Collagen Supplementation: Benefits and Potential Risks for Athletes and Health-Conscious Individuals

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Abstract

Collagen is the main structural protein of connective tissues and plays an essential role in the health of skin, joints, ligaments, tendons and muscle mass. Supplementation with hydrolyzed collagen may support skin elasticity and hydration, reduce joint pain, support muscle protein synthesis and contribute to the integrity of the musculoskeletal system, especially when combined with exercise and a healthy lifestyle. Preliminary evidence also indicates a potential role in maintaining intestinal health. Ingested collagen supports endogenous synthesis rather than serving as a complete substitute. Supplementation is a valuable complementary strategy for preventing tissue damage and maintaining physical performance.

Keywords: *collagen, protein supplements, skin, musculoskeletal system, muscle hypertrophy, intestinal health.*

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1. Introduction

Collagen is an essential structural protein that supports the health and function of the skin, bones, joints, and muscles. It plays a central role in maintaining tissue integrity and the proper functioning of organs, as evidenced by research from Proksch et al. (2014) and Bello & Oesser (2006). However, as individuals age, the body's natural collagen production gradually decreases. This decline can significantly impact skin health, reduce joint mobility, and contribute to muscle mass loss, as noted by Shaw & Martens (2020).

Given this decline in endogenous collagen synthesis, collagen supplements are often recommended to help counteract collagen loss. Despite their popularity, questions remain about the true effectiveness of these supplements in preventing or treating problems arising from reduced collagen production. The literature, including work by Zdzieblik, Oesser & Baumstark (2017), explores whether supplementation is indeed the optimal solution.

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This article aims to provide an in-depth analysis of current international research on collagen protein supplementation. Specifically, it will focus on three primary areas where collagen supplements are commonly recommended: the reduction of visible signs of skin aging, support for the musculoskeletal system, and the improvement of intestinal health.

- Reducing the visible signs of skin ageing by enhancing dermal elasticity and firmness;
- Supporting the musculoskeletal system by improving joint and tendon health, as well as meeting protein needs for maintaining muscle mass;
- Promoting intestinal health through potential positive effects on mucosal barrier integrity and microbiota balance.

In addition, this article will assess the impact of collagen supplementation within an integrated lifestyle framework, considering its interactions with nutrition, physical activity, and stress management—all critical components in sustaining homeostasis and general well-being. The discussion will further include an examination of quality standards for hydrolyzed collagen supplements and a review of potential adverse effects, aiming to offer a comprehensive evaluation of the advantages and limitations associated with this supplementation approach.

2. The Role of Collagen in the Body and its Importance for Physical Performance

Collagen is the most abundant structural protein in the human body, constituting approximately 25–30% of total protein. This fibrous protein is essential for the integrity of connective tissues, being present in skin, bones, tendons, ligaments, cartilage, blood vessels and teeth (Bello & Oesser, 2006). Its triple helical structure confers mechanical strength and stability, while its amino acid composition — rich in glycine, proline and hydroxyproline — is decisive for the biomechanical properties of tissues (Shoulders & Raines, 2009).

With advancing age, endogenous collagen synthesis progressively decreases, affecting the integrity of the skin, musculoskeletal system and bones. This has repercussions not only on general health and aesthetics, but also on sports performance, reducing ligament strength, tendon elasticity and the ability of muscles to adapt to effort (Shaw & Martens, 2020).

Collagen use in the sports context

Collagen supplementation has gained popularity among athletes and people concerned about health and aesthetics due to its potential to support connective tissue function, skin integrity, muscle mass and, more recently, intestinal health. However, the effects of this supplementation are not isolated and are best achieved in the context of a healthy lifestyle, which includes regular physical exercise, a balanced diet and adequate sleep (Shaw & Martens, 2020).

1. Tendons and ligaments: Collagen is the main component of these structures, which transfer the force generated by the muscles to the bones. Decreased endogenous synthesis can increase the risk of injuries and musculotendinous strains. Supplementation with hydrolyzed collagen, associated with strength training, can stimulate local protein synthesis and support adaptation to effort (Shaw et al., 2017). Also, collagen supplementation, combined with light strength exercises or stretching, can stimulate collagen synthesis in ligaments and tendons, supporting adaptation to exertion and preventing injuries (Shaw et al., 2017). In the context of tendon injuries, enhanced collagen synthesis can promote more rapid recovery by providing the affected tissues with essential structural components required for optimal healing. Collagen's beneficial role is especially significant during the post-injury regenerative phase, when the body's need for structural proteins is heightened. A review of current literature indicates no reported adverse effects associated with collagen supplementation for tendon recovery, thereby supporting its favourable safety profile in this application.
   While definitive dosage recommendations have not yet been universally established, the prevailing research supports a daily intake of 10 to 20 grams of collagen. This dosage range is most frequently cited across published studies (Serano, 2022).
2. Cartilage and joints: Type II collagen predominates in cartilage and contributes to maintaining elasticity and cushioning in the joints. Supplementation can improve joint pain and mobility, especially among athletes who experience repetitive strain or those with joint degeneration (Khatri et al., 2021; Zdzieblik et al., 2017). Collagen supplementation may contribute to:
   - Reducing joint pain, including in people with osteoarthritis
   - Improving joint mobility and flexibility
   - Supporting the regeneration of ligaments and tendons after intense exertion (Khatri et al., 2021; Zdzieblik et al., 2017).
   Collagen peptides possess protein properties that support joint integrity and may help alleviate joint pain (Munoz and Johnson, 2019). These benefits are attributed to collagen's ability to increase its concentration within connective tissues, thereby facilitating the repair and recovery of various connective and contractile structures. Supplementation with collagen can enhance the body's capacity to maintain and restore the normal function not only of joints but also of tendons, ligaments, and muscles by providing additional collagen to support tissues.
3. Muscle and performance: Although collagen is not a complete protein in terms of amino acids, studies show that, when combined with resistance training, it can support muscle mass and strength gains, especially in senior athletes (Zdzieblik et al., 2015). The effect is not comparable to

that of complete proteins, but it contributes to optimising protein synthesis and supporting the structure of connective tissues involved in movement. Regarding muscle hypertrophy, collagen contains essential amino acids such as glycine, proline and arginine, which can support muscle protein synthesis, especially in older people or athletes following resistance programs.

Studies show that collagen peptide supplementation, associated with strength training, can increase muscle mass and strength in older adults (Zdzieblik et al., 2015). However, collagen has a lower biological value than complete proteins (such as whey, eggs, and meat), so it cannot be considered a complete substitute for them.

4. Recovery and adaptation to exercise: The amino acids in collagen, once absorbed, serve as a substrate for tissue regeneration, helping to rebuild ligaments, tendons, and muscles after intense workouts. In endurance or strength sports, collagen can be an adjuvant factor in maintaining tissue strength and post-workout recovery, improving recovery time between training sessions.

Ingested collagen does not reach the tissues intact; it is digested into its constituent amino acids, absorbed in the intestine and used by the body for its own synthesis. Cofactors such as vitamin C are essential for the hydroxylation of proline and lysine, a critical step in the formation of collagen fibers (Proksch et al., 2014). Thus, supplementation should be considered a support for endogenous synthesis, not a substitute for it. Collagen supplementation can be useful in preventing injuries, supporting joints and tendons and optimizing post-workout recovery, but maximum efficiency is achieved only in combination with a balanced lifestyle, adequate nutrition and structured training.

As mentioned earlier, collagen is a structural protein essential for the integrity of connective tissues, including skin, bones, joints, ligaments, and tendons. Collagen supplementation has become a common practice in sports nutrition and preventive medicine, associated with maintaining musculoskeletal and skin health and, more recently, intestinal health. It is important to emphasize that the effects of supplementation depend on the context of lifestyle, including physical activity, balanced nutrition, proper hydration, sleep and stress management. Collagen administered in isolation cannot replace factors that stimulate endogenous synthesis and the body's natural regenerative processes (Shaw & Martens, 2020).

Effect of collagen supplementation on skin and gut health

Collagen is the main component of the dermis, providing the skin with elasticity and firmness and improving dermis hydration. The collagen peptides stimulate fibroblasts to produce endogenous collagen and other structural proteins, such as elastin and hyaluronic acid (Proksch et al., 2014).

Physical activity plays a significant role in skin health by:

- Improvement of blood circulation – increased blood flow favors the transport of nutrients and oxygen to the dermis, stimulating cellular metabolism and skin tissue repair.
- Secretion of interleukin-15 – a cytokine produced by muscles during physical activity that stimulates fibroblast proliferation and collagen synthesis (Crane et al., 2015).
- Activation of endogenous antioxidant mechanisms – physical exercise increases the production of free radicals, which in turn induce the body's own antioxidant mechanisms, protecting the skin against oxidative stress (de Sousa, 2017).
- Dermis structure – the study by Nishikori et al. (2023) showed that both aerobic and strength training can improve the elasticity and thickness of the dermis, giving the skin a younger appearance.

Aiming the Gut Health collagen administration may have effects on:

- Intestinal mucosal integrity
- Intestinal barrier function and inflammation reduction
- Potential for balancing microbiota (Li et al., 2021).

This area of collagen effects is less studied, but preliminary evidence suggests a positive role in supporting digestive health, especially in the context of leaky gut syndrome or chronic inflammation. - Amino acids such as glycine, glutamine, and proline, contained in collagen supplements, are essential for maintaining the integrity of the gut barrier, reducing inflammation and intestinal permeability, supporting the balance of the gut microbiota (Li et al., 2021).

Collagen supplementation should be viewed as a support for endogenous synthesis, not as an isolated method, but as an integrated part of a healthy lifestyle. Factors that maximize the effects of collagen include:

- Regular and structured physical activity, both aerobic and strength
- Diet rich in amino acids and cofactors (vitamin C, zinc, copper)
- Adequate sleep and stress management to promote endogenous regenerative processes.

Thus, combining supplementation with a healthy lifestyle offers the greatest likelihood of achieving visible benefits for the skin, joints, tendons and general health.

Purposes for collagen protein supplements

In injury prevention, type II collagen, prevalent in cartilage, along with collagen in ligaments and tendons, is essential for mechanical strength and preventing injuries. In this perspective, collagen supplementation can reduce joint pain and inflammation associated with osteoarthritis or sports-related wear and tear, increase joint mobility and flexibility, and support ligament and tendon regeneration after intense physical exertion (Khatri et al., 2021; Zdzieblik et al., 2017).

Collagen, taken before or after light-intensity training, can stimulate collagen synthesis in ligaments and tendons, contributing to exercise adaptation and injury prevention (Shaw et al., 2017). However, it should be noted that effects are variable between individuals, and the statistical significance reported in studies does not necessarily guarantee results immediately visible to the naked eye. The duration of supplementation, type of peptide, dosage, and product quality significantly influence the results.

Benefits for the musculoskeletal system: joints, tendons and muscle mass

Collagen is the main structural component of connective tissues, including cartilage, ligaments, tendons and bones. Supplementation with hydrolyzed collagen proteins has been studied for its ability to support the integrity of the musculoskeletal system, reduce pain and support muscle adaptations in the context of physical exercise and the physiological aging process.

Regarding the joints' flexibility, meta-analyses and clinical studies indicate that collagen peptide supplementation can reduce joint pain and stiffness in people with osteoarthritis, improve joint flexibility, and support the performance of athletes exposed to intense mechanical stress.

Among relevant literature examples, it can be mentioned:

- Khatri et al. (2021) reported that collagen supplementation reduces symptoms of pain and inflammation in osteoarthritis.
- Zdzieblik et al. (2017) demonstrated that athletes who consumed hydrolyzed collagen for 24 weeks experienced a significant reduction in joint pain and an increase in mobility.

The mechanisms through which Collagen peptides stimulate the synthesis of type II collagen in cartilage are by increasing the strength and elasticity of joint tissues. Additionally, specific amino acids in collagen (glycine, proline, and hydroxyproline) may help reduce inflammation and protect the extracellular matrix (Shaw & Martens, 2020).

Tendons and ligaments, composed mostly of type I collagen, respond positively to the combination of collagen supplementation and strength training. Collagen supplementation, together with vitamin C, can stimulate collagen synthesis in tendons. Light resistance exercises contribute to mechanical adaptation and tissue regeneration after injuries. Shaw et al. (2017) showed that administering a collagen-rich gelatin before exercise stimulates local protein synthesis, supporting tendon repair and strengthening.

This approach may help prevent injuries in athletes and accelerate recovery after minor tendon or ligament injuries. Although collagen has a lower biological value due to its lack of tryptophan, it can contribute to the maintenance and growth of muscle mass when combined with strength training.

In a study by Zdzieblik et al. (2015), elderly men who combined collagen supplementation with resistance exercise showed significant increases in muscle mass and strength compared with the placebo group. Collagen can be considered a

complementary protein supplement that supports muscle adaptations and protects connective tissues associated with muscles, especially in the elderly or in athletes with increased demands.

Conclusions

Hydrolysed collagen supplementation can be an effective tool for reducing joint pain and increasing mobility, supporting protein synthesis in soft tissues such as tendons and ligaments, and maintaining muscle mass. It can also contribute to maintaining musculoskeletal and skin health, as well as physical performance, but achieving maximum benefits depends on an integrated model of nutrition, physical activity, and a healthy lifestyle. Collagen does not replace physical therapies, complete proteins or medical treatments, but offers significant complementary benefits in preventing and ameliorating the effects of decreased endogenous synthesis. Collagen does not replace training, physical therapy or complete proteins for hypertrophy, but it does offer important complementary benefits for musculoskeletal health.

The effectiveness of collagen supplementation depends on its integration into a balanced lifestyle, which includes regular physical activity — both aerobic and strength — and complete nutrition rich in essential amino acids and cofactors for collagen synthesis (vitamin C, zinc, copper), adequate sleep, and stress management.

One limitation of collagen supplementation is that ingested collagen is broken down into amino acids and does not reach target tissues intact; supplementation serves as a support for endogenous synthesis rather than a complete substitute.

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