MLS – HEALTH & NUTRITION RESEARCH (MLSHNR)
http://mlsjournals.com/Health&nutritionrsearch-Journal
ISSN: 2603-5820
(2026) MLS-Health & Nutrition Research, 5(1), 42-63. doi.org/10.60134/mlshn.v5n1.422

Nutritional supplementation for recovery from excersice-induced muscle damage: omega-3 fatty acids, curcumin and collagen

Suplementación nutricional para la recuperación del daño muscular inducido por el ejercicio: ácidos grasos omega-3, curcumina y colágeno

Adrián Fernández Álvarez
Universidad Europea del Atlántico, Spain (adrianfa13@gmail.com) (https://orcid.org/0009-0001-4045-4512)

Manuscript information:

Recibido/Received:30/05/25
Revisado/Reviewed: 04/06/25
Aceptado/Accepted: 16/06/26

Keywords:
Sports supplementation, muscle soreness, muscle injury, inflammation, tissue recovery.

ABSTRACT

Introduction: Nutritional supplementation for recovery from exercise-induced muscle damage: omega-3 fatty acids, curcumin, and collagen. Methodology: A bibliographic review was conducted, incorporating 15 clinical trials for detailed discussion, as well as systematic reviews and meta-analyses for contextual background. Studies were selected if they involved one of the target supplements alongside a standardized exercise protocol to induce muscle damage. Except for specific exceptions, all trials reviewed were published within the las five years and exclusively enrolled in humans. Results: Longer interventions with higher omega-3 doses consistently attenuated EIDM, whereas lower and shorter doses did not yield significant benefits. Curcumin supplementation failed to produce positive changes in inflammatory or muscle damage biomarkers. Finally, extended collagen supplementation reduced perceived muscle soreness and decreased muscle damage biomarkers. The marked heterogeneity in dosing, study duration and exercise protocols highlight de imperative for future research employing standardized methodologies. Discussion The current evidence is mixed, not allowing clinical recommendations to be made. Further randomized, placebo-controlled clinical trials with larger, more diverse sample space and rigorous design are needed to establish clear guidelines on the effectiveness of these supplements in mitigating EIMD.

Palabras clave:
Suplementación deportiva, daño muscular, lesión muscular, inflamación, recuperación tisular.

RESUMEN

Introducción: Evaluar la eficacia de la suplementación con omega-3, curcumina y colágeno sobre la recuperación del daño muscular inducido por el ejercicio. Metodología: Se realizó una revisión bibliográfica de 15 ensayos clínicos para la discusión, además de revisiones sistemáticas y metaanálisis para la contextualización del tema. Para el análisis de estudios, se tuvieron en cuenta aquellos que involucrasen los suplementos mencionados y una pauta deportiva para inducir el daño muscular. Salvo excepciones puntuales, los ensayos analizados tienen un máximo de cinco años de antigüedad y están únicamente realizados en humanos. Resultados: Las intervenciones prolongadas con dosis más altas de N-3 afectaron positivamente al EIMD, mientras que dosis más pequeñas y durante periodos más cortos no mostraron esos efectos. La suplementación con curcumina no modificó de manera significative ni los marcadores inflamatorios ni los relacionados con el daño muscular. Finalmente, la suplementación con colágeno prolongada atenuó la percepción del dolor y redujo los biomarcadores de dolor muscular. La heterogeneidad de las dosis, duración y protocolos reafirma la necesidad de estudios futuros con metodologías estandarizadas. Discusión: La evidencia actual es mixta, no permitiendo realizar recomendaciones clínicas definitivas. Se requieren más estudios, con mayor espacio muestral y menos sesgados para definir pautas sólidas sobre la efectividad o no de los distintos suplementos evaluados.

Introduction

Exercise-induced muscle damage (EIMD) manifests with symptoms that may appear immediately after exercise and last up to fourteen days (1). Sports-related muscle injuries are a complex area of study, as they involve multiple factors such as gender, age, nutritional status, physical fitness, and genetics (2). In particular, DMIE usually occurs after movements to which the body is not accustomed, especially if they involve eccentric contractions (3). These injuries affect the musculoskeletal system and are associated with a loss of muscle mass and strength (4). In this context, nutrition plays a key role, as it can modulate inflammation and promote tissue regeneration (5).

The first report on the relationship between exercise and oxidative stress in humans was published more than four decades ago (6). In addition, muscle damage triggers an inflammatory response, as evidenced by swelling, decreased range of motion, and pain (7). Most studies reporting the discovery of dietary patterns with anti-inflammatory properties have been conducted in laboratories or on animals (8), so determining the effectiveness of nutritional ergogenic aids with antioxidant and anti-inflammatory properties could be of interest in terms of slightly modulating DMIE.

This topic is particularly relevant not only to health and physical performance, but also to understanding how certain supplements can influence recovery from exercise-induced muscle damage. Determining whether they are ergogenic and how to use them based on individual goals can be key to the success of nutritional interventions (9). An appropriate strategy could accelerate the recovery of musculoskeletal tissue, reduce the impact of the injury, and shorten the time it takes to return to activity.

According to the WHO, musculoskeletal disorders comprise more than 150 conditions that affect the musculoskeletal system, ranging from sudden, short-term injuries—such as fractures, sprains, and strains—to chronic conditions that cause permanent functional limitations and disability (10).

Musculoskeletal injuries are an inevitable part of every stage of human life, and they are exacerbated by lifestyle factors. Musculoskeletal injuries are very common among athletes during training or competition, resulting in lost time and time away from sports (11). Injuries among high-performance athletes are extremely common, affecting approximately 91.6% of athletes over the course of a year, with an average of 4.1 injuries per 1,000 hours of athletic activity (12). It is estimated that between three and five million sports-related injuries occur each year (13). On the other hand, lifestyle factors—such as progressive joint wear and tear and loss of muscle mass, which are sometimes the result of a sedentary lifestyle and poor nutrition—are catalysts for the onset of these types of problems (14). In both cases, the onset of this medical condition has a negative impact on the individual's independence, limiting their ability to work, play sports, or even perform everyday activities such as walking or getting up (15).

The recovery from damage to skeletal muscle follows a specific healing sequence, regardless of the cause of the injury. The first phase involves the rupture and subsequent necrosis of muscle cells. During the second phase, phagocytosis of the necrotic tissue occurs, along with the regeneration of myofibrillar tissue and the formation of connective scar tissue. Finally, the third and final phase is a period of maturation of the regenerated myofibrils, contraction and reorganization of the scar tissue, and recovery of muscle tissue function (16)

Understanding the underlying mechanisms involved in the onset and progression of lesions, as well as their relationship to nutritional supplementation, is essential for developing strategies that promote the regeneration of affected tissues.

Engaging in a sport that an athlete is not accustomed to, as well as strenuous, high-intensity, or long-duration exercise, are several factors that can lead to muscle damage. DMIE is characterized by a primary response resulting from mechanical stress that occurs during exercise, as well as a secondary inflammatory response. Excessive stretching and the resulting disruption of the sarcomeres, followed by an increase in Ca2+ influx into muscle cells, result in passive muscle tension, causing myofibrillar disruption. These responses subsequently trigger secondary inflammatory responses, including the production of reactive oxygen species (ROS) and pro-inflammatory cytokines (17).

Delayed-onset muscle soreness is a common experience among athletes, whether they are beginners or experienced. Symptoms range from muscle tenderness to severe pain. The most common times when cases of DMIT occur are at the start of the sports season, when athletes return to training after a period of reduced activity. It is also common when athletes first take up certain activities, regardless of the time of year (18).

As Diego Fernández-Lázaro points out, there is a link between oxidative stress, inflammation, and muscle damage, since oxidative stress can lead to muscle damage. Inflammatory cells can promote oxidative stress by releasing enzymes (neutral proteases, elastase, collagenase, acid hydrolases), reactive species (superoxide, hydrogen peroxide, hydroxyl radical, hypochlorous acid, nitric oxide), and extracellular messengers (cytokines and interleukins). Taken together, these compounds can exacerbate inflammation and muscle damage (19). Immediately after a muscle injury occurs, the inflammatory response initiates tissue repair and regeneration by stimulating the release of pro-inflammatory cytokines, such as interleukin-6 (IL-6), interleukin-1β (IL-1β), and tumor necrosis factor-alpha (TNF-α). Pro-inflammatory cytokines act on the liver, stimulating the production and release of C-reactive protein (CRP), a marker of acute systemic inflammation (20).

DMIE is associated with increased serum levels of muscle enzymes, such as creatine kinase, lactate dehydrogenase, and myoglobin, as well as decreased strength and neuromuscular deficits (21). One of the links between omega-3 fatty acids and muscle inflammation lies in the regulation of pro-inflammatory cytokines, such as TNF-α and IL-6, which decrease the production of arachidonic acid (AA) and reactive oxygen species (ROS), thereby reducing the inflammatory response. Furthermore, creatine kinase (CK) is a marker of muscle damage, thus establishing its relationship with TNF-α and IL-6 (22)

Two mechanisms have been proposed through which omega-3 (N-3) fatty acids might affect DMIE and promote tissue repair. The first theory holds that N-3s circulating in the blood are absorbed by muscle and incorporated into the phospholipid bilayer, where—due to their cis-configuration carbon-carbon double bonds—they increase membrane fluidity and resistance to mechanical stress, thereby reducing damage caused by applied tension, preserving the structure of muscle fibers, and mitigating DMIE. In addition, N-3 promotes muscle repair through its anti-inflammatory properties. The incorporation of N-3 into the phospholipid bilayer of muscle occurs at the expense of omega-6 fatty acids, which constitute the main substrate for the signaling pathways that regulate the production of eicosanoids, a process catalyzed by the enzymes cyclooxygenase and lipoxygenase. The signaling cascade reduces the formation of pro-inflammatory lipid mediators (prostaglandin E2, leukotriene B4) and increases the production of lipid mediators with low pro-inflammatory potential, such as prostaglandin E3, which stimulates blood flow and facilitates the repair of damaged tissue (23).

During the inflammatory response commonly seen in muscle injuries, the excessive production of reactive oxygen species contributes to muscle damage, can prolong the inflammatory phase, and delay tissue regeneration. Excess ERO further damages the structure of muscle cells, which can lead to the loss of myocytes and a decrease in muscle strength (24). A recent study has demonstrated an inverse relationship between the amount of antioxidants in the diet and sarcopenia, highlighting the potential benefits of antioxidant intake with regard to muscle mass loss (25). Antioxidant supplementation has emerged as a potential ergogenic strategy aimed at reducing oxidative stress and modulating the inflammatory response, thereby accelerating recovery from muscle injuries and improving the quality of tissue regeneration.

Curcumin, whose chemical formula is 1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadien-3,5-dione, is the main phenolic compound in turmeric root, which is used in traditional Chinese medicine to treat pain, inflammation, and various diseases (26). Dietary polyphenols are known for their ability to modulate inflammation and muscle pain without negative side effects, making them ideal for use in a sports context (27), although their effectiveness as a supplement has been limited by their low bioavailability; therefore, finding a new form of supplementation could improve their bioavailability (28), thereby enhancing the body's ability to recover from exercise-induced muscle damage (EIMD). Curcumin has been shown to have membrane-protective effects, antioxidant capacity, and anti-inflammatory action. The anti-inflammatory properties attributed to curcumin are due to its ability to inhibit nuclear factor kappa (NF-κB), which is considered a protective and muscle-regenerating agent that plays an important role in regulating the physiological mechanisms of inflammation and protein degradation (29).

Curcumin exerts anti-inflammatory effects by regulating inflammatory signaling pathways and inhibiting the production of inflammatory mediators, as shown in Figure 1.2. Curcumin binds to Toll-like receptors (TLRs) and regulates transcription factors and signaling pathways, such as NF-κB, mitogen-activated protein kinases (MAPKs), and activator protein 1 (AP-1), thereby modulating inflammatory mediators. Furthermore, it can inhibit the activation of NF-κB through the peroxisome proliferator-activated receptor (PPARγ). It also exerts anti-inflammatory effects by regulating the Janus kinase/signal transducer and activator of transcription (JAK/STAT) signaling pathway. Finally, curcumin can directly inhibit the formation of the NLRP3 inflammasome or its activation by suppressing the NF-κB pathway, which could represent one of its main mechanisms for treating inflammatory diseases (26).

Collagen is the main extracellular component of connective tissue, which gives tissues their elasticity. Collagen accounts for 25–30% of the body's total protein (30). The collagen-rich tissues of the muscular extracellular matrix play an important functional role in skeletal muscle; therefore, it is argued that the structure and function of musculoskeletal tissues—such as tendons, ligaments, and bones—depend on their collagen-rich extracellular matrix. Collagen also provides stability and protection, in addition to contributing to the structural integrity of tissues. Therefore, there is a constant process of collagen breakdown and synthesis to perform these functions, with a turnover rate of 0.5–2% per day (31). This collagen turnover rate translates to a half-life of between two and five months (30).

Muscle soreness after exercise is the result of an inflammatory response caused by direct damage to skeletal muscle and connective tissue (32). Collagen peptide supplementation appears to improve serum markers related to recovery from exercise-induced damage (31).

Method

This undergraduate thesis employs a literature review methodology, with the aim of evaluating the effectiveness of certain nutritional supplements (ω-3, curcumin, and collagen) on exercise-induced muscle damage.

The search for related articles and publications took place between Monday, February 10, 2025, and Saturday, April 12, 2025. For the most part, the search for information was limited to two databases: PubMed and Google Scholar. The primary database used to obtain information was PubMed, while Google Scholar was used to supplement the necessary information from the other database.

With regard to PubMed, several keywords were used, including the following:

- *"Omega-3 Supplementation"*
- *"PUFA Supplementation"*
- *"Fish Oil Supplementation"*
- *"Collagen Peptide Supplementation"*
- *"Curcumin Supplementation"*
- *"Inflammation"*
- *"Exercise-induced muscle damage"*
- *"Muscle Soreness"*
- *"Muscle Damage"*

All of these terms were used as MeSH terms, in combination with Boolean operators, such as: ("*Omega-3 Supplementation*" OR "*PUFA*" OR "*Fish oil*") AND ("*Exercise-induced muscle damage*" OR "*Muscle soreness*"). In this particular case, 5,099 results were obtained after applying the filters.

To ensure a more precise search, the following filters were applied: articles written only in English or Spanish, published within the last 5 years, and conducted exclusively in humans. The same strategy was replicated on Google Scholar, using similar keywords and including only studies published in the last five years.

In order to provide valuable information for the review, a set of inclusion and exclusion criteria was outlined. The inclusion criteria were scientific articles related to the topic published in the last five years, including meta-analyses, systematic reviews, and clinical trials, as well as books and clinical guidelines. Conversely, exclusion criteria have been established to include any studies that could bias the accuracy of the information, such as animal studies, in vitro studies, or studies older than five years, with certain exceptions that carry significant weight in the field of research.

Finally, the impact factors of the various journals that published the analyzed studies were verified using Scimago Journal & Country Rank, with an SCR journal impact factor > 1.5 established as the criterion.

Results

First, Table 1 summarizes the studies that evaluate the effect of omega-3 fatty acid supplementation on DMIE.

The studies analyzed show mixed results. Except in the study by Barquilha et al. (20), all studies were conducted in young male populations involved in sports, which may introduce potential biases when extrapolating the results to other population groups.

Barquilha et al. (20) and VanDusseldorp et al. (33), through high-dose fish oil supplementation over extended periods—three grams per day for six weeks (20) and six grams per day for seven and a half weeks (33), reported significant reductions in CK and LDH levels. On the other hand, Yang et al. (34) They reported an antioxidant effect and a decrease in CK levels following ten days of krill oil supplementation and a single training session, although there were no changes in inflammatory markers.

In contrast, the studies by Visconti et al. (35) and Kyriakidou et al. (22) They administered up to 8 g/day of N-3 for approximately one month (35) and 3 g/day for four weeks (22). None of the trials showed significant differences compared with the placebo group, either in biomarkers of muscle damage or in those related to inflammation.

Overall, the duration of supplementation—whether prolonged (20,22,33) or short (34) does not appear to be a determining factor in the results, but rather the source or composition of the supplement, the dose, or the individual's susceptibility.

The effect on systemic inflammation appears uncertain, as only the study by Barquilha et al. (20) found favorable changes in inflammation markers, despite using doses similar to or higher than those used by other researchers.

Taken together, these findings suggest that the efficacy of omega-3 fatty acids does not depend solely on the duration of supplementation, but may be influenced by factors such as the quality and source of the supplement, as well as its fatty acid composition and EPA/DHA ratio, the administered dose, and the individual susceptibility of those receiving the supplement.

Table 1. Studies linking omega-3 supplementation to DMIE.

Author and year	Study Type	Sample	Speech	Results
Barquilha et al. 2023 (20)	Randomized clinical trial	16 untrained young men	• Supplementation with 3 capsules per day of omega-3 or a placebo for 6 weeks. • Assessment of the biomarkers CK, LDH, IL-6, PCR, and redox balance following strength training.	• Reduction of exercise-induced muscle damage, inflammation, and oxidative stress. • Improved redox balance following supplementation.
Kyriakidou et al. 2021 (22)	Randomized clinical trial	14 young, healthy men	• Supplementation with 3 g/day of omega-3 or a placebo for 4 weeks. • DMIE Assessment Following a Running Protocol and Analysis of CK, IL-6, TNF-α, and Perceived Muscle Pain.	• Significant reduction in muscle pain with omega-3. • Lower levels of IL-6 in the group receiving supplementation. • No significant differences were observed for CK and TNF-α.
VanDusseldorp et al. 2020 (33)	Randomized clinical trial	32 young men trained in endurance	• Random assignment to placebo, 2 g/day, 4 g/day, or 6 g/day of omega-3 for 7.5 weeks. • Assessment of performance, muscle pain, and biomarkers following eccentric exercise.	• 6 g/day optimized recovery and reduced muscle pain. • 2 g/day and 4 g/day showed no significant benefits compared with placebo.

Yang et al. 2023 (34)	Randomized clinical trial	30 young men trained in endurance	• Supplementation with 3 g/day of krill oil or a placebo, 3 days before and 3 days after eccentric exercise. • Assessment of CK, LDH, SOD, CAT, ERO, MDA, IL-2, IL-6, and TNF-α.	• Significant reduction in CK levels 24 and 48 hours after exercise. • Increased levels of SOD and CAT, and decreased levels of MDA. • No differences in IL-2, IL-6, and TNF-α compared with placebo.
Visconti et al. 2021 (35)	A randomized, double-blind, placebo-controlled clinical trial	26 young men trained in endurance	• Placebo supplementation, 6 g/day or 8 g/day of omega-3 for 33 days. • Induction of Muscle Damage Through Eccentric Exercise • CK Analysis and Perceived Muscle Pain.	• Elevated CK levels were observed in all post-exercise groups. • There were no significant differences in muscle recovery. • No dose-response relationship was observed in recovery.

Second, the evidence regarding the use of curcumin for the treatment of DMIE is summarized in Table 2.

With regard to the modulation of the inflammatory response resulting from muscle damage, only the study by Tanner et al. (27) showed a statistically significant reduction in pro-inflammatory biomarkers following administration of a combined supplement of curcumin and pomegranate extract. Since this intervention involves a supplement containing several bioactive substances, its positive effects cannot be attributed solely to curcumin.

For their part, Mallard et al. (28) and Basham et al. (36) designed independent protocols with different doses but similar durations: three grams of curcumin daily for four weeks (28) or one and a half grams of curcumin for four weeks (36), but none of the studies reported significant changes in IL-6, IL-10, or TNF-α levels, nor in the serum biomarkers of muscle damage—CRP, LDH, and CK. The effectiveness of curcumin supplementation may depend on the dose threshold, the duration of supplementation, or even interindividual factors, such as genetic or nutritional factors.

With regard to muscle perception and damage, the clinical trial by Mallard et al. (28) It reported a significantly higher mean score for perceived muscle pain in the curcumin-treated group compared with the placebo group. In turn, Hillman et al. (37) They observed a reduction in perceived pain two and three days after taking 500 mg of curcumin twice daily. On the other hand, neither Basham et al. (36) nor Tanabe et al. (38) They observed significant differences in pain perception. The inconsistency in this evidence may be due to the variability of the different protocols used to induce DMIE, ranging from resistance exercises and plyometric jumps to soccer matches and participation in a half marathon.

Differences in the doses administered (ranging from 180 mg to 3 g per day), the duration of the supplementation protocol (ranging from a single dose to four weeks), and the protocol used to induce EIMD, as well as the small sample size (between 15 and 28 participants) and the use of combined supplementation sources, are factors that add complexity to the comparison of these studies.

Table 2. Studies linking curcumin supplementation to DMIE

Author and year	Study Type	Sample	Speech	Results
Tanner et al. 2021 (27)	Feasibility Study	18 recreational runners who completed a half marathon	• Supplementation with 1 g/day of curcumin combined with pomegranate extract compared to a control group. • Administration of the supplement before and after the race. • Measurement of inflammatory proteins and inflammation-related RNA.	• Attenuation of the systemic inflammatory response in the group receiving supplementation. • No adverse effects. • Proposal to combine curcumin with pomegranate as an effective strategy for reducing DMIE.
Mallard et al. 2021 (28)	Randomized, double-blind, placebo-controlled clinical trial	28 physically active young adults	• A curcumin-containing sports drink versus a placebo during endurance exercise to exhaustion. • Measurements taken before and up to 3 days after exercise of perceived muscle pain, lactate, LDH, CRP, IL-6, IL-10, myoglobin, and TNF-α	• Lower lactate levels in the curcumin group. • Lower perceived muscle pain scores in the intervention group. • Inflammatory biomarkers showed no significant differences. • No evidence of improvement in DMIE recovery.

Basham et al., 2020 (36)	Randomized, double-blind, placebo-controlled clinical trial	19 physically active young men	• 1.5 g/day of curcumin for 28 days. Induction of damage through eccentric exercises. • Assessment of total antioxidant capacity, MDA, TNF-α, CK, and perceived muscle pain	• Reduction in perceived exercise-induced muscle damage. • The inflammatory response was not modulated.
Tanabe et al. 2024 (38)	A randomized, crossover, double-blind, placebo-controlled clinical trial	15 young college-level soccer players	• 180 mg/day of curcumin vs. placebo, starting 1 hour before the game and continuing for up to 2 days afterward. • Measurement of muscle pain, jumping ability, and biomarkers of damage and inflammation	• No significant differences in muscle pain, performance, or biomarkers were observed between the groups. • No positive effect of curcumin on DMIE was observed.
Hillman et al. 2022 (37)	Randomized, double-blind, placebo-controlled clinical trial	22 adults, 5 women, and 17 men	• 500 mg of curcumin (or a placebo) twice a day for 10 days. • Hopping protocol for generating DMIE. • Assessment of CK, erythrocyte sedimentation rate, and perceived muscle pain (before and after)	• Elevated CK levels and pain in both groups after exercise. • Less perceived pain in the group that received curcumin supplementation. • Higher CK levels in the placebo group, but not statistically significant

				• No reduction in inflammation or pain indicators.

Finally, Table 3 presents data on studies that evaluate the relationship between collagen supplementation and DMIE.

The reviewed studies suggesting a positive effect used collagen supplementation of approximately 10 to 15 grams for at least four weeks, which may alleviate DMIE and accelerate functional recovery after exercise. The clinical trial by Kuwaba et al. (32), showed significant reductions in perceived pain and fatigue immediately following the exercise protocol, with no positive effect on CK and LDH levels. Similarly, studies such as those by Bischof et al. (39) and López et al. (40) showed a decrease in biomarkers related to muscle damage (CK, LDH, CRP, and myoglobin) following a prolonged supplementation intervention, suggesting that longer protocols—ranging from six (40) and twelve weeks of supplementation (39) could be effective in mitigating muscle damage and inflammation following exercise.

On the other hand, shorter-duration protocols, such as the intervention study conducted by Prowting et al. (41), in which 15 grams of collagen were administered daily over the course of a week. The study participants did not show any improvement in pain perception, but collagen supplementation reportedly did have a positive effect on athletic performance, suggesting that the benefits regarding pain and muscle recovery may require a longer supplementation regimen.

Similarly, the study conducted by Robberchts et al. (42) The study examined the partial replacement of whey protein with collagen, with the first group receiving only 45 grams of whey protein, while the second group received a combination of 20 grams of collagen and 25 grams of whey protein. None of the groups showed significant positive differences, so the use of collagen may not be necessary as long as the individuals' protein requirements are already being met.

In terms of functional recovery, most studies conclude that participants who receive collagen peptide supplementation maintain higher performance levels compared to control groups, which could shorten the rest time between sessions and reduce the risk of injuries caused by accumulated fatigue.

The heterogeneity of the studies highlights their limitations, as the different doses used (ranging from 3 to 20 grams per day), the duration of the supplementation protocol (ranging from a single acute dose to supplementation over twelve weeks), the differences in the exercise protocols used to induce muscle damage, and the small sample sizes represent methodological limitations that must be taken into account.

Table 3. Studies linking collagen supplementation and DMIE

Author and year	Study Type	Sample	Speech	Results
Kuwaba et al. 2023 (32)	A randomized, crossover, double-blind, placebo-controlled clinical trial	Middle-aged men with no experience in sports (*n* = 20, 52.6 ± 5.8 years)	• 10 g/day of collagen peptides or a placebo for 33 days. • Single exercise protocol for Day 29. • Isometric contraction, range of motion, CK, and LDH.	• Reduced perception of muscle pain and post-exercise fatigue. • Improved strength at 48 hours. • CK and LDH showed no significant differences between groups.
Bischof et al. 2024 (39)	Randomized, double-blind, placebo-controlled clinical trial	55 sedentary or moderately active men	• 15 g/day of collagen peptides or a placebo for 12 weeks. • Three training sessions per week. • CK, LDH, myoglobin, and CRP tests before and up to 2 days after exercise.	• A significant reduction in CK, LDH, and myoglobin was observed in the group that received collagen supplementation. • Improved post-exercise muscle regenerative capacity.
Prowting et al. 2021 (41)	Randomized clinical trial	Men familiar with endurance training (*n* = 15)	• 15 g/day of collagen peptides or a placebo for 7 days. • Eccentric Jump Protocol. • Measurements of isometric	• Maintaining performance over 24 hours. • There were no changes in pain perception.

			strength, jump height, perceived pain, and collagen turnover at 24, 48, and 120 hours.	• There were no changes in the collagen turnover rate at 24 and 48 hours.
Lopez et al. 2015 (40)	Randomized, double-blind, placebo-controlled clinical trial	8 healthy, physically active men with a mean age of 29.3 years	• 3 g/day of collagen (BioCell) or a placebo for 6 weeks. • Two resistance exercises on days 43 and 46. • Assessment of CK, LDH, CRP, perceived muscle pain, and functional recovery.	• Significant reduction in CK, LDH, and CRP in the group that received collagen supplementation. • Less loss of performance in the group that received the supplement. • Better adaptation to training in the group that received supplements.
Robberechts et al. 2024 (42)	Randomized clinical trial	22 healthy young men involved in sports (24.4 ± 2.4 years)	• 20 g/day of collagen peptides + 25 g/day of whey protein versus 45 g/day of whey protein. • 3-Week Eccentric Exercise Protocol. • Measurement of isometric strength, CK, and functional	• A 10% decrease in isometric strength in both groups. • Increased CK levels in both groups. • Partially replacing whey with collagen does not improve muscle damage or

			recovery.	performance.

Discussion and Conclusions

Based on the evaluation conducted in this study, it is important to note that the field of sports supplementation is highly controversial and heavily influenced by potential conflicts of interest, making it difficult to obtain high-quality information and to establish conclusions as definitive.

First, trials that used 3–6 g/day of omega-3 for at least six weeks showed a positive effect on recovery from DMIE. In contrast, shorter interventions and those involving <3 g/day did not yield clear benefits. Further studies are needed to establish specific recommendations, but the evidence gathered suggests that a minimum amount and duration are required to observe positive effects on DMIE.

With regard to curcumin, in studies involving daily doses ranging from 180 mg to 3 g for up to four weeks, no benefit was observed for DMIE. The only study that showed a positive effect is potentially biased by conflicts of interest, in addition to its combination with another active ingredient. It would be interesting to evaluate in the future whether there are other dosages and protocols that do have positive effects.

Finally, daily administration of 10–15 g of collagen for at least four weeks improved pain perception and had a positive effect on biomarkers of muscle pain, suggesting a beneficial effect on recovery from DMIE, whereas shorter treatment regimens had no effect on pain, nor did the partial replacement of total protein levels with collagen peptides.

The evidence evaluated in this bachelor's thesis is mixed; therefore, to accurately assess the results and make recommendations, it is necessary to conduct randomized, double-blind, placebo-controlled clinical trials with a larger and more diverse sample size, varying the exercise protocols and controlling participants' dietary patterns.

References

1. Owens DJ, Twist C, Cobley JN, Howatson G, Close GL. Exercise-induced muscle damage: What is it, what causes it and what are the nutritional solutions? Eur J Sport Sci. 2019;19(1):71-85. https://pubmed.ncbi.nlm.nih.gov/30110239/

2. Markus I, Constantini K, Hoffman JR, Bartolomei S, Gepner Y. Exercise-induced muscle damage: mechanism, assessment and nutritional factors to accelerate recovery. Eur J Appl Physiol. April 2021;121(4):969-92. https://pubmed.ncbi.nlm.nih.gov/33420603/

3. Clarkson PM, Hubal MJ. Exercise-Induced Muscle Damage in Humans. Am J Phys Med Rehabil. November 2002;81(11):S52. https://pubmed.ncbi.nlm.nih.gov/12409811/

4. Papadopoulou SK, Papadimitriou K, Voulgaridou G, Georgaki E, Tsotidou E, Zantidou O, et al. Exercise and Nutrition Impact on Osteoporosis and Sarcopenia—The Incidence of Osteosarcopenia: A Narrative Review. Nutrients. December 2021;13(12):4499. https://pubmed.ncbi.nlm.nih.gov/34960050/

5. Jannas-Vela S, Espinosa A, Candia AA, Flores-Opazo M, Peñailillo L, Valenzuela R. The Role of Omega-3 Polyunsaturated Fatty Acids and Their Lipid Mediators on Skeletal Muscle

Regeneration: A Narrative Review. Nutrients. February 8, 2023;15(4):871. https://pubmed.ncbi.nlm.nih.gov/36839229/

6. Powers SK, Deminice R, Ozdemir M, Yoshihara T, Bomkamp MP, Hyatt H. Exercise-induced oxidative stress: Friend or foe? J Sport Health Sci. September 2020;9(5):415-25. https://pubmed.ncbi.nlm.nih.gov/32380253/

7. Stožer A, Vodopivc P, Križančić Bombek L. Pathophysiology of exercise-induced muscle damage and its structural, functional, metabolic, and clinical consequences. Physiol Res. August 31, 2020;69(4):565-98. https://pubmed.ncbi.nlm.nih.gov/32672048/

8. Methenitis S, Stergiou I, Antonopoulou S, Nomikos T. Can Exercise-Induced Muscle Damage Be a Good Model for the Investigation of the Anti-Inflammatory Properties of Diet in Humans? Biomedicines. January 5, 2021;9(1):36. https://pubmed.ncbi.nlm.nih.gov/33466327/

9. Abreu R, Oliveira CB, Costa JA, Brito J, Teixeira VH. Effects of dietary supplements on athletic performance in elite soccer players: a systematic review. J Int Soc Sports Nutr. 20(1):2236060. https://pubmed.ncbi.nlm.nih.gov/37462346/

10. Trastornos musculoesqueléticos [Internet]. [cited April 12, 2025]. Retrieved from: https://www.who.int/es/news-room/fact-sheets/detail/musculoskeletal-conditions

11. Rocha-Rodrigues S, Leão C, Marinho M, Afonso J. Nutritional approaches applied to recovery of skeletal muscle injury immobilization: a review of nutrition aid for sport trauma. J Sports Med Phys Fitness. December 2024;64(12):1303-12. https://pubmed.ncbi.nlm.nih.gov/39287583/

12. Papadopoulou SK. Rehabilitation Nutrition for Injury Recovery of Athletes: The Role of Macronutrient Intake. Nutrients. August 2020;12(8):2449. https://pubmed.ncbi.nlm.nih.gov/32824034/

13. Giraldo-Vallejo JE, Cardona-Guzmán MÁ, Rodríguez-Alcivar EJ, Kočí J, Petro JL, Kreider RB, et al. Nutritional Strategies in the Rehabilitation of Musculoskeletal Injuries in Athletes: A Systematic Integrative Review. Nutrients. February 5, 2023;15(4):819. https://pubmed.ncbi.nlm.nih.gov/36839176/

14. Marshall RN, Smeuninx B, Morgan PT, Breen L. Nutritional Strategies to Offset Disuse-Induced Skeletal Muscle Atrophy and Anabolic Resistance in Older Adults: From Whole-Foods to Isolated Ingredients. Nutrients. May 25, 2020;12(5):1533. https://pubmed.ncbi.nlm.nih.gov/32466126/

15. Agostini D, Gervasi M, Ferrini F, Bartolacci A, Stranieri A, Piccoli G, et al. An Integrated Approach to Skeletal Muscle Health in Aging. Nutrients. April 7, 2023;15(8):1802. https://pubmed.ncbi.nlm.nih.gov/37111021/

16. SantAnna JPC, Pedrinelli A, Hernandez AJ, Fernandes TL. Muscle Injury: Pathophysiology, Diagnosis, and Treatment. Rev Bras Ortop. January 20, 2022;57(1):1-13. https://pmc.ncbi.nlm.nih.gov/articles/PMC8856841/

17. Tanabe Y, Fujii N, Suzuki K. Dietary Supplementation for Attenuating Exercise-Induced Muscle Damage and Delayed-Onset Muscle Soreness in Humans. Nutrients. December 24, 2021;14(1):70. https://pubmed.ncbi.nlm.nih.gov/35010943/

18. Cheung K, Hume P, Maxwell L. Delayed onset muscle soreness: treatment strategies and performance factors. Sports Med Auckl NZ. 2003;33(2):145-64. https://pubmed.ncbi.nlm.nih.gov/12617692/

19. Fernández-Lázaro D, Arribalzaga S, Gutiérrez-Abejón E, Azarbayjani MA, Mielgo-Ayuso J, Roche E. Omega-3 Fatty Acid Supplementation on Post-Exercise Inflammation, Muscle Damage, Oxidative Response, and Sports Performance in Physically Healthy Adults-A Systematic Review of Randomized Controlled Trials. Nutrients. June 27, 2024;16(13):2044. https://pubmed.ncbi.nlm.nih.gov/38999792/

20. Barquilha G, Dos Santos CMM, Caçula KG, Santos VC, Polotow TG, Vasconcellos CV, et al. Fish Oil Supplementation Improves the Repeated-Bout Effect and Redox Balance in 20-30-Year-Old Men Submitted to Strength Training. Nutrients. March 31, 2023;15(7):1708. https://pubmed.ncbi.nlm.nih.gov/37049548/

21. Xin G, Eshaghi H. Effect of omega-3 fatty acids supplementation on indirect blood markers of exercise-induced muscle damage: Systematic review and meta-analysis of randomized controlled trials. Food Sci Nutr. September 21, 2021;9(11):6429-42. https://pubmed.ncbi.nlm.nih.gov/34760272/

22. Kyriakidou Y, Wood C, Ferrier C, Dolci A, Elliott B. The effect of Omega-3 polyunsaturated fatty acid supplementation on exercise-induced muscle damage. J Int Soc Sports Nutr. January 13, 2021;18(1):9. https://pubmed.ncbi.nlm.nih.gov/33441158/

23. Mackay J, Bowles E, Macgregor LJ, Prokopidis K, Campbell C, Barber E, et al. Fish oil supplementation fails to modulate indices of muscle damage and muscle repair during acute recovery from eccentric exercise in trained young males. Eur J Sport Sci. August 2023;23(8):1666-76. https://pubmed.ncbi.nlm.nih.gov/37010103/

24. Wang K, Zhou Q, Jiang Z, Liu S, Tang H. The inverse associations between composite-dietary-antioxidant-index and sarcopenia risk in US adults. Front Endocrinol [Internet]. September 17 2024 [citado March 22, de 2025];15. https://pmc.ncbi.nlm.nih.gov/articles/PMC11442324/

25. Yao Y, Yao J, Tang D, Wang H, Zhang H, Qiu J, et al. Dietary antioxidant capacity and sarcopenia: A study from US population. Nutr Burbank Los Angel Cty Calif. February 2025;130:112613. https://pubmed.ncbi.nlm.nih.gov/39561653/

26. Peng Y, Ao M, Dong B, Jiang Y, Yu L, Chen Z, et al. <p>Anti-Inflammatory Effects of Curcumin in the Inflammatory Diseases: Status, Limitations and Countermeasures</p>. Drug Des Devel Ther. November 2 2021;15:4503-25. https://pubmed.ncbi.nlm.nih.gov/34754179/

27. Tanner EA, Gary ,Melody A., Davis ,Asheal A., Michalik ,Stephan, and McFarlin BK. Alterations in Systemic Inflammatory Response Following a Half-Marathon Race with a Combined Curcumin and Pomegranate Supplement: A Feasibility Study. J Diet Suppl. August 23, 2021;18(5):461-77. https://pubmed.ncbi.nlm.nih.gov/32657201/

28. Mallard AR, Briskey ,David, Richards, BExSSc ,Andrew, and Rao A. Curcumin Improves Delayed Onset Muscle Soreness and Postexercise Lactate Accumulation. J Diet Suppl. August 23, 2021;18(5):531-42. https://pubmed.ncbi.nlm.nih.gov/32705925/

29. Fernández-Lázaro D, Mielgo-Ayuso J, Seco Calvo J, Córdova Martínez A, Caballero García A, Fernandez-Lazaro CI. Modulation of Exercise-Induced Muscle Damage, Inflammation, and Oxidative Markers by Curcumin Supplementation in a Physically Active Population: A Systematic Review. Nutrients. February 2020;12(2):501. https://pubmed.ncbi.nlm.nih.gov/32075287/

30. Holwerda AM, van Loon LJC. The impact of collagen protein ingestion on musculoskeletal connective tissue remodeling: a narrative review. Nutr Rev. May 9, 2022;80(6):1497-514. https://pubmed.ncbi.nlm.nih.gov/34605901/

31. Bischof K, Stafilidis S, Bundschuh L, Oesser S, Baca A, König D. Influence of specific collagen peptides and 12-week concurrent training on recovery-related biomechanical characteristics following exercise-induced muscle damage-A randomized controlled trial. Front Nutr. 2023;10:1266056. https://pubmed.ncbi.nlm.nih.gov/38035363/

32. Kuwaba K, Kusubata ,Masashi, Taga ,Yuki, Igarashi ,Hiroshi, Nakazato ,Koichi, and Mizuno K. Dietary collagen peptides alleviate exercise-induced muscle soreness in healthy middle-aged males: a randomized double-blinded crossover clinical trial. J Int Soc Sports Nutr. December 31, 2023;20(1):2206392. https://pubmed.ncbi.nlm.nih.gov/37133292/

33. VanDusseldorp TA, Escobar KA, Johnson KE, Stratton MT, Moriarty T, Kerksick CM, et al. Impact of Varying Dosages of Fish Oil on Recovery and Soreness Following Eccentric Exercise. Nutrients. July 27, 2020;12(8):2246. https://pubmed.ncbi.nlm.nih.gov/32727162/

34. Yang S, He Q, Shi L, Wu Y. Impact of Antarctic krill oil supplementation on skeletal muscle injury recovery after resistance exercise. Eur J Nutr. April 2023;62(3):1345-56. https://pubmed.ncbi.nlm.nih.gov/36566465/

35. Visconti LM, Cotter JA, Schick EE, Daniels N, Viray FE, Purcell CA, et al. Impact of varying doses of omega-3 supplementation on muscle damage and recovery after eccentric resistance exercise. Metab Open. December 2021;12:100133. https://pubmed.ncbi.nlm.nih.gov/34693240/

36. Steven A. Basham M, Hunter S. Waldman P, Ben M. Krings P, John Lamberth P, JohnEric W. Smith P, Matthew J. McAllister P. Effect of Curcumin Supplementation on Exercise-Induced Oxidative Stress, Inflammation, Muscle Damage, and Muscle Soreness. J Diet Suppl [Internet]. July 3, 2020 [citado March 23, 2025]; https://pubmed.ncbi.nlm.nih.gov/31025894/

37. Hillman AR, Gerchman ,Alexa, and O'Hora E. Ten Days of Curcumin Supplementation Attenuates Subjective Soreness and Maintains Muscular Power Following Plyometric Exercise. J Diet Suppl. April 22, 2022;19(3):303-17. https://pubmed.ncbi.nlm.nih.gov/33480271/

38. Tanabe Y, Kondo E, Sagayama H, Shimizu K, Yasumatsu M, Nakamura D, et al. Impact of curcumin supplementation on exercise performance and muscle damage after a soccer match: a double-blind placebo-controlled cross-over study. Eur J Appl Physiol. July 2024;124(7):2161-70. https://pubmed.ncbi.nlm.nih.gov/38436665/

39. Bischof K, Stafilidis S, Bundschuh L, Oesser S, Baca A, König D. Reduction in systemic muscle stress markers after exercise-induced muscle damage following concurrent training and supplementation with specific collagen peptides - a randomized controlled trial. Front Nutr. 2024;11:1384112. https://pubmed.ncbi.nlm.nih.gov/38590831/

40. Lopez HL, Ziegenfuss TN, Park J. Evaluation of the Effects of BioCell Collagen, a Novel Cartilage Extract, on Connective Tissue Support and Functional Recovery From Exercise. Integr Med Encinitas Calif. junio de 2015;14(3):30-8. https://pubmed.ncbi.nlm.nih.gov/26770145/

41. Prowting JL, Bemben D, Black CD, Day EA, Campbell JA. Effects of Collagen Peptides on Recovery Following Eccentric Exercise in Resistance-Trained Males-A Pilot Study. Int J Sport Nutr Exerc Metab. January 1, 2021;31(1):32-9. https://pubmed.ncbi.nlm.nih.gov/33186897/

42. Robberechts R, Poffé C, Ampe N, Bogaerts S, Hespel P. Partly Substituting Whey for Collagen Peptide Supplementation Improves Neither Indices of Muscle Damage Nor Recovery of Functional Capacity During Eccentric Exercise Training in Fit Males. Int J Sport Nutr Exerc Metab. March 1, 2024;34(2):69-78. https://pubmed.ncbi.nlm.nih.gov/37922892/