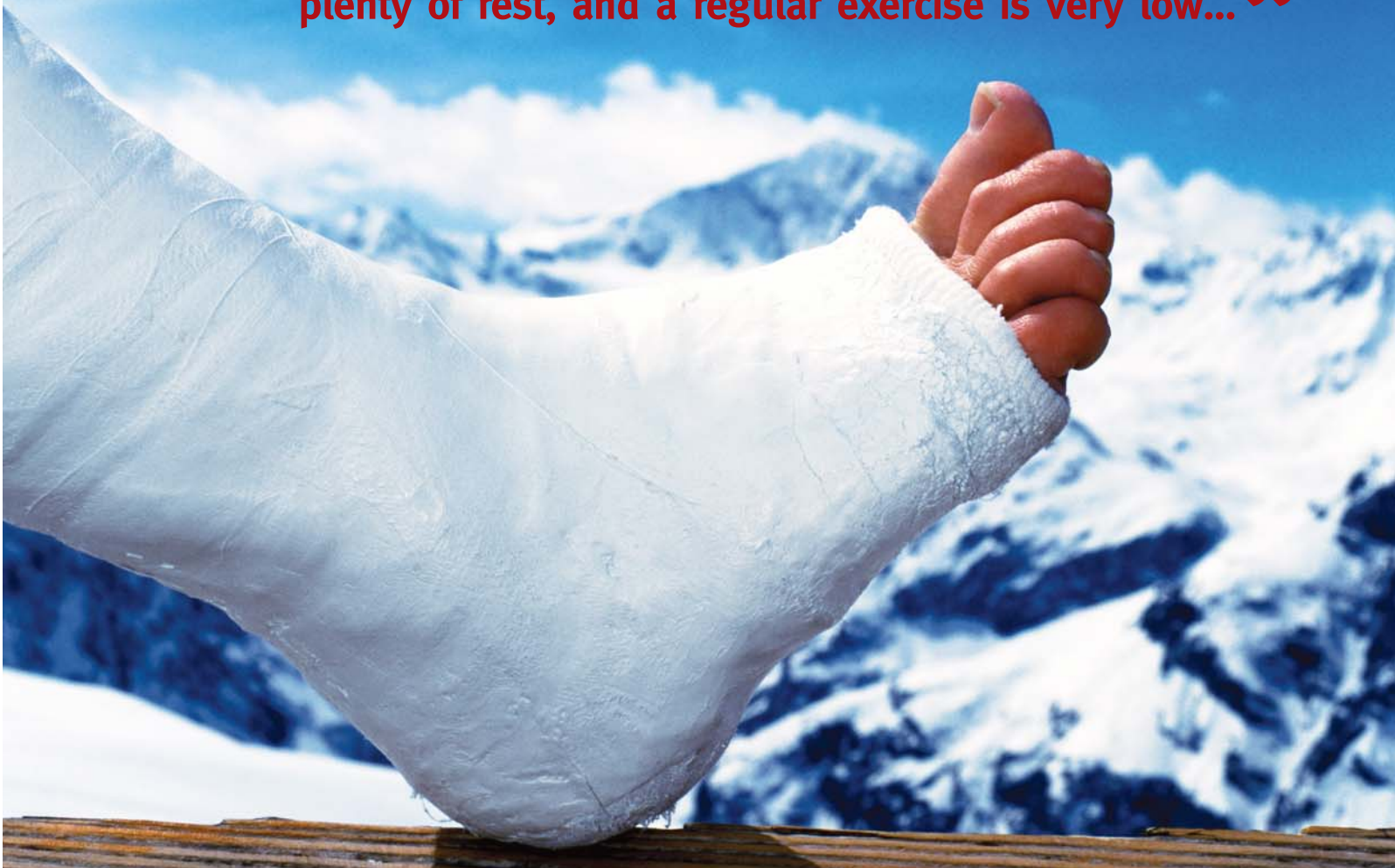


# No Time for Downtime

Nutrition applied to sports injury and rehabilitation

by Jennifer Cherry and Sandra DeSha

**“The likelihood of a patient being discharged into a world of perfect nutrition, consistent rehabilitation, plenty of rest, and a regular exercise is very low...”**



***The purpose of this article is to assist the physician or individual interested in optimizing the healing processes of the human body. It focuses on the use of specific nutrients and combinations of nutrients to more favorably affect the outcome of healing.***

## **PAIN RELIEF AND HEALING: TWO SEPARATE CONCEPTS**

It is important to understand that pain relief and healing are two very separate concepts. The removal of discomfort should never imply that the body is beginning to repair tissue damage. Often it is quite the opposite, and medications given to eliminate pain can sometimes hinder the body's attempts to heal. It is also a mistake to believe there can be recovery without pain or discomfort. Even in the final stages of the healing process, an individual can experience various uncomfortable symptoms.

## **THE CURRENT APPROACH**

The role of the physician in primary healing has been practiced with considerable skill for many years. Typically, the vast majority of patients heal quite well. Currently physicians treat pain and inflammation, and then to allow the body heal itself. Given time, it's true that the human body has an amazing ability to heal itself. However, a patient's full return to pre-injury status is rarely attained. Often there is a tendency for physicians to base treatment options in accordance with the patient's future performance requirements. Professional athletics has demonstrated the ability of modern medicine to decrease recovery time dramatically while healing an injury more completely. With simple additions to the recovery regimen, healing can now be optimized for every patient.

## **FACTORS THAT AFFECT HEALING**

- > Age
- > Type of Injury
- > Severity of Injury
- > Prior Health Status
- > Rest
- > Pharmacological Agents
- > Mobility (local and whole body)
- > Psychological Influences
- > Blood Supply
- > Nutritional Status
- > Dietary Intake

## **HEALING, MORE DIFFICULT THAN EVER?**

The current approach (treat pain/inflammation and let the body heal itself) makes the assumption that the American diet is sufficient enough to supply the body with the nutrients needed for repair of bodily tissue. The likelihood of a patient being discharged into a world of perfect nutrition, consistent rehabilitation, plenty of rest, and a regular exercise is very low.

## **NO TIME FOR DOWNTIME**

Although many Americans don't have time to focus on healing themselves, most do not have the luxury of extended downtime either. As daily responsibilities increase for individuals, so must their ability to recover rapidly. Modern science can help us handle this imbalance of time and necessity through efficient usage of bioactive nutrients.

## **FULLY HEALED!**

Though it's true that time heals all wounds, all wounds do not heal optimally. The ultimate goal in healing is to return the patient to his/her health status before the trauma or injury occurred. Ask any physician and they will confirm that an acute situation with a quick healing prognosis often becomes a chronic situation due to patient disregard, i.e. athletes compete frequently with injuries.

## **PROTEOLYTIC ENZYMES (Proteases)**

Enzymes are natural to all living organism. Enzymes are proteins that act as a catalyst to induce chemical changes in other substances. Enzymes are generally named by adding -ase to the name of the substance activated. For example lactase digests lactose into glucose and galactose. Proteases, often called proteolytic enzymes, decompose proteins via the hydrolysis of peptide bonds.

Proteolytic enzymes have been used since the 1960s in both the sports injury and post-surgical settings. Their use declined when NSAIDS became commercially available. A big reason was compliance; NSAIDS are easier to dose and their effects felt more quickly than proteolytic enzymes. Still,



there has been renewed scientific interest in the use proteolytic enzymes for musculoskeletal health.

Proteolytic enzymes have been available commercially in purified forms since the 1950s. Once their roles in the inflammatory process were ascertained, they were administered from exogenous sources by injection. A large number of clinical trials were conducted using this method, but many adverse reactions were encountered, and the injectable use of proteolytic enzymes was abandoned. Studies on oral use soon followed, and a large database of articles was compiled on the purported mechanisms, bioavailability, and clinical effects of oral proteolytic enzymes as therapeutic agents. <sup>(38)</sup>

(increased nutrient and waste transport to and from the injured site)

- > activation of endogenous proteases (plasmin) [see figure 1]
- > molecular debridement (removal of proteins and waste, aids in phagocyte function)

## BRIEF SUMMARY OF STUDIES ON THE PROTEOLYTIC ENZYME BROMELAIN:

### Bromelain and Musculoskeletal Health:

- > A clinical trial on bromelain was conducted on 75 boxers with bruises on the face and hematomas of the

**“While several clinically significant factors are known to impede wound healing, one that is often overlooked is a diet deficient in vitamins and minerals.”**

By supporting the body in the normal inflammatory response, proteolytic enzymes may ease some of the normal symptoms of inflammation – heat, swelling and redness. It is important to note that there is never a complete inhibition of the inflammatory response with the use of oral proteolytic enzymes. This is good because inflammation is necessary for the body to heal itself. <sup>(38)</sup> Inflammation triggers the chain of events that lead to the body’s ability to repair itself.

### Table 1 Types of Proteolytic Enzymes and their Source Found in Supplements

- Pancreatin (animal: porcine or bovine pancreas powders)
- Trypsin (animal: porcine and bovine)
- Chymotrypsin (animal: porcine and bovine)
- Bromelain (pineapple stems and fruit)
- Papain (green papaya fruit)
- Serrazimes (fungal: *Aspergillus oryzae* fungi)

This article will focus on the use of bromelain, as it has been studied for more than 30 years. It seems to be the most commercially available proteolytic enzyme and has the least amount of controversy surrounding it.

## ROLES AND FUNCTIONS OF PROTEOLYTIC ENZYMES: <sup>(34, 35, 36, 37, 38)</sup>

- > destroy or inactivate bradykinins [see figure 1] (bradykinin is a chemical messenger that binds to nerve receptors causing them to fire)
- > reduction of viscosity of extracellular fluid

lips, ears, chest and arms. Bromelain was given four times a day for four days or until all signs of bruising had disappeared. A control group of 72 boxers were given a placebo. In 58 of the boxers taking bromelain, all signs of bruising cleared completely in four days. In the placebo group, only 10 had complete clearance within four days. <sup>(3)</sup>

- > In an observation study involving 59 patients with blunt injuries to the musculoskeletal system, the efficacy and tolerability of high-dose bromelain, in addition to the usual therapeutic measures, was investigated. Treatment with bromelain resulted in a clear reduction in all four parameters tested; swelling, pain at rest, pain during movement and tenderness. <sup>(3)</sup>
- > Knee injuries are common. The knee is vulnerable to twisting or shearing forces while walking or even crouching and this can be sufficient to traumatize the knee. In this study, there were seventy-seven otherwise healthy volunteers: 43 took a lower dose bromelain, while 34 took a higher dose. After one month, the higher dose group reported significant improvements in physical symptoms as well as improvements in psychological well-being. It was also noted that the enzyme preparation was as effective as diclofenac, a NSAID, in treating symptoms while being generally better tolerated. A lack of significant side effects with the use of bromelain was also reported. <sup>(5)</sup>

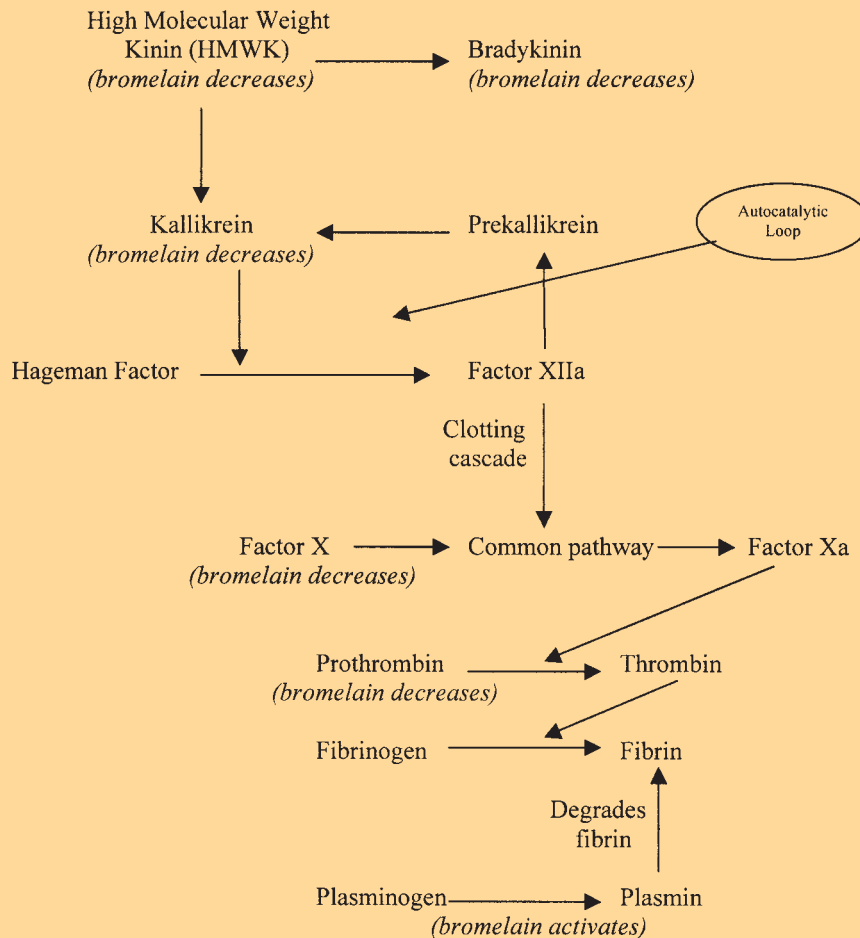


## Bromelain and Post-Surgical:

> Fifty-five pre-surgical patients were divided into two groups. Group one, consisting of 22 patients, took bromelain four times a day for 48-72 hours prior to surgery and continued for 72 hours after surgery. Group two, consisting of 33 patients, took bromelain starting on the day of surgery, with the first dose administered one hour prior to surgery. 55% of group one and 42.4% of group two had complete cessation of pain and inflammation within 72 hours.<sup>(3)</sup>

> A double-blind study was conducted with 160 postpartum patients who had each received a mediolateral episiotomy. Eighty patients were given the proteolytic enzyme, bromelain, and the other eighty a placebo. A statistically significant decrease in edema, inflammation and pain associated with mediolateral episiotomy was demonstrated in the patients given bromelain. It was also noted that the amount of medication, especially narcotics, was definitely decreased in the patients given bromelains therapy. Additionally, no side effects were noted.<sup>(4)</sup>

Figure 1: Kinin System



G. Kelly. Bromelain: A Literature Review and Discussion of its Therapeutic Applications. *Alternative Medicine Review* 2001; 1: 243 – 257.

## SUMMARY AND GUIDELINES FOR USE:

In numerous studies, proteolytic enzyme therapy was shown to be a highly effective nutritional therapy for athletic injuries, trauma and other musculoskeletal conditions.<sup>(1,3,4,5,6,7,38)</sup> Their mechanism of action, bioavailability and clinical uses have been well-documented. Oral proteolytic enzymes have been proven to be safe and well-tolerated by over 30 years of clinical experience.<sup>(6)</sup> It is important to administer proteolytic enzymes as soon as possible following trauma. Proteolytic enzymes seem to work best when taken 3-4 times per day on an empty stomach. This article does not advocate the use of proteolytic enzymes post-surgically. It has not been studied for drug interactions with anesthesia and medications used during surgery. In fact, proteolytic enzymes are known to potentiate the effects of antibiotics,

which are often used post-surgically.

In order for proteolytic enzymes to exert systemic effects, they must be able to enter circulation intact and have high serum levels in order to saturate the inflamed site. That is why it is important to take proteolytic enzymes on an empty stomach. If food is present in the stomach or proximal small intestine, proteolytic enzymes will be slowed in their serum uptake. Be sure to check your formulation to make sure that it does not contain any protein substances. Enteric coating of tablets to resist stomach acidity has been shown to be helpful for achieving high serum levels with chymotrypsin and trypsin. However, bromelain, with its wide range of pH stability, does not have to be enteric coated.

## VITAMINS AND MINERALS IN MUSCULOSKELETAL HEALING

Research has consistently shown the importance of vitamins and minerals in the body's repair process. There is only a small percentage of Americans whose daily diets are nutritionally balanced. This poses a problem when injury occurs because nutrient intake following an acute injury needs to be higher than normal to provide the materials needed for building and repairing tissues.

**“Magnesium is so important to all aspects of health it will one day be considered more important than calcium.”**

For the healing and rehabilitation process to be successful, the body must be well nourished. Adequate nutrient intake helps to promote new tissue formation, suppress oxidation of tissue, improve wound function and keep the immune system strong. While several clinically significant factors are known to impede wound healing, one that is often overlooked is a diet deficient in vitamins and minerals.

Researchers who have examined the biochemical aspects of wound repair have identified several key nutrients thought to be critical for tissue regeneration.

### ROLES AND FUNCTIONS OF VITAMINS AND MINERALS IN MUSCULOSKELETAL HEALTH:

#### Role of Vitamin A <sup>(19,20,21,22)</sup>

Vitamin A was probably the first vitamin discovered. Vitamin A can be generally divided into two primary compounds: Preformed vitamin A (retinols) and Pro vitamin A (carotenoids). Carotenoids can be converted to retinoids when intake of retinoids is low. Carotenoids possess unique antioxidant capabilities not seen in retinoids.

- > support epithelial and bone tissue development
- > support cell differentiation
- > stimulate immune response

#### Role of Vitamin C <sup>(13,14,15,16)</sup>

Few nutrients have drawn as much as interest as vitamin C. The primary role of vitamin C in connective tissue is in the activation of alpha ketoglutarate linked hydroxylases. These enzymes are essential for the formation of the amino acids hydroxyproline and hydroxylysine. These amino acids are necessary for the proper function of collagens. Collagen biosynthesis is essential for the repair of connective tissue.

- > essential co-factor in the formation of collagen

- > essential co-factor for synthesis proteoglycans and other organic compounds of the intracellular matrix of tissues such as bone, skin and connective tissue
- > support immune response
- > direct antioxidant

#### Role of B Vitamins <sup>(2,12,23)</sup>

The primary role of B vitamins is bioenergetics. B vitamins are involved in the many biochemical steps in the breakdown of food into molecules that enter cellular respiration.

Although there has been little research of the effects of B-vitamins and healing, one can easily deduce that a deficiency in cellular function and energy will inhibit the healing process. A good example is the fibroblast cell. Without cellular energy, the fibroblasts would not be able to proliferate. This would result in production of less proteoglycans and collagen, which are essential for connective tissue healing.

The two most promising enhancers of healing appear to be thiamine and pantothenate, as they are critical for the production of cellular energy.

- > aid in the production of ATP, the major energy source for the cell
- > role in bioenergetics
- > involved in the breakdown of food into molecules that enter cellular respiration

#### Role of Zinc <sup>(9,11,17,18,39)</sup>

Zinc compounds are one of the oldest therapies for wound healing, dating back to 1550 BCE. Calamine (a crude form of zinc oxide) was applied topically to skin wounds. Interestingly enough, Calamine is still used today as an agent for topical wound healing. Approximately 300 enzymes utilize zinc for activation. Zinc is essential for DNA synthesis, cell division and protein synthesis, all necessary events for tissue repair.

- > activates zinc metalloenzymes necessary for the normal healing response
- > stabilizes structural conformation of polysomes, which are involved in protein synthesis, collagen synthesis and normal cell growth
- > a component of the key enzymes involved in basic cellular events such as DNA synthesis, RNA synthesis and protein synthesis



## Role of Magnesium <sup>(24,25,26,27)</sup>

Magnesium is often the forgotten mineral even though it is involved in hundreds of reactions that are essential for life. Magnesium fulfills so many essential functions, that it is impossible to list all that pertain to musculoskeletal health. Magnesium is so important to all aspects of health, it will one day be considered more important than calcium.

- > co-factor for over 300 enzymatic reactions
- > regulator of cellular energy metabolism
- > key role in protein synthesis
- > activates hormone receptors
- > key role in amino acid metabolism

## Role of Manganese <sup>(10,11,39)</sup>

Manganese is another mineral essential for musculoskeletal health that is often forgotten. It is required for activating glycosyltransferase enzymes that attach modified sugars to collagen and each other. Manganese is involved in the activation and stimulation of triple helix formation, which is the structure of collagen. Manganese is extremely important for the synthesis of proteoglycans, which are essential for the repair of connective tissue. It is important to note that manganese supplements should be of organic chelates, such as gluconate or ascorbate.

- > essential co-factor and catalyst in glycosaminoglycan synthesis
- > essential co-factor and catalyst in proteoglycan synthesis
- > essential co-factor and catalyst in collagen synthesis
- > necessary for the glycosylation of hydroxyproline residues in the formation of collagen

## CHONDROITIN SULFATES

Long before chondroitin sulfate was studied for its effects on osteoarthritis, it was being investigated for its role in connective tissue healing. Chondroitin sulfates were extracted and purified in the 1960s, and studies were performed with the goal of accelerating connective tissue healing. Several investigators using animal models found that chondroitin sulfate accelerated surgical wound healing in rats. <sup>(28)</sup>

Furthermore, exogenous administration of chondroitin sulfates was found to stimulate secretion of proteoglycans in cartilage or chondrocyte cultures. These studies suggested that if sufficient chondroitin sulfates were presented to cells manufacturing proteoglycans, matrix synthesis could be stimulated, which may, in turn, accelerate the healing process. <sup>(2, 40,41,42,43)</sup>

## ROLES AND FUNCTIONS OF CHONDROITIN SULPHATE IN MUSCULOSKELETAL HEALTH:

Most sports injuries involve trauma to connective tissue. It surrounds bones, and in various forms, connective tissue holds us together on every level from molecular to whole-body. Connective tissues are not made up solely of cells. A substantial part of their volume is filled by an intricate network of macromolecules constituting the extracellular matrix. Variations in the amounts of different types of macromolecules and the way in which they are organized in the extracellular matrix is how they adapt to the functional requirements of a particular tissue. For example, the matrix can become calcified to form bone, or it can adopt the rope-like organization that gives tendons their enormous tensile strength. <sup>(50)</sup>

The macromolecules that constitute the extracellular matrix are mainly produced locally by cells inside the matrix. In most connective tissues, the matrix macromolecules are secreted by cells called fibroblasts. In specialized connective tissues such as cartilage and bone, they are secreted by cells of the fibroblast family that have specific names; (chondrocytes form cartilage and osteoblasts form bone). There are two main classes of macromolecules in the extracellular matrix:

- 1- glycosaminoglycans (GAGs), which are usually found covalently linked to protein in the form of proteoglycans
- 2- fibrous proteins; including collagen, elastin, fibronectin and laminin.

The proteoglycan molecules in connective tissue form a highly hydrated, gel-like “ground substance” in which the fibrous proteins are embedded. <sup>(50)</sup>

GAGs are unbranched polysaccharide chains composed of repeating disaccharide units. They are called GAGs because one of the two sugars in the repeating disaccharide is

### Table 2 Functions of Proteoglycans in the body: <sup>(50)</sup>

- provide hydrating space around and between cells
- serve as selective sieves to regulate traffic of molecules and cells
- plays a major role in chemical signaling between cells
- bind and regulate the activities of other types of secreted proteins
- plasma membrane proteoglycans act as co-receptors that aid in binding cells to the extracellular matrix



always an amino sugar (N-acetylglucosamine or N-acetylgalactosamine), which in most cases is sulfated. There are four main groups of GAGs: <sup>(50)</sup>

- 1- hyaluronan
- 2- chondroitin sulfate and dermatan sulfate
- 3- heperan sulfate
- 4- keratan sulfate

Except for hyaluronan, all GAGs are covalently attached to protein in the form of proteoglycans. Proteoglycans (PGs) are very large aggregates of proteins and glycosaminoglycans (GAGs).

Proteoglycan	Type of GAG Chains	Location
Aggrecan	chondroitin sulfate + keratan sulfate	cartilage
Decorin	chondroitin sulfate + dermatan sulfate	widespread in connective tissue
Syndecan-1	chondroitin sulfate + heparan sulfate	epithelial cell surface

**BRIEF SUMMARY OF STUDIES ON CHONDROITIN SULPHATE:**

**Effects on Extracellular Proteases involved in the Metabolism of Connective Tissues**

- > Various enzymes are involved in the degradation of cartilage. Chondroitin sulfate was shown *in vitro* to inhibit the enzyme elastase by formation of electrostatic bonds between the negatively charged sulfate residues and the positive charges at the catalytic site of the enzyme. <sup>(44)</sup> These result were later confirmed *in vivo* in rats.
- > Cathepsin B is a thiolprotease produced by chondrocytes and is directly involved in the destruction of cartilage. *in vitro* studies of rabbit articular chondrocytes show that chondroitin sulfate reduces the release of cathepsin B. <sup>(45)</sup>
- > An *in vitro* study was performed to evaluate the impact of chondroitin sulfate and interleukin -1 $\beta$  (IL-1 $\beta$ ) on chondrocyte production of proteoglycans, type II collagen and prostaglandin E2 (PGE2). Dosing of 100 to

1000 ug/mL of chondroitin sulfate decreased total PGE2 synthesis and increased total proteoglycan production. There was no impact on collagen synthesis. IL-1 $\beta$  decreased proteoglycan and collagen production and increased PGE2 synthesis. The chondroitin sulfate counteracted the IL-1 $\beta$  effects in each component. <sup>(46)</sup>

**Anti-inflammatory/Scavenging Properties**

- > In rats, the oral administration of chondroitin sulfate significantly decreased granuloma formation and lysosomal enzyme release.
- > Patients requiring joint aspiration were treated for 10 days with oral CS 800 mg/day. The hyaluronan concentration and the intrinsic viscosity of the joint fluid significantly increased. Collagenolytic activity, phospholipase A2 and N-acetylglucosaminidase (NAG) decreased. These mechanisms may explain the anti-inflammatory and chondroprotective actions of chondroitin sulfate in patients with osteoarthritis. <sup>(47)</sup>
- > Chondroitin sulfate also exhibits some scavenger properties in the Fenton reaction (where oxygenated free radicals are generated). This effect appears to protect cartilage matrix against degradation by oxygenated free radicals. <sup>(48)</sup>

**Regulation of Chondrocyte and Proteoglycan Function**

- > Numerous *in vitro* studies have shown that exogenous chondroitin sulfate stimulates the production of proteoglycans. Added at 200  $\mu$ g/mL to monolayer cultured chondrocyte, chondroitin sulfate increased sulfate incorporation into chondroitin sulfate proteoglycans. <sup>(48)</sup> Chondroitin sulfate has also been shown to affect the synthesis of hyaluronan. When chondroitin sulfate was added to monolayer cultures of synovial lining cells, chondroitin sulfate stimulated the synthesis of hyaluronan. <sup>(48)</sup> In rabbit knee synovial membranes, sulfated GAGs also increased hyaluronic acid biosynthesis. <sup>(49)</sup>
- > An animal study evaluated the effectiveness of chondroitin sulfate protection in chymopapain induced articular cartilage proteoglycans loss. Rabbits were used and serum concentration of keratan sulfate levels were monitored to ensure degradation was occurring. Animals were either given chymopapain injection with no further treatment (control), intramuscular injection of chondroitin sulfate, or oral administration of chondroitin sul-



fate beginning 11 days prior to induced degradation. After sacrifice, cartilage proteoglycan content was evaluated. Oral administration of chondroitin sulfate resulted in significantly higher cartilage proteoglycan content as compared to control. The injected chondroitin sulfate group also had significantly higher proteoglycan content but not as high as the orally dosed group. This indicates a protective effect of chondroitin sulfate on degradation of articular cartilage in rabbits. <sup>(49)</sup>

### Disease Modifying Effects

> Recently at the annual meeting of the ACR (American College of Rheumatology), significant new study results were presented by B. Michel, MD. The aim of the study was to determine whether chondroitin sulfate is effective in inhibiting cartilage loss in knee osteoarthritis (OA.) In this randomized, double-blind placebo-controlled trial, 300 patients with knee OA were recruited and assigned to receive either 800 mg of chondroitin or a placebo once daily for 2 years. The 150 patients

**“The study concluded that chondroitin sulfate qualifies as a Disease Modifying Drug for the treatment of osteoarthritis. It is especially active in overweight patients, patients under 60 years of age and patients with mild to moderate osteoarthritis.”**

> An *in vitro* study evaluated the impact of chondroitin sulfate A (4-sulfate) and chondroitin sulfate C (6-sulfate) on mRNA expression of aggrecan and type II collagen. Results showed that chondroitin sulfate C markedly increased the expression level of type II collagen mRNA. This suggests the addition of chondroitin sulfate C might contribute to the accumulation of type II collagen and assist in the regeneration of cartilage. <sup>(51)</sup>

### Inhibitory Effects of Cytokine Production

> *In vitro* studies have shown chondroitin sulfate to inhibit IL-1 $\beta$ , TNF-alpha and IL-6 production by mononuclear cells from peripheral blood and by differentiated U-937 cells. <sup>(48)</sup> This suggests that chondroitin sulfate acts on TNF-alpha metabolism (a cytokine involved in cartilage degradation) by limiting its synthesis and by blocking its receptor.

### Effects on Synovial Fluid

> Hyaluronan is the simplest of the GAGs. Hyaluronan is produced in large quantities during wound healing, and it is an important constituent of synovial fluid (joint fluid), where it serves as a lubricant. *In vitro* studies have shown that chondroitin sulfate increases the intrinsic viscosity of hyaluronan solutions. <sup>(48)</sup> This same effect was observed after oral administration of chondroitin sulfate in rabbits, and after proteoglycan depletion induced by bradykinins in rats. <sup>(48)</sup> This data was later confirmed *in vivo* by 42 days of administration of chondroitin sulfate to arthritic horses, which lead to an increase in synovial fluid viscosity. <sup>(48)</sup>

receiving placebo had progressive joint space narrowing while the 150 patients taking chondroitin had no change in mean joint space width. The differences in loss of joint space between the two groups were significant, and the chondroitin sulfate was well-tolerated. The study concluded that chondroitin sulfate qualifies as a Disease Modifying Drug for the treatment of osteoarthritis. It is especially active in overweight patients, patients under 60 years of age and patients with mild to moderate osteoarthritis. In all of the study's groups, chondroitin sulfate proved statistically superior to placebo. <sup>(30)</sup>

### SUMMARY AND GUIDELINES FOR USE:

Based on the information available, purified chondroitin sulfates are the best choice for providing nutritional support for the normal wound healing process of connective tissue. <sup>(29)</sup> Purified chondroitin sulfate has been shown to be bioavailable and exhibit a selective tropism toward GAG rich tissues, such as joint cartilage, the eyes, the lumbar discs and the corresponding vertebral epiphysis. Chondroitin sulfate seems to be a good chondroprotective agent as it has been shown *in vitro* and *in vivo* to increase chondrocyte anabolic activity, while suppressing the degradative actions of certain mediators (cytokines and prostaglandins) on cartilage. In numerous studies, it was noted that purified chondroitin sulfates are well-tolerated and show no adverse effects. It has also been noted that the positive effects continue to be evident after the treatment has been discontinued.

The ideal time to incorporate the use of chondroitin sulphate seems to be in the repair and remolding phase. The repair



phase is characterized by cell growth and production of extracellular matrix. When choosing a supplement it is important to look for purified chondroitin sulphate. There is a vast difference in the quality of commercially available chondroitin sulphates. In fact, some companies sell bird-derived trachea powder as chondroitin sulphate. Available scientific literature supports only the use of *purified* chondroitin sulphate for musculoskeletal health, as opposed to trachea and crude cartilage powders. Our research shows that the best raw material manufacturers of *purified* chondroitin sulphate are Bioiberica and Cargill. Before purchasing a chondroitin sulphate supplement, call the manufacturer to ascertain their source.

## PROTEIN

Numerous studies have been done on the caloric needs of humans after injury and trauma. Protein appears to be as important as total calories for healing to occur. Much of the human body is constructed of proteins (collagen represents 6% of total body weight), so it would make sense that protein would be essential for normal healing to occur. <sup>(31)</sup>

### ROLES AND FUNCTIONS OF PROTEIN IN MUSCULOSKELETAL HEALTH:

Dietary protein is digested and converted to its component amino acids, which then become protein currencies in the body. Amino acids are the basic building blocks of collagen, elastin, proteoglycan core proteins, fibronectin and laminin, all key components of musculoskeletal tissues. <sup>(31)</sup> Amino acids also make up cell receptors, transport proteins and enzymes. Dietary proteins and their precursor amino acids are vital to almost every body and cellular function, especially so during wound healing. <sup>(32)</sup>

When caloric intake is deficient, protein intake is usually deficient as well. The consensus of a vast amount of research has shown that malnutrition (caloric depletion) has a detrimental effect on wound healing. <sup>(31)</sup> Adequate protein intake is essential for proper wound healing. Protein depletion appears to delay wound healing by

- > prolonging the inflammatory phase
- > by inhibiting fibroblast, collagen and proteoglycan synthesis
- > inhibiting wound remodeling. <sup>(33)</sup>

### BRIEF SUMMARY OF STUDIES ON PROTEIN IN MUSCULOSKELETAL HEALTH:

Experimental protein depletion in animals caused a decrease

in the tensile strength of wounds. Rats fed a diet deficient in protein exhibited decreased wound integrity and strength versus control animals. In a study of 108 human patients with experimental wounds, individuals with either low serum protein or serum albumin had significantly weaker wounds than those with normal protein values. <sup>(33)</sup>

Inadequate protein intake associated with an energy deficiency is called protein-energy malnutrition (PEM). This is the largest known nutrient deficiency worldwide. It is most common in populations such as the elderly, poor, hospitalized and wounded individuals. PEM is typically defined by a history of inadequate protein and energy intake, unintentional weight loss, or low body weight for height. <sup>(32)</sup> In medical and surgical wards in Europe and North America, it was found that almost half of the patients admitted show some degree of malnutrition. Also, it appears that the effects of malnutrition on wound healing are more pronounced if there is malnutrition within the immediate period prior to wounding. <sup>(31)</sup>

### SUMMARY AND GUIDELINES FOR USE:

The importance of protein to the healing process has been regularly and consistently documented in leading journals for decades. We know that one of the metabolic responses after injury or surgery is a net loss of body protein. The duration of protein loss is 3 to 6 weeks when protein intakes are usual (0.8 g/kg/d). Thus, it is important to ensure adequate protein intake during times of stress or injury. The injured or trauma patient may exist in a state of metabolic stress, with the severity of the stress depending on the severity of the wound. An injured patient requires more protein than a non-injured patient because of the increased metabolic activity associated with wound healing. <sup>(31,33)</sup>

In a non-injured state, adults require approximately 0.8 g/kg body wt/day dietary protein. Elderly patients have a higher protein requirement (1-1.2 g/kg body wt/day) due to a decreased ability to synthesize proteins. During recovery from an injury, the recommended amount of protein intake is 1.5 g/kg body wt/day. <sup>(33)</sup>

## SUMMARY

The body will do its best to heal an injury regardless of its nutritional status. However, Americans' nutritional status is deficient in most cases, and an injury requires an even higher than normal nutrient intake to build and repair tissues. Science has been lagging in the field of nutrition and healing. The guidelines below attempt to put findings regarding



nutrition and musculoskeletal healing into practical usage. The guidelines below offer a starting point for further research and application of nutrition and its effects on musculoskeletal healing.

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## NUTRIENT PROTOCOLS

### Joint Trauma: Sprains, Strains, Dislocations

Proteolytic Enzymes	To be administered q.i.d. on an empty stomach
Vitamin C	1000-2000 mg daily
Antioxidant/bioflavonoid mix	
Vitamin B1 (thiamine)	50-200 mg daily
Pantothenate	100-200 mg daily
High potency Vitamin/Mineral Formula	
Purified Chondroitin Sulfate	800 mg daily

### Acute Trauma: Ligament and Tendon Injuries (rotator cuff, pectoralis major, distal biceps, quadriceps femoris, patellar and the Achilles)

Purified Chondroitin Sulfate	800 mg daily
Proteolytic Enzymes	To be administered q.i.d. on an empty stomach
Protein	1-1.5 g/kg body wt/d
Zinc	15-30 mg daily
Vitamin C	1000-2000 mg daily
Manganese	10-15 mg daily
High potency Vitamin/Mineral Formula	
Antioxidant/bioflavonoid mix	

### Acute Soft Tissue: Contusions, Bruises

Proteolytic enzymes	To be administered q.i.d. on an empty stomach
Vitamin C	1000-2000 mg daily
Zinc	15-30 mg daily
Antioxidant/bioflavonoid mix	

### Acute Skin Trauma: Surgical wounds, Abrasions, Lacerations

Proteolytic Enzymes	To be administered q.i.d. on an empty stomach
Protein	1-1.5 g/kg body wt/d
Vitamin C	1000-2000 mg daily
Vitamin A	20,000-25,000 IU daily
Zinc	15-30 mg daily
Manganese	10-15 mg daily
Antioxidant/bioflavonoid mix	
Curcuminoids	500-1000 mg daily

### Intervertebral Disc Injury:

Purified Chondroitin Sulfate	800 mg daily
Manganese	10-15 mg daily
Magnesium	200-500 mg daily
Vitamin C	1000-2000 mg daily
Zinc	15-30 mg daily
High potency Vitamin/Mineral Formula	
Antioxidant/bioflavonoid mix	

### Bone Trauma:

Purified Chondroitin Sulfate	800 mg daily
Proteolytic Enzymes	To be administered q.i.d. on an empty stomach
Protein	1-1.5 g/kg body wt/d
Vitamin A	20,000-25,000 IU daily
Zinc	15-30 mg daily
Magnesium	200-500 mg daily
Manganese	10-15 mg daily
Calcium	200-500 mg daily
Vitamin C	1000-2000 mg daily
High potency Vitamin/Mineral Formula	
Antioxidant/bioflavonoid mix	

### Connective Tissue Inflammation: Tendinitis, Bursitis, Synovitis

Proteolytic Enzymes	To be administered q.i.d. on an empty stomach
High potency Vitamin/Mineral Formula	
Purified Chondroitin Sulfate	800 mg daily
Magnesium	200-500 mg daily
Manganese	10-15 mg daily
Vitamin B6	20-50 mg daily
Vitamin C	1000-2000 mg daily
Fish Oil	1 gram daily
Curcuminoids	500-1000 mg daily
Antioxidant/bioflavonoid mix	

### Connective Tissue Overuse Non-Inflammatory: Tendinosis

Purified Chondroitin Sulfate	800 mg daily
High potency Vitamin/Mineral Formula	
Magnesium	200-500 mg daily
Manganese	10-15 mg daily
Vitamin B6	20-50 mg daily
Vitamin C	1000-2000 mg daily
Antioxidant/bioflavonoid mix	