

Enhancing Recovery in Soccer: A Scoping Review on Nutritional and Supplementation Strategies

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Purpose: This scoping review aimed to synthesize and map the evidence on nutritional and supplementary strategies used to enhance postexercise recovery in soccer players. Specifically, it sought to (1) identify effective interventions across physical, physiological, perceptual, and biochemical outcomes; (2) describe methodological designs; and (3) highlight research gaps for future investigation. **Methods:** Following Cochrane and PRISMA-ScR guidelines, 4 databases (PubMed, Web of Science, Scopus, SportDiscus) were searched without date limits. Eligible studies included randomized controlled trials involving adult soccer players (≥ 18 y) that examined nutritional or supplementary interventions administered within 72 hours postmatch or after an exercise-induced muscle damage protocol. Data extraction, synthesis, and a risk-of-bias assessment were performed independently by 2 reviewers. **Results:** Eleven studies ($n = 135$ players) met inclusion criteria. Interventions included carbohydrates, proteins (casein, whey, and milk protein), tart cherry juice, curcumin, caffeine, and ketones. The most frequently assessed outcomes were physical (jumping, sprinting, and strength) and perceptual (muscle soreness, and well-being), while biochemical and physiological measures were less common. Curcumin ($500 \text{ mg} \cdot \text{d}^{-1}$) and presleep casein supplementation (40 g) demonstrated beneficial effects on physical and perceptual recovery markers up to 36 hours postmatch in professional soccer players. In contrast, carbohydrates, caffeine, and milk protein showed inconsistent or negligible effects. Most studies (82%) presented a high risk of bias, small sample sizes, and heterogeneous methodologies. **Conclusions:** Current evidence on nutritional and supplementary recovery strategies in soccer is limited and methodologically weak. Curcumin and casein show the most promise for enhancing short-term recovery. Future research should include well-controlled trials with standardized protocols, larger samples, and inclusion of female players to inform evidence-based recovery nutrition in soccer.

Keywords: postmatch recovery, dietary supplements, soccer performance, adult players

The increased frequency of professional soccer matches has led to congested fixture schedules.^{1,2} For instance, the winner of the UEFA Champions League 2023–2024, Real Madrid, played 57 matches during the 10-month competitive season (August to May). This includes 38 matches in La Liga, 13 in the UEFA Champions League, 2 in the Spanish Cup, and 2 in the Spanish Super Cup

(<https://fbref.com/en/>). Not surprisingly, the physical, technical, and tactical demands of the best competitive leagues are actually higher compared to few years ago.^{3,4} Consequently, an effective recovery in soccer is central for repairing muscle damage, optimizing performance, allowing adaptations, reducing fatigue, and reestablishing the energy stores.^{5,6} Soccer physiologists are thus responsible for implementing an effective and science-based recovery strategies.⁶ A worldwide survey conducted over 13 countries and including 80 soccer practitioners found that most frequently used strategies were active recovery, structured recovery day, extra rest day, massage, cold-water therapy, and carbohydrates supply.⁷

Two reviews have highlighted that various strategies can effectively promote recovery and enhance performance outcomes including compression garments, cold water immersion, sleep hygiene, partial body cryotherapy, hyperbaric oxygen therapy, and vibratory therapies.^{8,9} More recently, a review of 39 randomized and nonrandomized studies assessed the effectiveness of recovery methods across different outcomes (physical, physiological, and perceptual) up to 72 hours postmatch in both male and

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female soccer players. The authors provided graded recommendations, identifying cold water immersion and massage as particularly effective strategies for improving perceptual outcomes.¹⁰ The mentioned review highlights that only 3 studies were identified regarding specific nutritional interventions: whey protein,¹¹ semi-skimmed milk,¹² and a combination of whey protein with carbohydrates.¹³ The methodological quality of the studies varied from 35.7% to 56.1%, indicating moderate to low rigor. Consequently, the authors stated that there is currently no solid scientific evidence to draw definitive conclusions about the effects of these nutritional interventions on recovery or the enhancement of physical performance. Meanwhile, the search strategy employed in the Querido et al¹⁰ review only included the term “nutrition,” which is limited for identifying studies related to sport foods or supplements that may enhance the recovery process (eg, carbohydrates, protein, omega-3, sodium bicarbonate).

Reviews focusing on nutritional strategies to enhance performance and optimize recovery were primarily narrative, aiming to describe the effects of sports, foods, and supplements. For example, the narrative review by Naderi et al¹⁴ emphasizes the positive effects of carbohydrates on glycogen replenishment and subsequent improvements in performance. It also highlights the roles of protein, omega-3 fatty acids, antioxidants, and sodium bicarbonate in reducing muscle damage. However, this review did not differentiate the main findings based on the type of sport. Another narrative review by Heaton et al¹⁵ provides an overview of the main effects of micronutrients, antioxidants, and supplements on recovery outcomes in team sport participants. Nevertheless, the findings from this review cannot be exclusively generalized to soccer. A structured scoping review focusing on effective nutritional and supplementary strategies that enhance recovery and subsequent exercise performance in soccer is needed. Additionally, this type of review would allow for a comprehensive description of methodological issues within the current literature, identifying limitations and gaps in existing studies, and guide researchers in developing more effective recovery interventions. It could also inform nutritionists about the most evidence-based strategies to optimize recovery.¹⁶

Since previous reviews on recovery have tended to overlook nutritional and supplementation-related strategies or have not specifically focused on adult elite soccer players, the aims of this scoping review were to: (1) bridge the gap between science and practice by identifying effective nutritional and supplementation strategies associated with physical, physiological, perceptual, and biochemical recovery outcomes; (2) describe the methodological designs used in the existing literature; and (3) identify directions for future research.

Methods

The present review was conducted in accordance with the methodological standards established by the Cochrane guidelines,¹⁷ the PRISMA guidelines,¹⁸ and the PRISMA extension for scoping reviews.¹⁹ The protocol was registered on the Open Science Framework platform and is available for consultation elsewhere (doi:10.17605/OSF.IO/XWRGJ).

Eligibility Criteria

The inclusion criteria were based on the Participants, Intervention, Comparator, Outcomes, and Study design (PICOS) framework:

Participants: Adult soccer players (≥18 y old). No restrictions were applied regarding competitive level or sex.

Intervention: Nutritional or supplementary interventions administered within 72 hours after a soccer match, soccer protocol, or exercise-induced muscle damage protocol.

Comparator: Control or placebo groups. Studies that did not allocate participants into at least 2 groups were excluded.

Outcomes: Physical outcomes (eg, velocity, strength, total distance covered); physiological outcomes (eg, heart rate); perceptual outcomes (eg, rate of perceived exertion); and biochemical outcomes (eg, creatine kinase levels).

Study design: Parallel-group or crossover randomized controlled trials.

Information Sources and Search Strategy

A comprehensive search was conducted across 4 electronic databases—Web of Science, PubMed, Scopus, and SportDiscus—using the following search strategy: (soccer OR football) AND (recovery OR “subsequent exercise performance” OR fatigue OR congested) AND (nutrition OR supplement OR carbohydrate OR protein OR fluid OR electrolyte OR “sodium bicarbonate” OR creatine OR caffeine OR “omega 3” OR “eicosapentaenoic acid” OR “docosahexaenoic acid” OR micronutrient OR “tart cherry” OR beetroot OR “vitamin E” OR “vitamin D” OR “vitamin C” OR curcumin OR antioxidant OR nitrate). The detailed search strategies for each database are provided in [Supplementary Material S1](#) (available online). Additionally, the same search strategy was applied with the inclusion of terms such as “AND (review OR meta-analysis)” to identify studies meeting the eligibility criteria. To enhance the review process, the titles of reference lists of included studies were consulted. All selected studies were checked for errata and corrections. No filters were applied regarding publication date, and studies written in English, Portuguese, and Spanish were included in this review.

Selection Process

A reference management software, EndNote 21.0 (Clarivate), was used to extract the records. The software also facilitated the removal of duplicates and management of the remaining records. After using EndNote to eliminate duplicates, a manual confirmation was performed by 2 authors. The remaining records were initially screened by 2 authors based on the abstracts. Subsequently, full-text assessments were conducted to evaluate eligibility according to predefined criteria. Studies that did not meet these criteria were excluded from the review. The screening and inclusion processes were carried out by two researchers (Martinho/Clemente), and in cases of disagreement, a third author (Sarmento) was consulted to reach a consensus.

Data Extraction and Items

The necessary information from each study was organized into a Microsoft Excel spreadsheet. Two authors independently conducted this process. The data extracted from each study included: country, competitive level, sample size, protocol used to induce muscle damage, supplement type, form, dosage, timing of ingestion, and effects on physical, physiological, perceptual, and biochemical outcomes. When relevant information was not available in the manuscripts, we contacted the corresponding authors via email, LinkedIn, or ResearchGate for clarification. Studies for which relevant data could not be obtained, despite attempts to contact the corresponding authors, were excluded to ensure the

accuracy and consistency of the data extraction process. Although this procedure may introduce a potential selection bias, it was considered necessary to avoid assumptions or estimations based on incomplete reporting. To extract data from figures, we used a specialized software called GetData Graph Digitizer, which is effective for collecting means and standard deviations from graphical representations (getdatagraph-digitizer.software.informer.com). This tool has been validated for extracting data from visual representations.²⁰

Risk of Bias

The revised Cochrane Risk of Bias tool for randomized trials (RoB 2.0) was used to analyze the risk of bias in the randomized studies included in this review.²¹ The tool consists of 5 domains, each with specific questions: (1) Bias arising from the randomization process; (2) Bias due to deviations from intended interventions; (3) Bias due to missing outcome data; (4) Bias in measurement of the outcome; (5) Bias in the selection of the reported result. Based on an algorithm, responses to these questions were classified as “yes,” “probably yes,” “probably no,” “no,” or “no information,” which allowed each domain to be categorized as having low risk of bias, some concerns, or high risk of bias. The overall risk of bias for each study was also determined using the tool guidance. The robvis tool was employed to create risk-of-bias plots.²² Two independent authors (Martinho/Clemente) completed the RoB 2.0 assessments, and any disagreements were resolved through consultation with an author (Sarmiento).

Data Synthesis Methods

We conducted a narrative synthesis study purpose and methods. Quantitative data (mean [SD]) for preintervention and postintervention outcomes were extracted from each study. To provide an overview of current research on nutritional and supplemental strategies to enhance recovery in soccer and to highlight research gaps, we developed an evidence map showing study country, type of nutritional or supplemental strategy, and outcome categories, stratified by competitive level.

Results

Study Identification and Selection

The search across 4 databases yielded 2247 records. Of these, 1150 duplicates were removed prior to screening, leaving 1097 records based on titles and abstracts. After screening, 1027 records were excluded, resulting in 25 studies for full-text review. Fifteen studies were excluded for the following reasons: (1) 8 studies used nutritional or supplementary interventions only before the exercise-induced muscle damage protocol; (2) 5 studies examined interventions for more than 72 hours postexercise; (3) one study involved team sports players; and (4) one study did not report physical, physiological, technical, tactical, perceptual, or biochemical outcomes. Ten studies were initially included in this review. Reviewing the reference lists of previous reviews and the included studies allowed to identify one additional study. In total, 11 studies met the eligibility criteria and were analyzed for this review (Figure 1).

Study Characteristics

Our review includes 135 soccer players across 11 studies, with sample sizes ranging from 6 to 22 players. Ten studies focused

specifically on male soccer players.^{11,13,23–30} One study included both male and female players.³¹ The players were classified as professional (5 studies; 45%), semiprofessional (1 study; 10%), recreational, or amateur (2 studies; 18%). Two studies (18%) did not specify the competitive level.

As summarized in Table 1, regarding nutritional and supplementary interventions, 2 studies examined the effects of carbohydrate diets,^{26,28} while one study investigated the benefits of chocolate milk on recovery outcomes.³¹ Two studies investigated the impact of protein on physical, perceptual, and biochemical outcomes.^{11,29} The remaining studies focused on tart cherry juice,²³ casein,²⁴ curcumin,²⁵ carbohydrate,²⁷ caffeine,²⁷ and ketone.³⁰ Finally, one study tested the effects of a high carbohydrate diet with whey protein on physiological and biochemical outcomes.¹³

Intervention Characteristics

The exercise-induced muscle damage protocol involved a soccer match or training sessions in 5 and 3 studies, respectively. Two studies used the Loughborough Intermittent Shuttle Test, while 2 studies employed a treadmill protocol to induce fatigue before supplementation. Additionally, one study induced mental fatigue. Approximately 45% of the studies utilized nutritional or supplementary strategies in the form of drinks. Table 2 also includes details on the dosage and composition of these nutritional and supplementary interventions.

Results of Individual Studies

Physical Outcomes

The jumping performance (squat jump, countermovement jump, and reactive strength index) was examined in 5 randomized trials to assess the impact of nutritional or supplementary interventions on recovery^{23–25,27,29} as summarized in [Supplementary Material S2](#) (available online). Concerning tart cherry juice, jumping performance decreased 12 hours postexercise, with no significant differences observed between the placebo and tart cherry juice supplementation.²³ After ingesting 40 g of casein presleep, countermovement jump performance was attenuated until 36 hours postexercise, while the reactive strength index improved at 36 hours postexercise.²⁴ Ingesting curcumin immediately after, as well as 12 and 36 hours following a soccer match, improved jumping performance up to 60 hours postmatch.²⁵ The effect of 3 dosages of 80 g of milk protein concentrate did not differentiate between protein and placebo trials.²⁹ The combined effects of carbohydrates and caffeine are negligible after the application of Loughborough Soccer Passing test and a repeated sprint test.²⁷ Linear velocity, assessed through 10-m, and 30-m sprint times, was measured before and after the implementation of an exercise-induced muscle damage protocol in one study.²⁹ The effects of milk protein on 10-, 20-, and 30-m sprint times were not observable. Strength outputs were assessed through isokinetic dynamometry.²⁹ The effects of milk protein on isokinetic dynamometry outcomes were not observed. Time to fatigue was reduced after consuming chocolate milk in male soccer players, while no significant differences were observed for female players.³¹ The combination of caffeine and carbohydrates yielded results comparable to a placebo in the Loughborough Soccer Passing Test, as well as in best and total sprint times.²⁷ Additionally, time to fatigue, number of sprints, and distance covered did not differ between carbohydrate meals with different glycemic index values.²⁸

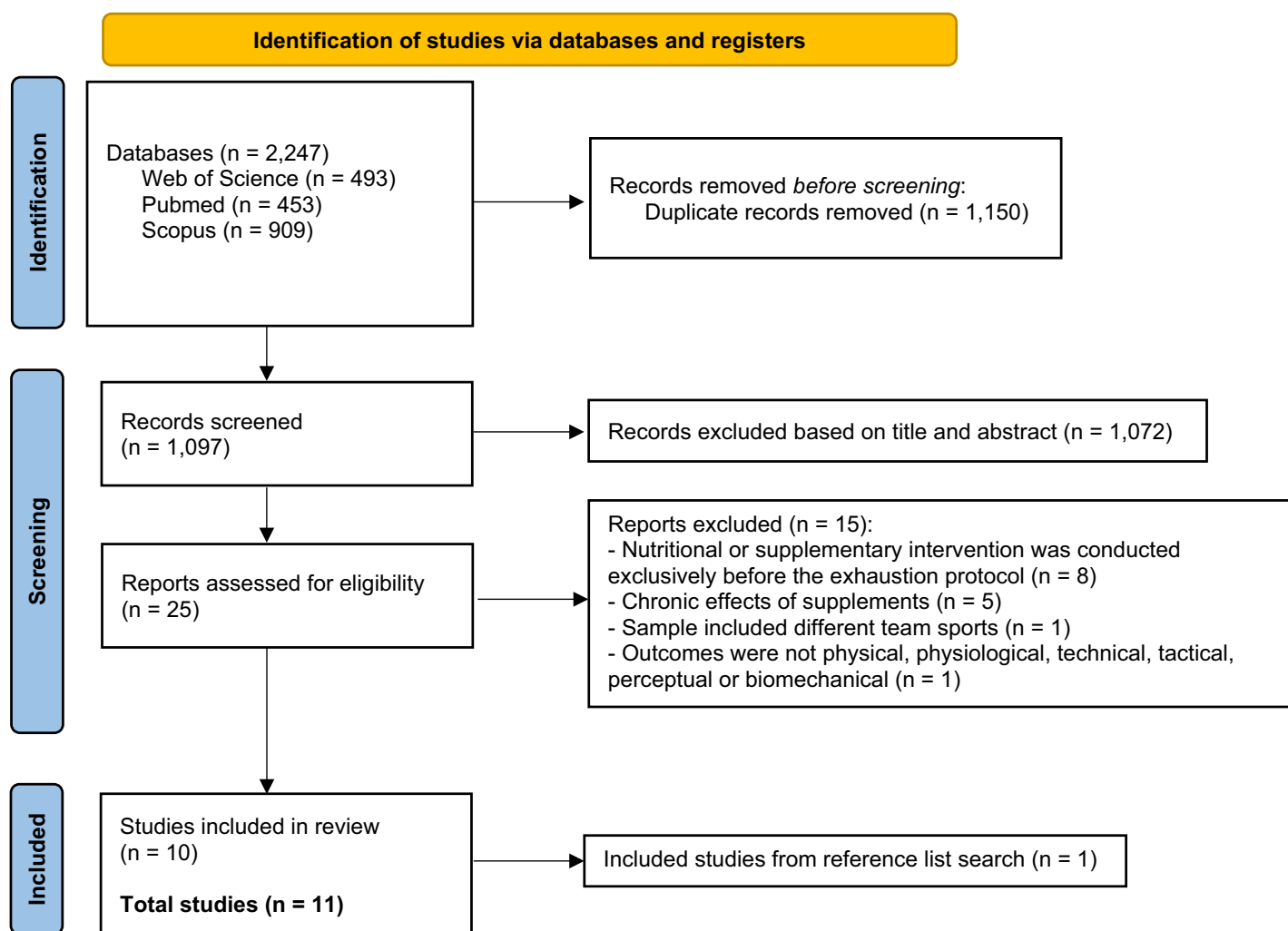


Figure 1 — Flow chart diagram identifying the screening process and the studies included in the present scoping review.

Table 1 Characteristics of the Studies Included in the Present Review, Supplement or Nutritional Strategy Implemented, and Type of Outcomes

Study	N	Sex	Country	Competitive level	Supplement/ nutritional strategy	Outcome
Abbot et al ²³	10	M	England	Professional	Tart cherry juice	Physical, perceptual
Abbot et al ²⁴	10	M	England	Professional	Casein	Physical, perceptual
Abbot et al ²⁵	11	M	England	Professional	Curcumin	Physical, perceptual
Abt et al ²⁶	6	M	Australia	Recreational	Carbohydrate diet	Technical, biochemical
Andrade-Souza et al ²⁷	11	M	Brazil	Amateur	Carbohydrate, caffeine	Physical, physiological, perceptual
Erith et al ²⁸	7	M	England	Semiprofessional	Carbohydrate diet	Physical, biochemical
Gunnarsson et al ¹³	19	M	Denmark	Professional	Carbohydrate diet, whey protein	Biochemical
Poulios et al ²⁹	17	M	Greece	Professional	Milk protein	Physical, biochemical perceptual
Quinones and Lemon ³⁰	9	M	Canada	Recreational	Ketone	Biochemical, perceptual
Spaccarotella and Andzel ³¹	13	M/F	United States	NR	Chocolate milk	Physical, perceptual
Mor and Ipekoglu ¹¹	22	M	Turkey	NR	Whey protein	Biochemical

Abbreviations: F, female; M, male; NR, not reported.

Table 2 Types of Exercise-Induced Muscle Damage Protocols and Characteristics of Nutritional and Supplementary Interventions

Study	Exercise-induced muscle damage protocol	Supplement/nutritional intervention	Form	Dosage	Composition
Abbot et al ²³	Soccer match	Tart cherry juice	Gel	30 mL	94 kcal, 22 g CHO, ~0 g PRT, ~0 g FAT
Abbot et al ²⁴	Soccer match	Casein	Drink	40 g	NR
Abbot et al ²⁵	Soccer match	Curcumin	Capsule	500 mg	NR
Abt et al ²⁶	Intermittent Treadmill Test	CHO	Diet	80%	80% CHO, 10% PRT, 10% FAT
Andrade-Souza et al ²⁷	Loughborough Intermittent Shuttle Test	Caffeine, CHO	Caffeine: NR CHO: liquid	Caffeine: 6 mg kg ⁻¹ CHO: 1.2 g kg ⁻¹	Caffeine: NA CHO: maltodextrin
Erith et al ²⁸	Loughborough Intermittent Shuttle Test	CHO	Diet	72%	72% CHO, 17% PRT, 11% FAT
Gunnarsson et al ¹³	Simulated Soccer match	PRT, CHO	PRT: Drink CHO: Diet	PRT: 500 mL CHO: 71%	71% CHO, 21% PRT, 8% FAT
Poulios et al ²⁹	Training session, soccer match	Milk PRT	Drink	25–30 g	25 g PRT: 133 kcal, 4.7 g CHO, 1.6 g FAT 30 g PRT: 160 kcal, 5.6 g CHO, 1.9 g FAT
Quinones and Lemon ³⁰	Mental fatigue task	Ketone	Drink	125 mL	NR
Spaccarotella and Anzel ³¹	Training session	Chocolate milk	Drink	~615 mL	160 kcal, 27 g CHO, 8 g PRT, 3 g FAT
Mor and Ipekoglu ¹¹	Incremental ergometer test	PRT	Drink	300 mL	30 g PRT

Abbreviations: CHO, carbohydrates; FAT, fat; NA, not applicable; NR, not reported; PRT, protein.

Perceptual Outcomes

Delayed-onset muscle soreness was investigated in 4 studies^{23–25,29} as summarized in [Supplementary Material S3](#) (available online). Supplementation with tart cherry juice,²³ casein,²⁴ curcumin,²⁵ and milk protein²⁹ was found to reduce muscle soreness. However, comparisons of tart cherry juice, casein, and milk protein against control or placebo trials did not demonstrate statistically significant differences. Curcumin was significantly effective in reducing delayed-onset muscle soreness immediately and at 12 or 24 hours postexercise, respectively. The well-being questionnaire was used in 3 studies^{23–25} to assess postmatch recovery. The effects of tart cherry juice and casein on well-being were not observed, whereas curcumin improved well-being 12 hours after the muscle damage protocol. There was no observed effect of carbohydrates combined with caffeine²⁷ or chocolate milk³¹ on the rate of perceived exertion.

Biochemical Outcomes

[Supplementary Material S4](#) (available online) presents the effects of nutritional and supplementary interventions on biochemical outcomes. Creatine kinase was used as a biochemical marker in 3 studies,^{11,13,29} while lactate dehydrogenase was assessed in one study.¹¹ The combination of a high-carbohydrate diet and whey protein showed no significant effect on recovery.¹³ Additionally, creatine kinase was, on average, reduced in both milk²⁹ and whey protein¹¹ trials compared to placebo following a soccer match.

Technical and Physiological Outcomes

Two studies investigated the effects on physiological outcomes (blood lactate),^{13,26} while another examined technical outcomes (shooting accuracy).¹³

Risk of Bias

The risk of bias in the included studies is illustrated in Figures 2 and 3. Figure 2 presents the risk of bias assessed across each domain for individual studies, while Figure 3 shows the percentage of studies categorized as low, moderate, or high risk of bias.

Regarding the first domain (bias arising from the randomization process), 8 studies provided no information about the methods used to generate the allocation sequence.^{11,13,26–31} The details regarding how interventions were allocated to participants were not reported in these studies. As a result, a high risk of bias in this domain was noted in 8 studies (~73%).

In the second domain (bias due to deviations from intended interventions), 5 studies were rated as “some concerns.”^{11,13,26,28,31} In the studies by Abt et al²⁶ and Mor and Ipekoglu,¹¹ blinding of athletes and researchers was not performed. In Erith et al,²⁸ the blinding of the researchers delivering the intervention was not described. Gunnarsson et al¹³ did not provide sufficient information regarding the blinding of researchers and soccer players. For these studies, question 2.3 (“Were there deviations from the intended intervention that arose because of the trial context?”) was marked as “no information.” Consequently, 45% of the studies were rated with some concerns in this domain, while 55% were classified as low risk of bias.

In the third domain (bias due to missing outcome data), one study was rated with some concerns,²⁹ one with a high risk of bias,³¹ and 9 with a low risk of bias. In the studies by Spaccarotella and Andzel³¹ and Poulios et al,²⁹ less than 95% of data from players was available after randomization, and no bias correction or sensitivity analyses were conducted. In both studies, the missingness in the outcomes was dependent on the loss to follow-up. However, the question 3.4 (“Is it likely that missingness in the outcome depended on its true value?”) was answered as “yes” for

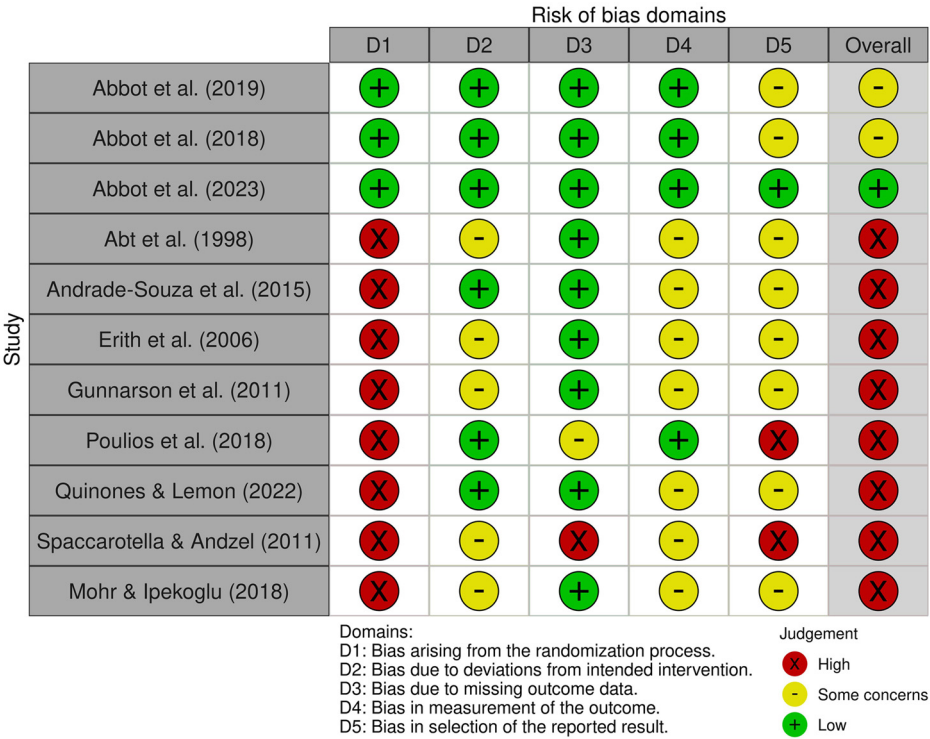


Figure 2 — Risk of bias assessment for each study using the ROB 2.0 tool.

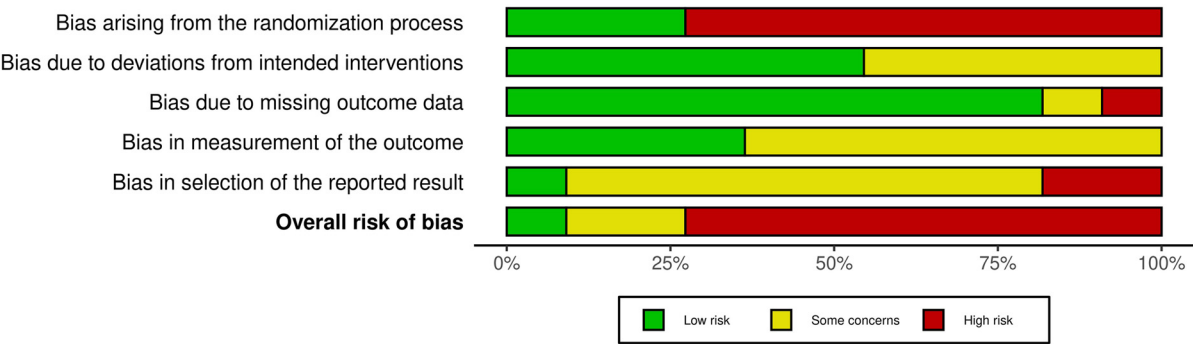


Figure 3 — Percentage of studies classified as low risk, some concerns, and high risk of bias for each domain and overall assessment.

the study by and “no” for Poulios et al²⁹ The study by Spaccarotella and Andzel³¹ did not clarify whether the players were excluded before or after the randomization process, which could potentially bias the differences observed between the intervention and comparator groups regarding the outcome.

In domain 4 (risk of bias in measurement of outcome), 7 studies were rated as having some concerns, while 4 were judged to have a low risk of bias. In 7 studies, it was not specified whether the outcome assessors were blinded. The assessment of outcomes in 5 could have been affected by the assessors’ knowledge of the intervention received, whereas in 2 studies,^{11,13} the knowledge of assessors did not impact the biomarker outcomes.

In the fifth domain (risk of bias in the selection of the reported result), only 3 studies reported a prespecified analysis plan.^{25,29,30} One study used multiple outcomes within the strength domain,²⁹ and another study reported different methods of data analysis without a registered trial.³¹ Consequently, in this domain, 2 studies

were rated as high risk of bias,^{29,31} one study was rated as low risk of bias,²⁵ and the remaining studies were classified as having some concerns.

Overall risk of bias was classified as some concerns in 2 studies (18%) and high risk in 10 studies (82%).

Evidence Gap Map

Only one study included female soccer players. Figure 4 illustrates the types of outcomes used to investigate the effects of nutritional or supplementary interventions on recovery in soccer players, organized by competitive level. Among professional soccer players, physical and perceptual outcomes were assessed in 4 studies, while no studies included technical or physiological outcomes. In the remaining competitive levels (semiprofessional and amateur), there was a negligible percentage of studies that used physical, technical and physiological outcomes.

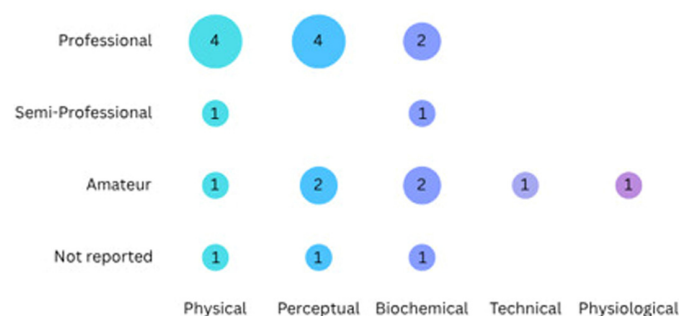


Figure 4 — Evidence gap map of the interaction between type of recovery outcomes and competitive level.

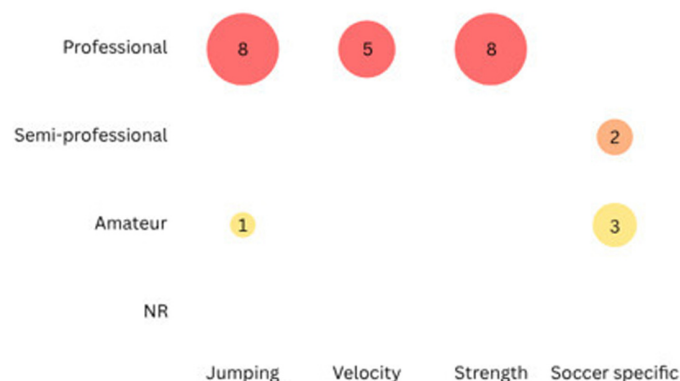


Figure 5 — Evidence gap map of the interaction between physical outcomes and competitive level. *Note.* NR, competitive level was not reported.

Within the physical outcomes, the number of outcomes related to performance assessment at the professional level is presented in Figure 5. Eight outcomes focused on jumping performance (countermovement jump, squat jump, and reactive strength index) and strength (maximal voluntary contraction, knee extension concentric movement for both legs, and knee flexion eccentric movement for both legs). Additionally, 5 physical outcomes related to soccer-specific activity were observed at the semiprofessional and recreational levels, including Loughborough Soccer Passing Test time, best time, total passing time, distance covered, and number of sprints.

Delayed onset of muscle soreness and well-being scales were mentioned 11 and 3 times, respectively, in studies of professional soccer players. Creatine kinase levels were reported in 3 studies of professional soccer players. At other competitive levels, the use of perceptual and biochemical indicators to investigate recovery was negligible (Figures 6 and 7).

Discussion

Recognizing the importance of nutrition in enhancing recovery after soccer matches, our review aims to describe the evidence-supported nutritional and supplementary interventions used by soccer players. We also highlight some limitations within the studies included and provide suggestions for future research. We reveal a substantial heterogeneity in the nutritional and supplementary interventions applied to soccer players across different competitive levels. The effects of these interventions on recovery

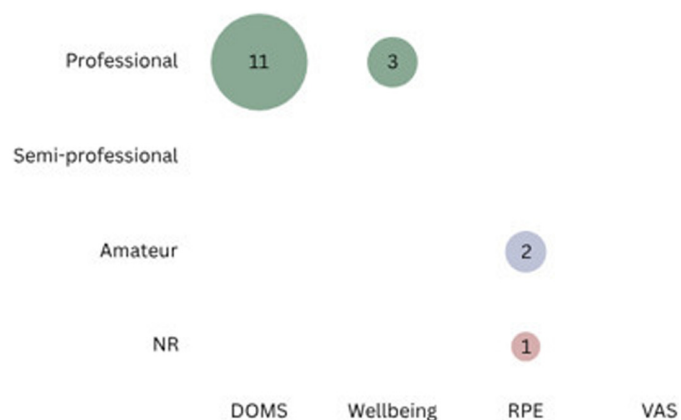


Figure 6 — Evidence gap map of the interaction between perceptual outcomes and competitive level. *Note.* NR indicates competitive level was not reported; RPE, rate of perceived exertion; VAS, visual analogue scale.



Figure 7 — Evidence gap map of the interaction between biochemical outcomes and competitive level. *Note.* CK indicates creatine kinase; LDH, lactate dehydrogenase; NR, competitive level was not reported.

following exercise-induced muscle damage have been investigated, although different outcomes have been used across the studies. Notably, a significant percentage of the interventions included in our review exhibited a high risk of bias, underscoring the need for more rigorous randomized trials. Considering the well-designed trials by Abbott et al²⁴ and Abbott et al,²⁵ curcumin and casein appear to be evidence-based strategies for enhancing recovery in soccer players.

Soccer Player Characteristics and Methodological Issues

Systematic review and meta-analysis are the most effective methods to summarize the efficacy of supplements on recovery. Meanwhile, the sample size and characteristics of the studies included in these reviews are crucial for generalizing the main effects of supplements.³² Our review indicates that evidence supporting supplementary or nutritional strategies for professional players is limited, and there is a paucity of randomized controlled or placebo trials examining different approaches. Each of the 11 studies focused on a specific supplement or nutritional intervention applied across

different competitive levels. Professional athletes tend to be more resistant to inflammation and strength impairments following exercise-induced muscle damage. Consequently, the effects of a supplement or nutritional strategy cannot be generalized to all competitive levels. Additionally, we specifically focused on soccer players. A previous review aimed to identify the best nutritional strategies used by team sports to enhance recovery during the in-season period.¹⁵ However, conclusions from that review should not be generalized to soccer players, as the sampling characteristics, training and competition demands, and testing protocols varied across different team sports.³³ In our review, some variability among the included studies exists despite being considered only soccer players, regarding factors such as the exercise muscle-damage protocol and the types of recovery outcomes assessed.

The type of exercise used to induce fatigue in soccer players varied across studies: 3 studies employed free-running soccer simulation,^{13,27,28} 2 used incremental ergometer tests,^{11,26} and one applied the Stroop Test.³⁰ An important consideration regarding these protocols is whether they accurately simulate the evolving demands of match play.³⁴ The description of the Loughborough Intermittent Shuttle Test in 3 studies^{13,28} was based on Nichols et al³⁵; however, the protocol is characterized by an overestimation of physical demands and an underestimation of cardiac demands compared to actual match conditions.^{34,36} The implementation of the Loughborough Intermittent Shuttle Test in recovery studies should consider adaptations of the original protocol (ie, including changes of direction with sprinting) since these are more reflective of match demands.³⁴ From the studies that used an incremental ergometer test, one was classified as a motorized soccer-specific simulation.²⁶ Although this simulation is comparable to match demands in terms of total distance covered and physiological outcomes, the total duration is approximately 30 minutes shorter, and the total distance in each movement category is overestimated compared to an official match. Consequently, the protocol does not seem to accurately represent match demands.³⁴ Another incremental protocol was used to assess the effects of whey protein consumed immediately after and 2 hours postexercise on biochemical markers.¹¹ However, this protocol did not replicate the specific demands of a soccer match, which limits the generalizability of the findings to real-world soccer scenarios. Real-match play was implemented in 4 studies.^{23–25,29} While it is considered the ideal exercise-muscle damage protocol for assessing the effects of supplements or nutritional interventions on recovery, applying match situations can sometimes be impractical for researchers, especially during the competitive period. When studies are conducted during soccer training sessions or matches, authors are encouraged to report the external and internal load demands of exercise, as demonstrated by Abbott et al^{23–25} and Poulos et al,²⁹ to facilitate the interpretation and practical application of nutritional interventions.

The use of different outcomes to assess recovery also complicates the interpretation of the main findings of each study. In our review, physical and perceptual outcomes were predominantly used, particularly assessments of jumping, velocity, strength, and muscle soreness. However, examination of biochemical outcomes was limited. Although multiple outcomes were utilized in later reviews on recovery in soccer,^{10,37–39} the relationship between different recovery outcomes requires further investigation. A systematic review identified 20 studies examining biochemical and physical markers and found that changes in countermovement jump and squat jump were significantly positively associated with testosterone and the testosterone/cortisol ratio, respectively.³⁸ Conversely, nonsignificant associations were observed between these biomarkers and

linear-sprint and agility performance.³⁸ This suggests that performance outcomes should not be used indiscriminately by researchers in recovery studies. Additionally, testosterone and cortisol levels were not assessed in studies focusing on nutritional or supplementary interventions for recovery. Future research should explore which physical outcomes are most closely related to delayed muscle soreness, well-being, and commonly used biomarkers such as creatine kinase or lactate dehydrogenase.

Nutritional and Supplementary Interventions on Recovery

According to the International Olympic Committee Consensus Statement, sport foods and supplements (protein, carbohydrates, creatine monohydrate, omega-3 fatty acids, curcumin, and tart cherry juice) can help athletes recover more quickly.³² However, in soccer, there is limited evidence regarding the effects of these supplements or sport foods on recovery. Additionally, the quality of randomized controlled trials may influence the main findings of each study, and this issue will be considered in the subsequent sections of the discussion.

Tart Cherry Juice

The study by Abbot et al²³ supplemented soccer players with tart cherry juice in gel format (30 mL, equivalent to 100 cherries) on the morning of the match, immediately after the match, and then at 12 and 36 hours postmatch. However, this study did not evaluate the effects of tart cherry juice on recovery outcomes such as countermovement jump, reactive strength index, muscle soreness, or well-being. It was cited by the UEFA Nutrition Consensus Statement to indicate that evidence regarding the use of tart cherry juice in soccer is limited.⁴⁰ Although 4 of 5 domains in this study were classified as low risk of bias, suggesting it was a well-designed randomized controlled trial, the timing of tart cherry juice supplementation on match day and the subsequent days is a major critique.⁴¹ This narrative emphasizes the importance of dosing timing, especially on days before exercise, to potentially enhance recovery. Within this review, only the study by Abbot et al²³ did not include supplementation on the days prior to the match and did not report potential benefits of tart cherry juice on days following an exercise-induced muscle damage protocol. Another study involving 16 semiprofessional soccer players found that 7 days of tart cherry concentrate (4 d before and 3 d during the trial) led to improved performance in muscular voluntary contraction, countermovement, and agility compared to placebo. Muscle soreness was also lower in the tart cherry group.⁴² These findings support the conclusions proposed by McHugh,⁴¹ but they did not confirm tart cherry juice as an effective recovery strategy 72 hours after a soccer match. Furthermore, an additional question remains regarding how many days prior to exercise tart cherry juice should be consumed and whether it is beneficial on the day of exercise.⁴¹

Protein

Protein ingestion is commonly used to mitigate muscle damage and/or accelerate the tissues' remodeling process.⁴³ The nutritional recommendations for high-quality protein intake immediately after a soccer match are 20 to 25 g or 0.25 to 0.4 g·kg⁻¹ in the subsequent hours.^{40,43} In our review, 2 studies examined the effect of protein intake on recovery. Abbot et al²⁴ investigated the ingestion of 40 g of casein before sleep following a nighttime soccer match, while

Poulios et al²⁹ evaluated the consumption of 80 g of milk protein divided into 3 doses after the match. Both approaches are valid strategies for aiding recovery in soccer players. However, it is important to note that in the study by Poulios et al,²⁹ the players did not meet the recommended daily protein intake of 1.6 to 2.2 g·kg⁻¹.

A previous review highlighted the benefits of postexercise protein intake in reducing muscle soreness and biomarkers of muscle damage, particularly when nitrogen or energy balance is negative.⁴⁴ These findings align with Poulios et al²⁹; however, to confirm the effects of protein on recovery outcomes, future studies should ensure that participants meet the recommended protein intake of 1.6 to 2.2 g·kg⁻¹. Additionally, Poulios et al²⁹ did not specify whether a random component was used in the sequence generation during randomization. The study also assessed multiple outcomes of isokinetic strength, which limits the clarity and interpretability of the findings.

In the study by Abbot et al,²⁴ both the control and casein groups consumed approximately 1.9 g·kg⁻¹ of protein. Since both groups met the protein requirements for soccer players, the timing of casein intake after the night match was key to enhancing recovery. This study was a well-designed randomized controlled trial, with only one domain rated as “some concerns” due to the lack of a prespecified analysis plan. Consuming 40 g of casein after a match, especially at night, appears to be a valid strategy to promote recovery in professional soccer. Literature outside of soccer also supports the benefits of casein for muscle protein synthesis when ingested after nighttime exercise.⁴⁵

Curcumin

The only study that examined the effects of acute curcumin supplementation on recovery from a soccer match in male professional players was classified as having a low risk of bias.²⁵ This study confirmed that an acute intake of 500 mg·day⁻¹ of curcumin had positive effects up to 36 hours postmatch, including reductions in muscle soreness and improvements in physical outcomes such as countermovement jump and reactive strength index. However, no effects were observed up to 60 hours postmatch. The benefits of curcumin are believed to stem from its antioxidant and anti-inflammatory properties.^{46,47} It appears that the supplement decreases the release of proinflammatory cytokines, which in turn impacts muscle soreness.⁴⁷ An important issue regarding curcumin supplementation is the variation in duration and dosage across studies, which has been considerable.⁴⁸ Although Abbot et al²⁵ reported that curcumin reached peak blood concentrations within the first few hours after intake, this typically occurs when high doses of curcumin are ingested (eg, 4000 mg).⁴⁹ Future research should explore the bioavailability of curcumin following an exercise-induced muscle damage protocol and incorporate biomarkers of inflammation and muscle damage to better understand how curcumin can be an effective recovery strategy.

Carbohydrates

The 3 studies included in the current review examined the effects of carbohydrate-rich diets on recovery.^{13,26,28} The percentage of carbohydrates in these studies ranged from 71% to 80%. Abt et al²⁶ and Gunnarsson et al¹³ found that a diet high in carbohydrates did not have a significant impact on recovery, while Erith et al²⁸ observed no differences when different types of carbohydrate meals with varying glycaemic indices were prescribed. However, these studies were classified as high risk of bias, primarily due to

issues in the randomization process and the apparent lack of blinding of outcome assessors. This nonblinding could potentially influence the measurement of outcomes, especially those related to physical, technical, or perceptual recovery.^{26,28} The findings of these studies should therefore be interpreted with caution, as the daily carbohydrate intake was not prescribed in accordance with official recommendations.⁴⁰ Given the importance of meeting carbohydrate guidelines in soccer,^{50,51} it is surprising that few studies have investigated the impact of carbohydrates on the recovery process. According to the UEFA consensus, carbohydrate intake during recovery should involve the ingestion of meals and snacks of approximately 1 g·kg⁻¹ body mass per hour for 4 hours following a match.⁴⁰ None of the studies reviewed employed this approach, highlighting a significant gap in well-designed experimental trials about carbohydrate guidelines, particularly involving professional and world-class soccer players.⁵²

Other Interventions

Other 3 interventions were implemented using different approaches: a combination of caffeine and carbohydrates,²⁷ intake of chocolate milk,³¹ and the use of ketones to improve recovery outcomes.³⁰ All these studies were classified as having a high risk of bias. The isolation or combination of carbohydrates and caffeine did not improve physical recovery outcomes; however, the authors did not report baseline values for the physical tests.²⁷ In the study assessing chocolate milk intake, differences in baseline characteristics between the chocolate milk and control beverage groups were not reported, and no information about blinding of players was provided. Additionally, all 3 studies did not describe how randomization was performed. Given the high risk of bias and the methodological limitations identified in these studies, the conclusions drawn should not be generalized. Future research should employ more rigorous study designs to provide more definitive evidence on the topic. The rationale for the study of a specific sport food or supplement should also be clearly explained by the researchers. Currently, it is not advisable to investigate the effects of caffeine combined with carbohydrates on recovery, as the existing literature on the effects of carbohydrates alone is scarce.

Limitations

Our review has certain limitations that should be acknowledged. First, it includes soccer players of varying competitive levels, which may influence the effectiveness of supplements or nutritional strategies aimed at enhancing recovery. Second, substantial heterogeneity existed across studies in terms of the type of supplement or dietary intervention and protocol characteristics (eg, exercise-induced muscle damage model, form, dosage, composition, and timing), which warrant caution when interpreting the findings. The authors attempt to interpret the main findings of each study by assessing the risk of bias and recognize that interventions such as tart cherry juice, curcumin, casein, and carbohydrates are necessary. Additionally, other supplements like creatine and omega-3 fatty acids warrant further investigation. Finally, the interventions reviewed are limited to a 72-hour period following muscle damage protocol.

Practical Applications

Practical applications from this review emphasize the potential value of evidence-based nutritional strategies to support recovery

following soccer matches. Current evidence suggests that consuming 20 to 25 g of high-quality protein, such as casein, immediately postmatch and before sleep may support recovery, while curcumin supplementation (~ 500 mg·d⁻¹) may aid recovery through its anti-inflammatory properties. However, these recommendations should be interpreted with caution, as the evidence supporting casein and curcumin is derived from a small number of well-designed studies. In contrast, the evidence regarding carbohydrate-based interventions and tart cherry juice remains limited and inconclusive, preventing definitive practical recommendations. Further well-designed randomized controlled trials are required to clarify the effectiveness of these nutritional strategies and to establish evidence-based recovery guidelines for soccer players.

Conclusion

Our review highlights the current evidence regarding nutritional and supplementary interventions aimed at improving recovery outcomes in soccer players. Despite the recognized importance of effective recovery strategies, the existing evidence remains limited and highly heterogeneous across soccer studies. Notably, a significant proportion of interventions exhibit a high risk of bias, emphasizing the need for more rigorously designed randomized controlled trials. Among the available evidence, well-designed studies (even those with limited sample sizes) suggest that curcumin and casein may be promising strategies for enhancing recovery, particularly in professional soccer players. Further research is needed to confirm the effects of carbohydrate intake during recovery and to establish clear guidelines for soccer players. Additionally, given that the International Olympic Committee recommends the use of other supplements, such as creatine monohydrate and omega-3 fatty acids, to enhance recovery, future studies on these supplements should be prioritized. This will help develop scientifically based recommendations tailored to soccer players, ultimately optimizing recovery protocols and athletic performance.

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