2024.e29180.

80. Bibić E, Barišić V, Katanić B, Chernozub A, Trajković N. Acute effects of foam rolling and stretching on physical performance and self-perceived fatigue in young football players. *J Funct Morphol Kinesiol*. 2025;10(1):36. doi: 10.3390/jfink10010036.
81. Pa WAMW, Nazarudin MN, Nasir MFM. Supporting learning sustainability in university sport: effects of structured sports massage on mental toughness and psychological well-being. *Int J Learn Teach Educ Res*. 2026;25(3):116-132. doi: 10.26803/ijlter.25.3.6.
82. Avandi RI, Rochmania A, Nirwansyah WT, Mustar YS, Arisanti RRS, Pramono BA, et al. Optimization of athlete recovery strategies: Analysis of massage methods to determine the best approach after high-intensity interval training. *Retos*. 2024;57:125-130. doi: 10.47197/retos.v57.103963.
83. Dakić M, Ilić V, Toskić L, Duric S, Šimenko J, Marković M, et al. Acute effects of short-term massage procedures on neuromechanical contractile properties of rectus femoris muscle. *Medicina (Kaunas)*. 2024;60(1):125. doi: 10.3390/medicina60010125.
84. Boguszewski D, Kaaroud C, Adamczyk J. Assessment of the effect of classic sports massage on the reduction of delayed onset muscle soreness in the rectus abdominis. *Balt J Health Phys Act*. 2025;17(1):9. doi: 10.29359/BJHPA.17.1.09.
85. Boguszewski D, Kaminska M. Evaluation of the effect of lymphatic massage on delayed onset muscle soreness reduction of the quadriceps femoris. *Rehabilitacja Medyczna*. 2025;29(1):17-23. doi: 10.5604/01.3001.0055.1351.
86. Nunes GS, Guterres BD, Diel AP, Machado ACO, Da Rosa NK, dos Santos Turchetto V, et al. Pain reduction following massage after induced fatigue is not mediated by changes in muscle stiffness or intramuscular fluid content. *J Athl Train*. 2025;60(10):737-745. doi: 10.4085/1062-6050-0074.25.
87. Hong WH, Lo SF, Wu HC, Chiu MC. Effects of compression garment on muscular efficacy, proprioception, and recovery after exercise-induced muscle fatigue onset. *PLoS One*. 2022;17(2):e0264569. doi: 10.1371/journal.pone.0264569.
88. Megivern S, Gorea A. Addressing hamstring muscle soreness in female NCAA athletes: design and evaluation of a user-centered compression sleeve for recovery. *Fash Text*. 2026;13(1):21. doi: 10.1186/s40691-026-00471-0.
89. Bahri S, Adnyana IK, Hasan MF, Ray HRD, Paramitha ST. Science mapping for nutrition education in sports recovery research: A bibliometric analysis. *Int J Educ Math Sci Technol*. 2022;10(4):795-811. doi: 10.46328/ijemst.2620.
90. Sampson G, Morton JP, Areta JL. Mind the gap: Limited knowledge of carbohydrate guidelines for competition in an international cohort of endurance athletes. *J Nutr Sci*. 2023;12:e68. doi: 10.1017/jns.2023.49.
91. Zhang J, Chen J, Sui X, Drenowatz C, Wang Q. Association between different types of exercise and intake of nutrients including carbohydrate, fat, protein, and B vitamins in young adults. *Nutrients*. 2023;15(4):806. doi: 10.3390/nu15040806.
92. Chang B, Yangyang L. Effects of sports training associated with nutritional intervention on athletes' post-competition recovery. *Rev Bras Med Esporte*. 2023;29:e2022-0739. doi: 10.1590/1517-8692202329012022_0739.
93. Nojumi M, Kakhki AH, Sardar MA, Jafari A, Esfehiani AJ, Rezvani R. Beetroot plus vitamin C for performance and recovery: Protocol of a double-blind, placebo-controlled, randomized crossover trial in semi-professional wrestlers. *Health Sci Rep*. 2026;9(5):e72218. doi: 10.1002/hsr2.72218.
94. Kerrou NS, Guendouze N, Remini H, Lakhdara N, Zaabar S. Effects of beetroot and pomegranate juice supplementation on creatine kinase and C-reactive protein in amateur soccer players. *North Afr J Food Nutr Res*. 2025;9(20):271-286. doi: 10.51745/najfnr.9.20.271-286.
95. Morgans R, Lee D, Di Virgilio T, Ryan B, Oliveira R. A comprehensive review of the effects of cherry juice and chocolate milk supplementation on football performance and recovery. *J Phys Educ Sport*. 2024;24(5):1249-1265. doi: 10.7752/jpes.2024.05143.
96. Rezaei G, Hemmatinafar M, Willems MET, Mastouri D, Imanian B, Rezaei R. Individual responses to pomegranate juice on recovery from exercise-induced muscle damage in collegiate male volleyball players. *J Int Soc Sports Nutr*. 2026;23(1):2642149. doi: 10.1080/15502783.2026.2642149.
97. García-Giménez A, Pradas F, Lecina M, Ochiana N, Castellar-Otín C. Impact of ad libitum hydration on muscle and liver damage and electrolyte balance in ultra-trail events. *Biology (Basel)*. 2025;14(2):136. doi: 10.3390/biology14020136.
98. Lu TL, He CS, Suzuki K, Lu CC, Wang CY, Fang SH. Concurrent ingestion of alkaline water and L-glutamine enhanced salivary alpha-amylase activity and testosterone concentration in boxing athletes. *Nutrients*. 2024;16(3):454. doi: 10.3390/nu16030454.
99. Demirkan E, Tosun Mİ, Kaplan A, Ayrancı M, Cosmin DG, Arıcı M, et al. Post-training breakdown: acute effects of different training types on body hydration status and performance. *Front Psychol*. 2024;15:1528840. doi: 10.3389/fpsyg.2024.1528840.
100. Dobashi S, Kobayashi T, Tanaka Y, Shibayama Y, Koyama K. Effects of carbohydrate-electrolyte dissolved alkaline electrolyzed water on physiological responses during exercise under heat stress. *Curr Res Physiol*. 2022;5:389-398. doi: 10.1016/j.crphys.2022.09.007.
101. Hassanmirzaei B, Schumacher Y, Tabben M, Bahr R. Developing a data-driven multimodal injury and illness prevention programme in male professional football. *BMJ Open Sport Exerc Med*. 2024;10(4):e002101. doi: 10.1136/bmjsem-2024-002101.
102. Wenzel C, Kolodziej M, Lippelt L, Laux P, Millard M, Kipper K, et al. High frequency saliva-based targeted MultiOmics as screening tool in professional soccer. *Dtsch Z Sportmed*. 2026;77(1):7-14. doi: 10.5960/dzsm.2025.650.