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Review Article

Collagen Supplementation and Current Application to Athletic Performance

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Introduction

Athletics are becoming more competitive at all levels. This increased competition is seen among all levels, from youth sports to professional leagues. One example of this phenomenon is increased sport specialization at an early age [1]. The theory behind this approach is allowing the youth athlete to develop in that sport and its movement patterns, allowing longer time for technical proficiency and its sport movements. This theory has been disproven and can prove harmful to young participants through increased injury rates due to lack of recovery [2]. In baseball, it is not uncommon for kids to play year-round which places their shoulder girdle and elbow for injuries to the UCL and the growing bony structures. Similarly, the old dogma that more volume equals better skill acquisition and more optimal adaptations may still be prevalent in sports like football, soccer, and basketball. During the sports, having two practice sessions during pre-season is common [3]. One practice occurs in the morning followed by a weightlifting session, and a tactical or another practice in the afternoon. Once again, these ideas have been disproven by the work of Tim Gabbett and the acute to chronic workload ratio. From a skill acquisition standpoint, it is known that cognitive overload in long practice session create a negative environment for learning [4]. Rather, it is beneficial to have small, more frequent learning blocks. These are two examples about more optimal workload does not necessarily equate to "more work". However, in the pursuit of winning and increased performance, many organizations are constantly trying to find the smallest margin of gains which could be the difference between winning and losing.

In this pursuit for optimal performance and winning, practitioners of all types strive to leave no stone unturned. Coaches are constantly reviewing film, strength and conditioning coaches are looking for new ways to periodize their programs, and sport scientists are combing through data points to find better ways of increasing availability to play. Lost in the mix, however, is how nutrition and supplementation have help athletes perform their best. The three core pillars of performance are sleep, hydration, and nutrition. Sleep is important because this is when a bulk of repair and regeneration takes place [5]. Sleep is when growth hormones are elevated and released. Proper hydration is important to aid in the proper sequence of various organ systems. Even slight dehydration can cause feelings of being unwell such as headaches and dizziness [6]. Finally, proper nutrition is vital to fueling the body to perform and playing a large role in its macro and micronutrient intake to repair and rebuild.

Unfortunately, nutrition is one area that is largely overlooked and undervalued. Starting with youth athletes, they may be drinking "sports drinks" with large amounts of added sugars and small amounts of protein. In high school, the growing body of student athletes may be fueled with fast food and processed foods because they are cheap and convenient. This trend may continue into college, where dorm rooms are stocked with processed foods

that provide little nutritional value [7]. There may be a paradox where adequate calories are being consumed, yet macro and micronutrient requirements are not being met. If student athletes have the opportunity to continue playing at the recreational, semi-pro, or professional level, nutrition becomes more important because the older an athlete becomes and the higher the level of competition the more all variables matters. For the recreational athlete, sport may be a form of socialization and physical activity. Thus, if injury occurs, this may hinder the individual's ability to work and decrease their overall quality of life. At the semi-pro and professional levels, sport is how athletes make a living. And anything that impedes the ability to play, such as fatigue, pain, and injury can hurt salary incentives for players.

Although injury is an inevitable part of sport and physical activity, the risk can be mitigated by numerous interventions. Of these interventions, proper nutrition and supplementation can play a key role [8]. Injuries in sport can be classified as acute or chronic. Acute injuries are those which occur suddenly and the mechanism of injury can be recalled. Although trauma such as collisions and contact are common, non-contact injuries like to the ACL can also occur. Chronic injuries are those which occur over longer periods of time and can begin as soreness or tightness but progress to hinder athletic participation.

In sport, it is typically the musculoskeletal (MSK) system that becomes injured in acute or chronic mechanisms. Within the MSK, the tendons, joints, and muscle tissues present a vulnerable structure subject to repetitive loads which may result in injury. On the acute end of the spectrum, tendon strains or ruptures can be seen. While on the chronic end, tendinopathies can occur [9]. Although the mechanisms may be different, the end result is damage to the tendon and potential loss in playing time. Recently, there has been increased popularity within supplementation and tendon healing, specifically with collagen. The purpose of this paper will be to explore tendon injuries from a structural standpoint, the role of collagen in tendon injuries, if exogenous collagen can have an effect on tendon healing and make practical recommendations into collagen supplementation.

The Tendon

The tendon is a structure classified as dense fibrous connective tissue; it serves to attach muscle to bone [10]. Its function is to transmit mechanical forces from the muscle to the bone and create movement. Tendons are composed of tenocytes which in turn stimulate the creation of the extracellular matrix [11]. The extracellular matrix is primarily composed of collagen fibers. It is these collagen fibers, and small amounts of elastin which give tendons their unique properties of being able to store load as potential energy and release it as kinetic energy [12]. This elastic potential is part of why tendons are valuable when it comes to sport and physical activity. However, through repetitive cycles of movement, they become prone to both acute and chronic injuries. Injuries to tendons can result in pain, dysfunction, and time lost. Thus, interventions are sought after to either minimize injury through building more robust tendons or increase their healing rates. One such supplement is collagen, which seeks to do this through increasing collagen synthesis within the tendon itself [13].

Tendon Healing

The healing process is universal in the body and follows the steps of inflammation, repair/proliferation, and remodeling [14]. It seems logical that collagen supplementation seeks to influence the proliferation and remodeling phases. The proliferation phase could be influenced into producing more extracellular matrix along with collagen. In the remodeling phase, type 3 collagen which is disorganized and weaker is converted into type 1 collagen which is organized and of a stronger quality. Thus, if adding an exogenous form of collagen into the healthy or injured tendon, the underlying mechanism of proliferation or remodeling could have positive implications to athletic performance [15].

Collagen

Collagen is a protein makes up about 60-85% of a tendons weight, making it important within its role and structure [16]. Although collagen is abundant in the human body, it can also be found in animal flesh (with connective tissue) and various of its components are present in some leafy vegetables. It is important to note that increasing age and lifestyle factors (smoking, lack of exercise, and alcohol consumption) can have a negative effect role on collagen production. This is where collagen supplementation first become popular in the role of "anti-aging" in skins serums and skin care routines [17]. Using the basis of collagen as a protein, oral supplementation began to permeate into the fitness and sports industry.

Collagen supplementation and athletic performance

In the realm of athletic performance, collagen is proposed to increase overall joint and tendon health. However, it is also important to note how Vitamin C is usually included in supplementation because this vitamin plays an integral role in collagen synthesis [18]. The positive effects of collagen seem to come from increases synthesis which improves recovery time between training sessions. Furthermore, muscular soreness after taxing training sessions is decreased through having more structural support from collagen. The peptide (protein) properties of collagen also mean it can play a role in reducing joint pain via the increased integrity it may provide [19]. It seems like many of the reported benefits from collagen come from its ability to be increased in amount which aids in the recovery process of all types of connective and contractile tissue. The following section will compare these claims to current evidence.

The evidence of collagen supplementation and athletic performance

[20] Baar (2017) explores tendon health from the perspective of soft-tissue injuries (muscle, ligaments, tendons) [20]. Baar points out that tendons are unique in that they attach a stiff tissue to a compliant tissue, thus tendons themselves must be more compliant at the muscle junction than vs the bony junction [20]. Furthermore, the turnover of tendons occurs at the proximity only, meaning adult tendons are not positively turning over at the core which may have implications to tendon injuries. Baar found that supplementing with gelatin (15g) and vitamin-C enriched collagen increased collagen synthesis within bio-engineered tendons. Since collagen is comprised of amino acids (glycine, proline, and hydroxyproline), this may aid in increase structural integrity of the previously mentioned soft and hard tissues. [21] Khatri et al. (2021) performed a systematic review into collagen supplementation and body composition, collagen synthesis, and recovery from joint injury [21]. The found that collagen supplementation was effective in reducing joint pain and increasing overall joint function. The authors postulate this decrease in pain and increase in function may come increased collagen and elastin in the articular cartilage to lubricate the damaged joint. It was also found that 15g/day of collagen supplementation did improve collagen synthesis which may help with tissue repair and mitigate injury risk [21]. Specific to the athletic population however, Gemalmaz et al. (2017) studies how supplementation would affect healing rates on Achilles' tendons in rats [21]. A concoction of mucopolysaccharides (220mg), vitamin C (30 mg), and hydrolyzed collagen type 1 (40mg) was given to the intervention group. There were no differences found in the mechanical strength or amount of collagen deposited after 3 weeks which point to no effect found through collagen supplementation [21]. To make things more applicable, [22] gave collagen peptides to an intervention group in combination with a resistance training program [22]. The intervention group received 5g/day for 14 weeks of collagen which resulted in increased cross-sectional area of the Achilles tendon and increased muscle thickness within the gastrocnemius-soleus complex. It is interesting to note the differences of findings between Gemalmaz et al. (2017) which may have come from their lack of human subjects and lack of resistance training program. Besides resistance training, it is important to also explore how collagen may affect endurance sports. Aranda et al. (2021) explored collagen supplementation in a group of long-distance runners and its affects into repairing elastic and osteoarticular tissues [23]. The dosage given was 10g of collagen protein with vitamins B and C for 16 weeks and performed a 21-km race at the end of the 16-week intervention period. The authors found an improved time after supplementation intake; however, this was a pilot study making the power analysis a limiting factor.

Types of Collagen Supplementation

Within the realm of collagen supplementation, it can originate from a bovine (cow), porcine (pig), or marine (fish) source [24]. Bovine collagen is made from cow hides while marine collagen is made from fish skin/scales, and it found to be of higher bioavailability. Marine collagen is almost all type 1 collagen while bovine is a mixture between types 1 and 3. The type 1 collagen is smaller in size, making it easier for the body to absorb [25]. Porcine collagen is derived from pig bones and skin and is also a mixture of type 1 and 3 collagen peptides. Overall, the literature points to sourcing collagen a matter of personal preferences and dietary restrictions. However, each source of collagen chosen by the consumer should be of the highest quality (pasture-raised, pasture-based, and no fish farms).

Practical Recommendations for Athletes

Evidence suggests similar effects from the 3 sources of collagen taken in the morning or prior to training. Since collagen supplements are usually flavorless, they are easy to mix into daily meals and drinks. Although there are no universal standards for proper collagen dosage, the literature seems to center between 10-20g/day for optimal affects. Collagen may be taken by both healthy and injured athletes for the purpose of increasing performance and increased recovery rates.

Conclusion

The musculoskeletal system is comprised of soft and hard tissues. The soft tissues as relevant to this paper include skeletal muscle tissue, tendons, and ligaments. Bony tissue includes bones and connecting tendons which create tendons. In the pursuit of athletic performance, athletes look for ways to explore marginal gains which may be the difference between winning and losing. One new avenue that has gained traction is collagen supplementation. Collagen supplementation has become popular because it is primary constituent of tendons, the extracellular matrix, and bone. When collagen is combined with vitamin C, it may have positive effects on tendons through increasing collagen synthesis and increased cross-sectional area/integrity of the tendon [22]. Similarly, collagen is an essential building block to skeletal muscle and may play a role in recovery and maintaining a positive sarcomere turnover. Lastly, in injuries to the joint itself such as degeneration and osteoarthritis, collagen may play a role in pain reduction by increasing the content of the extra-cellular matrix which could function as cushion between the two bones [26]. Within tendon injuries, increased collagen synthesis could aid in a quicker recovery process by giving the damaged area an extra amount of building blocks needed for the healing process to occur. Of the articles examined, there seem to be no negative affects linked to or associated with collagen supplementation. Lastly, although there are no universal guidelines

for dosage, a majority of the literature is centered around 10-20g/day. Collagen supplementation seems to be a viable way to increase athletic performance through the maintenance of healthy and increased repair of the musculoskeletal system.

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Conflict of Interest

None.

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