REVIEW

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Dose, timing, and population effects of curcumin and vitamin D3 supplementation on exercise-induced muscle damage: A systematic review

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ABSTRACT

Background: The exercise-induced muscle damage (EIMD), which results from intense exercise and eccentric actions, is associated with elevated levels of inflammation, muscle damage, and delayed-onset muscle soreness (DOMS). All these factors may negatively affect both recovery process and athletic performance. Nowadays, curcumin and vitamin D become increasingly popular nutritional compounds due to their ability to exert anti-inflammatory, antioxidative, and immunomodulatory effects that may contribute to recovery. The current systematic review is designed to investigate the impact of curcumin and vitamin D supplementation on inflammatory biomarkers, muscle damage biomarkers, and DOMS after EIMD.

Methods: A systematic literature review was performed based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines using the PICO approach. All studies that have been published from 2016 to 2026 in PubMed and Scopus databases have been searched for inclusion. The studies considered eligible in the review were randomized controlled trials and intervention studies conducted among healthy humans. Methodological quality was evaluated using the RoB 2 tool developed by the Cochrane Collaboration. Overall, 14 articles were included for narrative analysis. The study was prospectively registered on PROSPERO (CRD420261426087).

Results: Supplementation with curcumin provided fairly consistent results in lowering CK, TNF-α, IL-8, and muscle soreness, along with aiding in functional recovery after eccentric exercise. Supplementation with vitamin D resulted in inconsistent results; however, it was shown to be effective in mitigating inflammation and muscle damage, especially in endurance trained people, and people with insufficient levels of vitamin D at the beginning. The effect of the two supplements was dependent on the dose of the supplement, time of administration, exercise method, and participants' level of training. Chronic and post-exercise supplementation proved to be more effective than acute supplementation.

Conclusion: Curcumin and vitamin D have the potential to be nutritional strategies to support recovery after EIMD

Keywords: Curcumin, delayed-onset muscle soreness, exercise-induced muscle damage, inflammation, recovery, vitamin D
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INTRODUCTION

Exercise-induced muscle damage (EIMD) is one of the most frequent physiological reactions to high-intensity exercises especially those involving extensive eccentric muscle contractions.[1] Exercise-induced muscle damage involves structural damage to muscle fibers, increases in membrane permeability, immune cell infiltration into muscles, and muscle damage and inflammation markers such as CK, IL-6, and TNF-α.[2,3] The above-mentioned physiological changes often result in delayed onset of muscle soreness (DOMS) which entails muscle pain and stiffness appearing 24-72 hours after performing unusual and intense exercise as well as limited ROM, temporary muscle weakness, and impaired athletic performance.4 While inflammation is a part of tissue regeneration and physiologic adaptation after exercise, prolonged or excessive inflammation may adversely impact recovery and further athletic performance.[5]

The inflammatory cascade associated with EIMD is largely initiated by mechanical and metabolic stress imposed on skeletal muscle during exercise.[6] This process stimulates the release of pro-inflammatory cytokines, including IL-6, TNF-α, and IL-1β, while simultaneously increasing oxidative stress and promoting the release of muscle damage biomarkers such as CK and myoglobin into the circulation.[7] However, when inflammation and oxidative responses are exaggerated, recovery can be prolonged, perception of muscle soreness can be elevated, and performance capabilities may be hindered during ensuing physical activities.[8] Therefore, nutritional interventions designed to control inflammation and oxidative stress have become a major issue in the field of sports nutrition and exercise recovery research.

Among the nutritional components being studied for the improvement of

recovery processes, curcumin is one of the most popular nutrients because of its strong anti-inflammatory and antioxidant actions.[9,10] Curcumin is a compound that is considered to be the main bioactive polyphenol of Curcuma longa which has a potential to inhibit NF-κB activation, lower the level of pro-inflammatory cytokines, and decrease the effects of oxidative stress caused by exercise.[11,12] It was found in previous researches that curcumin could have an influence on reducing the concentration of CK, TNF-α, IL-8, and the perception of muscle soreness after EIMD. Moreover, curcumin is supposed to promote the maintenance of muscle function and recovery processes after eccentric and endurance exercises.[13,14,15] However, the level of these positive effects could differ between the studies.

Vitamin D plays a role in regulating neuromuscular function and muscle physiology, with deficiency linked to declines in strength and performance.[16,17] Beyond its well-established role in calcium regulation and bone health, vitamin D exerts immunomodulatory and anti-inflammatory effects through activation of the vitamin D receptor (VDR) in multiple tissues, including skeletal muscle.[18,19] Evidence suggests that vitamin D supplementation may attenuate systemic inflammatory responses, reduce concentrations of pro-inflammatory cytokines such as TNF-α and IL-1β, and limit elevations in muscle damage biomarkers following endurance and eccentric exercise.[18,19] Notably, these effects appear to be more pronounced among individuals with insufficient or deficient vitamin D status, indicating that baseline physiological conditions may influence the effectiveness of supplementation.[20]

Even with the rising interest in curcumin and vitamin D supplements, there is no conclusive proof to support their effectiveness yet. Some researchers have found positive results with regard to the inflammation markers, muscle damage markers, and DOMS, while others have found otherwise.[21,22] These inconsistencies may be attributed to substantial heterogeneity in study design, participant characteristics, exercise protocols, supplementation regimens, and outcome measures.[23] Moreover, many investigations have focused primarily on whether supplementation is effective, rather than examining the conditions under which these interventions may produce optimal benefits.

Population characteristics may further contribute to variability in supplementation outcomes. Endurance-trained athletes, recreationally active individuals, and untrained participants exhibit distinct physiological adaptations related to inflammation, oxidative stress, and recovery processes.[8] Additionally, much of the available research has been carried out on healthy males, thus providing insufficient knowledge about women as well as vitamin D deficient subjects. In terms of mode of physical activity, there is a possibility that the results could be affected due to the fact that eccentric resistance exercises cause more tissue damage and DOMS than endurance training does.[19,24]

Several systematic reviews have examined the effects of curcumin on DOMS and exercise recovery. However, these reviews generally focus on a single supplementation strategy strategy and provide limited evaluation of how dosage, supplementation timing, and population characteristics influence inflammatory and recovery-related outcomes.[25,26] Furthermore, comparative evidence synthesizing the effects of both curcumin and vitamin D within the context of exercise-induced inflammation remains scarce.[27] To our knowledge, no recent systematic review has comprehensively evaluated how supplementation dosage, administration timing, and participant characteristics jointly influence the effectiveness of both curcumin and vitamin D following EIMD. Consequently, a more comprehensive synthesis of the available literature is warranted.

Therefore, this systematic literature review was conducted to synthesize and critically evaluate the current evidence regarding the effects of curcumin and vitamin D supplementation on inflammatory biomarkers, muscle damage markers, and DOMS following EIMD. Specifically, this review aimed to determine whether variations in supplementation dosage, administration timing, and participant characteristics influence the effectiveness of curcumin and vitamin D in attenuating inflammation, muscle damage, and DOMS after EIMD. Specific focus was laid on the role of the amount of supplementation, time of administration, and individual differences, since these can significantly contribute to the variation between studies. In order to determine the circumstances in which curcumin and vitamin D supplementation might be the most effective in aiding the recovery after exercising, this paper attempts to analyze the literature related to various kinds of exercise and different populations. It is hoped that the results of this paper will help develop evidence-based nutritional strategies for exercise recovery in physically active people and athletes.

METHODS

This study was conducted using a systematic literature review (SLR) design and followed the preferred reporting items for systematic reviews and meta-analyses (PRISMA 2020) guidelines.[28] The review protocol was registered prospectively with the International Prospective Register of Systematic Reviews (PROSPERO; registration no. CRD420261426087). The research question was developed using the PICO (population, intervention, comparison, outcome) framework to evaluate the influence of supplementation dosage, timing of administration, and participant characteristics on the effects of curcumin and vitamin D supplementation on inflammatory biomarkers and DOMS following EIMD.

The study sample was made up of healthy subjects who were performing vigorous exercise or eccentric exercise. The interventions applied included administration of curcumin, turmeric, vitamin D, and cholecalciferol. The outcome measures include markers of inflammation, muscle damage, and muscle soreness.

A systematic literature search was conducted in PubMed and Scopus databases. The search combined keywords related to curcumin, vitamin D, inflammation, delayed-onset muscle soreness, recovery, and exercise-induced muscle damage using boolean operators (AND/OR). Studies published between 2016 and 2026 were considered eligible. Additional filters included English-language publications, open-access

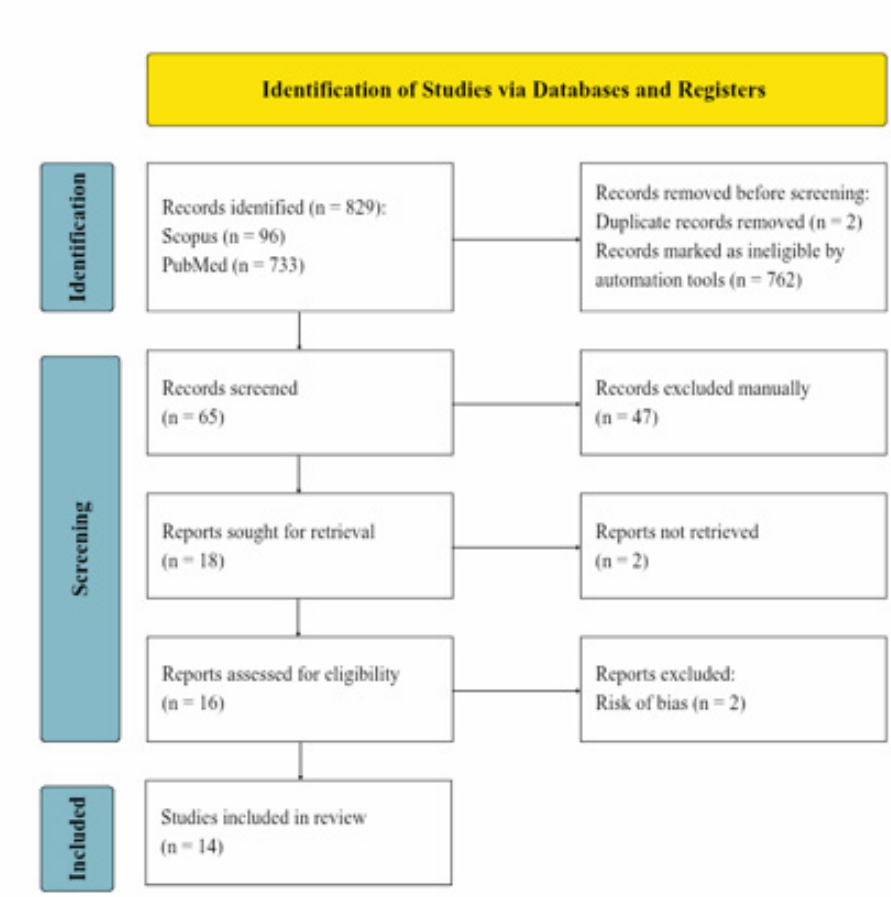


Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flowchart

availability, and study designs limited to randomized controlled trials and intervention studies.

The selection of studies was done through a systematic process that involved title, abstract, and full-text article screening based on predetermined inclusion and exclusion criteria. The selected studies were primary research papers that had used healthy human subjects to investigate the effect of curcumin or vitamin D supplementation on inflammation, muscle damage, or recovery outcomes. Review articles, meta-analyses, animal studies, conference abstracts, and studies not directly relevant to the review objectives were excluded from the synthesis.

Study quality was evaluated using the cochrane risk of bias tool version 2 (ROB2). Risk-of-bias evaluation was performed independently by two reviewers to ensure methodological rigor and consistency.[29] Data extracted from each study included participant characteristics, exercise protocols, intervention type and dosage, supplementation timing, inflammatory biomarkers, muscle damage markers, DOMS outcomes, statistical findings, and RoB 2 assessment results.

Narrative synthesis of the studies involved structuring results based on the dimensions of dose and timing of the supplements, subject demographics, biomarkers for inflammation, markers of muscle damage, and outcomes for recovery. This helped in highlighting similarities, heterogeneity, and consistencies within the studies about the role of curcumin and vitamin D supplementation in the recovery from EIMD. Meta-analysis could not be performed due to considerable heterogeneity within the studies.

RESULTS

The **table 1** below presents the features of the selected studies. The study includes 14 studies that were published from 2016 to 2025 and that satisfied the inclusion criteria (**Figure 1**). There were between 18 and 60 subjects in the studies, most of whom were healthy adult males. The participants belonged to such groups as recreationally active people, endurance runners, moderately active adults, and amateur ultramarathoners. Exercise protocols varied across studies and included eccentric resistance exercise, treadmill running, half-marathon races, ultramarathon events, and downhill running protocols. Nine studies evaluated curcumin or turmeric-derived supplementation, whereas five studies investigated vitamin D supplementation. The primary outcomes assessed included inflammatory biomarkers, muscle damage markers, DOMS, range of motion (ROM), muscle strength, and functional recovery measures.

Among the included studies, curcumin supplementation was associated with reductions in CK, tumor necrosis factor-alpha (TNF-α), interleukin-8 (IL-8), and measures of muscle soreness following exercise-induced muscle damage.[6,18] Several studies also reported improvements in recovery-related outcomes, including pain intensity, range of motion, and muscle function after eccentric exercise protocols. However, some studies did not observe significant changes in inflammatory or oxidative stress markers following curcumin supplementation. Vitamin D supplementation was associated with changes in inflammatory and muscle damage biomarkers, particularly in studies involving endurance exercise and ultramarathon events[11,19] Reported outcomes included reductions in TNF-α, interleukin-1 beta (IL-1β), creatine kinase, myoglobin, and troponin concentrations. In studies involving ultramarathon athletes, vitamin D supplementation was also associated with lower post-exercise increases in selected inflammatory biomarker.

Variations in supplementation dose, timing of administration, and participant characteristics were observed across the included studies. Curcumin doses ranged from 180 mg/day to 2 g/day, whereas vitamin D interventions ranged from 2,000 IU/day to 10,000 IU/day, with one study administering a single

Table 1. Data extraction results

No	Author & year, journal	Population	Exercise protocol	Intervention	Timing	Biomarkers	Doms / recovery outcome	Main statistical results	Risk of bias
1	McFarlin et al., 2016, BBA Clinical[11]	28 healthy recreationally active subjects	Eccentric dual-leg press, 6 × 10 repetitions at 110% 1RM	Curcumin Longvida® 400 mg/day vs placebo	2 days before until 4 days after EIMD	CK, TNF-α, IL-6, IL-8, IL-10	Quadriceps soreness, ADL soreness	Significant reductions in CK, TNF-α, and IL-8; no significant effect on IL-6, IL-10, or DOMS	Low Risk
2	Bańkowski et al., 2022, Redox Report[22]	30 middle-aged amateur long-distance runners	Incremental treadmill exercise test	Curcumin 2 g/day for 6 weeks vs placebo	Pre- and post-6-week supplementation	SOD, CAT, GPx, CK, LDH, Mb, MDA, SIRT3	Not directly assessed	No significant changes in inflammatory or oxidative stress markers; significant increase in SIRT3	Low Risk
3	Kusnanik et al., 2023, Retos[51]	18 healthy males	High-intensity squat and leg press exercise	Curcumin 400 mg vs placebo	24 h after exercise	CK, MDA	Not directly assessed	Significant reduction in CK; no significant effect on MDA	Low Risk
4	Ayubi et al., 2023, Retos[52]	24 healthy males	High-intensity squat and leg press exercise	Curcumin 400 mg vs placebo	24 h post-exercise	Not directly measured	VAS pain intensity, ROM	Significant reduction in pain intensity and improvement in ROM	Low Risk
5	Helder et al., 2025, Physiological Reports[15]	34 recreationally active males	Eccentric leg press exercise at 110% 1RM	Hydrolyzed curcumin 750 or 1500 mg/day vs placebo	48 h before until 7 days after EIMD	CK, IL-6, FORT	Pain score, muscle endurance	High-dose curcumin significantly reduced CK, IL-6, oxidative stress, and pain	Low Risk
6	Faria et al., 2020, European Journal of Applied Physiology[53]	28 healthy male runners	Half-marathon race	Curcuma longa extract 1500 mg/day vs placebo	4 weeks before race	CK, LDH, AST, ALT, myoglobin, IL-6, IL-10	VAS soreness	Increased IL-10 and reduced myoglobin after race	Low Risk
7	Tanabe et al., 2019, Journal of Nutritional Science and Vitaminology[12]	24 healthy young males	30 maximal eccentric elbow flexor contractions	Curcumin 180 mg/day pre- or post-exercise	PRE: 7 days before; POST: 4 days after exercise	CK	ROM, muscle soreness, MVC torque	Post-exercise curcumin more effective in reducing DOMS and preserving ROM	Low Risk
8	Żebrowska et al., 2020, JISSN[54]	24 endurance runners	Incremental and eccentric exercise protocol	Vitamin D 2000 IU/day vs placebo	3 weeks supplementation	Troponin, myoglobin, CK, LDH, TNF-α	Not directly assessed	Significant reductions in TNF-α, CK, myoglobin, and troponin	Low Risk
9	Pilch et al., 2020, JISSN[24]	60 healthy young males	Downhill treadmill eccentric exercise	Individualized vitamin D supplementation for 3 months	Before and after exercise	IL-1β, myoglobin, CK, LDH	DOMS indirectly discussed	Significant reductions in IL-1β and myoglobin	Low Risk
10	Mallard et al., 2021, Journal of Dietary Supplements[14]	28 trained healthy males	Resistance exercise to exhaustion	Curcumin + LipiSperse® vs placebo	Pre- and post-exercise	CK, LDH, hs-CRP, myoglobin, IL-6, IL-10, TNF-α	VAS pain, thigh circumference	Reduced DOMS and lactate accumulation	Low Risk

Table 1. Continued

No	Author & year, journal	Population	Exercise protocol	Intervention	Timing	Biomarkers	Doms / recovery outcome	Main statistical results	Risk of bias
11	Kasprowicz et al., 2020, IJERPH[21]	20 amateur ultramarathon runners	100-km ultramarathon	Vitamin D3 10,000 IU/day vs placebo	2 weeks before race	Hepcidin, IL-6, iron markers	Not assessed	No significant IL-6 differences; improved iron metabolism	Low Risk
12	Mieszkowski et al., 2021, Nutrients[36]	35 amateur ultramarathon runners	Ultramarathon up to 240 km	Single-dose vitamin D 150,000 IU vs placebo	24 h before race	IL-6, IL-10, resistin, leptin	Not assessed	Lower increases in IL-6 and IL-10 after race	Low Risk
13	Bańkowski et al., 2025, PLOS ONE[55]	30 amateur runners	Graded treadmill exercise test	Curcumin 2 g/ day vs placebo	6 weeks supplementation	CRP, IL-6, TNF-α, IL-1β, BDNF	Not assessed	No significant inflammatory changes; increased BDNF	Low Risk
14	Schönenberger et al., 2025, JISSN[56]	44 moderately active adults	Downhill running at 70% VO_2max	Turmeric formulation 300 mg/day vs placebo	5 days supplementation	CK	Muscle soreness, ROM, torque, jump power	Faster DOMS recovery and improved muscle function	Low Risk

1RM, one-repetition maximum; ADL, activities of daily living; ALT, alanine aminotransferase; AST, aspartate aminotransferase; BBA Clinical, Biochimica et Biophysica Acta Clinical; BDNF, brain-derived neurotrophic factor; CAT, catalase; CK, creatine kinase; CRP, C-reactive protein; DOMS, delayed-onset muscle soreness; EIMD, exercise-induced muscle damage; FORT, free oxygen radicals test; GPx, glutathione peroxidase; hs-CRP, high-sensitivity C-reactive protein; IJERPH, International Journal of Environmental Research and Public Health; IL-1β, interleukin-1 beta; IL-6, interleukin-6; IL-8, interleukin-8; IL-10, interleukin-10; IU, international units; JISSN, Journal of the International Society of Sports Nutrition; LDH, lactate dehydrogenase; Mb, myoglobin; MDA, malondialdehyde; MVC, maximal voluntary contraction; PLOS ONE, Public Library of Science ONE; ROM, range of motion; SIRT3, sirtuin 3; SOD, superoxide dismutase; TNF-α, tumor necrosis factor-alpha; VAS, visual analogue scale; and VO_2max, maximal oxygen uptake.

dose of 150,000 IU before competition. Several studies reported greater reductions in inflammatory biomarkers and muscle soreness at higher curcumin doses.[20] Considerable heterogeneity was identified among studies with respect to participant characteristics, exercise modalities, supplementation formulations, intervention duration, and outcome measures. Eccentric resistance exercise protocols were more frequently used to assess DOMS, range of motion, and muscle function, whereas endurance-based exercise protocols primarily evaluated inflammatory and muscle damage biomarkers.

DISCUSSION

As evident from the findings of this systematic literature review, curcumin and vitamin D supplementation can help in achieving better recovery post EIMD. It appears that curcumin was more effective than placebo groups for the management of DOMS, CK levels, and other inflammatory markers. More specifically, decrease in TNF-α, IL-8, and CK levels was seen post eccentric training while curcumin supplementation was found to lower down the DOMS and maintain range of motion post eccentric contraction.[11,12] These findings suggest that curcumin may help attenuate exercise-induced muscle damage and inflammatory responses, thereby facilitating post-exercise recovery.

The beneficial effects of curcumin may be explained by its anti-inflammatory and antioxidant properties.[31] Curcumin has been shown to possess the ability to suppress the activation of nuclear factor kappa-B (NF-κB), which is an important mediator in inflammatory pathways, thus reducing the formation of pro-inflammatory cytokines like TNF-α, IL-1β, and IL-6.[32,33] Furthermore, curcumin can enhance antioxidant protection from exercise-induced oxidative stress. Curcumin may be able to reduce secondary muscle injury and expedite recovery following EIMD through these processes.[34]

Vitamin D supplementation also demonstrated promising effects, particularly in relation to systemic inflammation and muscle damage biomarkers following endurance

exercise and ultramarathon events. Reductions in TNF-α, CK, and myoglobin concentrations were reported after vitamin D supplementation, while a single high-dose vitamin D intervention attenuated post-race increases in IL-6 and IL-10.[35] These findings suggest that vitamin D is potentially involved in regulating inflammatory responses as well as alleviating physiological stress induced by exercise. Apart from its known roles in maintaining calcium balance and bone structure, vitamin D acts as an immunomodulator through stimulation of the vitamin D receptor (VDR) in both muscle tissue and immune cells.[36,37] The VDR stimulation affects the cytokine secretion, muscle tissue repair, and regulation of inflammation, which could explain the improved recovery process after high-intensity exercises. This biological rationale supports the aforementioned decline of inflammatory and muscle damage biomarkers seen in several included studies.[38] Nevertheless, the magnitude and consistency of these effects varied considerably across studies, highlighting the complexity of vitamin D-mediated responses to exercise-induced stress.

Despite these promising findings, the effects of vitamin D were generally less consistent than those observed for curcumin. Considerable variability was reported across studies, particularly for biomarkers such as IL-6 and C-reactive protein (CRP).[32] This variability may be contributed by the difference in dosage of supplementation, time period of supplementation, type of exercise, training status of subjects, and vitamin D levels of subjects before supplementation. In addition, the differences in types of exercise can also partly explain the differences in results. This is because eccentric resistance exercise leads to DOMS, while endurance exercise is more related to inflammatory response and metabolism. Therefore, the effects of curcumin and vitamin D supplementation on body can be different depending on the type of exercise done. Importantly, several studies suggested that individuals with insufficient or deficient vitamin D status may derive greater benefits from supplementation than participants with adequate baseline levels.[39] Therefore, baseline nutritional status appears to be an important factor influencing the effectiveness of vitamin D interventions.[40]

The findings of this literature review coincide with the conclusions drawn from previous systematic reviews where the anti-inflammatory effects of curcumin and its potential for aiding recovery were stressed. Post-exercise, there was evidence of decreased levels of DOMS, signs of muscle injury, and functional impairments in muscle, with curcumin supplementing contributing to neuromuscular recovery and reduced muscle soreness.[41] Likewise, the decrease in CK levels and pro-inflammatory biomarkers found in various trials considered in this review support the proposed mode of action of curcumin in the regulation of exercise-induced inflammation and oxidative stress.[11]

Evidence supporting the impact of vitamin D supplementation supports the previous finding that vitamin D is important for immune regulation and muscle function. However, according to this review, the efficacy of vitamin D supplementation could be influenced by the supplementation regimen as well as individual factors, such as vitamin D levels before the experiment and the nature of the exercise regime.[42] These observations highlight the importance of considering individual physiological characteristics when designing recovery interventions.

One of the key findings of this review is the influence of supplementation dosage and timing on recovery outcomes. Curcumin doses varied substantially across studies, ranging from 180 mg/day to 2 g/day, whereas vitamin D interventions ranged from 2,000 IU/day to 10,000 IU/day, with one study administering a single dose of 150,000 IU before competition.[26] Despite the existence of several studies that show positive effects associated with the increased intake of curcumin, differences in research designs and supplement protocols do not allow drawing any conclusive results about the ideal dosage-effect relationship.[43] However, current evidence is not sufficient to prove the presence of an optimal dose for either curcumin or vitamin D, since there is great variability in terms of protocol design, length of intervention, and measurement outcomes. Besides, post-workout supplementation proved more beneficial compared to pre-workout one in terms of DOMS and flexibility.[44,45] These findings indicate that both dosage and timing may be important determinants of supplementation effectiveness.

Population characteristics also appeared to influence recovery outcomes. Most included studies involved healthy young male participants, recreationally active individuals, endurance runners, or trained athletes.[46-48] Differences in training status may partially explain variations in inflammatory and recovery responses, as trained individuals typically exhibit greater physiological adaptations to exercise-induced stress than untrained populations.[2,49,50] Therefore, the response to such interventions will depend on the participants' physical condition and physiology. One of the contributions of the current review is the combined analysis of the impact of curcumin and vitamin D supplements on EIMD. Another strength of the review is the use of research that considered different types of exercises, types of interventions, and participants. This diversity allowed for more complete assessment of the factors that can affect recovery outcomes after EIMD and detection of the possible moderators of intervention effectiveness. Prior literature reviews were mainly focused on particular supplements and their effectiveness. In turn, the current review took into consideration the effect of supplementation as well as the effect of the dose, timing, and other factors on recovery outcomes.

From a practical perspective, the findings suggest that curcumin supplementation may be particularly useful for reducing muscle soreness and supporting functional recovery following eccentric or high-intensity exercise. Meanwhile, vitamin D supplementation may be especially relevant for endurance athletes and individuals with suboptimal vitamin D status. These observations may assist sports nutritionists, physiotherapists, coaches, and other healthcare professionals in developing individualized recovery strategies based on athlete characteristics and training demands.

There are several limitations of this literature review that should be highlighted. First, considerable

variability was found in the studied parameters including supplementation dosage, intervention period, exercise routines, subjects' age and gender, and measurements. Second, most of the studies were conducted on healthy young males, and hence cannot be generalized to females and older individuals as well as to patients. Third, variability in the timing of measurements and methodology used may have influenced the consistency of results. Fourth, few studies were carried out on vitamin D, and no studies directly compared vitamin D supplementation to curcumin supplementation.

However, more research needs to be conducted in order to assess the joint action of curcumin and vitamin D supplementation since these compounds might have a beneficial effect on one another when used for anti-inflammatory purposes and muscle recovery in case of EIMD; they have not been thoroughly researched before. Also, new randomized controlled trials should be designed involving various demographics of people such as females, older subjects, and athletes with different levels of experience in order to increase the validity of the existing information.

CONCLUSION

This systematic literature review demonstrates that both curcumin and vitamin D supplementation have the potential to support recovery following EIMD. Curcumin had more pronounced influence on reducing DOMS, CK and other inflammatory markers, especially after eccentric training sessions. Supplementation with vitamin D was effective in affecting systemic inflammation and markers of muscle injury, especially in endurance athletes or those with poor vitamin D levels. Other interesting findings were the fact that efficacy of supplementation depends on dosage, timing of ingestion, type of training and athlete characteristics.

However, variability in study design, supplementation protocols, and outcome measures limits the ability to establish definitive recommendations regarding optimal dosing and administration strategies. Future studies can be designed using randomized control trials that have more subjects and a longer follow up time period to strengthen the current scientific evidence.

ETHICAL CONSIDERATION

This article review is based on published studies; therefore, no human or animals were involved. Moreover, all of the materials are correctly referenced and included only peer-reviewed articles from renowned sources.

CONFLICT OF INTEREST

Regarding this article, the authors declare that they have no conflicting interests.

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AUTHOR CONTRIBUTIONS

Concepts, design, intellectual content definition, literature search, data collection, data analysis, article preparation, manuscript editing, and guarantorship were all supplied by NAR. AH helped define intellectual content and review manuscripts. HR helped define intellectual content and assess manuscripts. Data collection, analysis, and manuscript editing were all aided by FAF. The final paper was approved by all authors.

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