

# You Are What You Eat

## Nutrients, nutraceuticals, and healing



By Tamara Mitchell

Repetitive Strain Injuries (RSI) arise primarily from forceful, awkward, repetitive motions, but there are some people who do these motions for years and do not suffer RSI, or if they do experience problems, they are able to heal and recover quickly. Nutrition is extremely important in building healthy tissues, improving circulation and cardiovascular health, and aiding in healing when injuries happen. In this article, we look at current research and try to give guidance about what you can do to supply your body with the nutrients necessary to build and maintain a healthy body, and to aid in the repair of injured tissues. Nutrition and diet alone will not prevent RSI. A lifestyle of healthy choices is extremely important in preventing RSI and other disorders including:

- exercise
- sleep
- proper equipment and practices while at work and home, in the car, and during sports and hobby activities
- stress reduction
- self-care
- smoking abstinence
- good eating habits

There are some exciting discoveries being made that can help your body reduce painful and damaging inflammation as well as rebuild muscle tissue, connective tissues like tendons and ligaments, and even nerves. There are things we can do to minimize cartilage damage and deterioration, too. We will help you make choices that can not only make your life more comfortable, it can potentially help you recover from the daily stresses of life and injuries. There is no question about it, diet has a huge impact on what building blocks you supply your body, how your genetics are expressed, and how your body regenerates after stress and injury.<sup>1</sup>

### **Nutrients Today**

It is easy to get misled when seeking information regarding proper nutrition. There is a lot of false, biased, or unverified information, loads of fads, and research is constantly discovering new things about how our bodies use components of food and dietary supplements. But we begin by looking at the quality of our food supply today. What food is available in the market and what are the best choices for us?

Our diets have changed a lot since the days of our hunter-gatherer ancestors, and with that change, we have become a society afflicted with RSI, chronic disease, and obesity. Displacement of fruits and vegetables with too much unhealthy fat, refined grains and sugars contributes to these problems.

One single diet is not right for everyone since we all have different genetic predispositions, digestive systems, lifestyles, and metabolisms. But, we can all be healthier if we learn to enjoy lots of fresh fruits and vegetables with no fatty adornments, cut back our consumption of processed foods and saturated fats, and perhaps even plant an organic garden.

**Less food value today.** Some researchers view our current diet in terms of how it has changed over the past 5-7 million years. Before agricultural development and animal husbandry, dietary choices were limited to minimally processed wild plant and animal foods.<sup>2</sup> The Neolithic and Industrial Periods altered the crucial nutritional characteristics of our ancestors' diet, which is a probable cause underlying chronic diseases including those that increase risk of RSI. Our genes are not adapted to process most of the foods that we eat today.<sup>2</sup> Clinical trials that use dietary treatments with nutritional characteristics similar to those found in pre-industrial and pre-agricultural diets have confirmed the health benefits of this theory.<sup>2</sup>

Foods today contain only a fraction of the minerals and micronutrients the same foods contained less than 100 years ago.<sup>3</sup> A comparison study based on the government of England's periodic analysis of nutrient content in common foods from 1940 to 1991 found a drastic reduction in minerals of virtually all foods.<sup>3</sup> Although the analysis continues to this day and data is published, a comparative study of this data has not been conducted to continue tracking the mineral and micronutrient content of the same foods.

Below are a few of the foods with the most significant mineral losses found in the original comparison paper, updated with recent data from the same database.<sup>3,4</sup>

<b>FOOD</b>		<b>1940</b>	<b>1991</b>	<b>2015</b>
Spinach (boiled) - 13-572	Potassium	490 mg	130 mg	500 mg
	Phosphorous	93	28	45
	Iron	4	1.6	2.10
	Copper	0.26	0.01	0.04
Runner Beans – 13-112	Sodium	6.5	Trace	Trace
Potatoes – 13-489	Potassium	568	360	443
Carrots – old – 13-448	Magnesium	12	3	11
Beef, sirloin roast – 18-062	Iron	4.6	1.9	2.0
Beef topside roast – 18-084	Iron	4.7	2.8	1.90

Other research has shown similar nutrient losses in modern wheat varieties in comparison to historical wheat varieties. The decline is primarily in soft white wheat varieties used in pastry-flour.<sup>5</sup> Hard wheat varieties used in bread-making did not show similar declines.

**Soil depletion and fertilizer use.** In the first days of cultivating vegetables, it was known by farmers that they needed to move to different fields, to replenish the soil and to let fields lay fallow between crops. In the early 1900's it was found that by adding Nitrogen, Phosphorous, and Potassium (potash) to the soil, plant growth was enhanced.<sup>3</sup> Mineral content of most vegetables has risen since 1991 levels, but that is primarily true for Potassium and Phosphorus. Minerals that are not contained in fertilizers are continuing to decline in the vegetables that we consume. Fruits do not show such significant losses in minerals perhaps because, whereas most

vegetables are consumed as a whole plant, fruits are just a small part of the plant. Maybe it's because the plant puts a lot of effort into packing nutrients into fruits which are used to produce the next generation or because fruits often come from trees that are not dug up and replanted every year in the same field; they establish deep roots that can absorb minerals from farther down in the soil. Fruits did show significant losses in mineral content, but not as much as vegetables. Meats that are produced by feeding animals produce and grains that are grown on depleted soils may explain a significant loss of minerals in meats.<sup>3</sup> Perhaps the huge loss in iron in red meat can be explained by a change in diet from grassfed to grainfed beef, but for whatever reason, our beef today is quite anemic with very low levels of iron. Mineral losses from 1940 to 1991 were not found in some meats, specifically pork loin, rabbit, veal fillet, venison, trip, sheep's tongue, ox tongue, grouse, goose, partridge, pheasant, and pigeon.<sup>3</sup> Most of these are wild meats rather than farmed.

Overuse of fertilizers is leading to huge problems in farming areas where excess nitrogen has leached into the groundwater system, lakes, and streams.<sup>6,7</sup> Decades of nitrogen runoff results in nitrate in drinking water which is harmful to health including infant death, complications during pregnancy and spontaneous abortions, toxic affects to the thyroid gland, and carcinogens produced by the body in the presence of nitrate.<sup>8</sup> Runoff of excess nitrates into lakes, streams, and rivers results in algae blooms that deplete oxygen in the water creating dead zones where no fish or water life can exist in the absence of oxygen.<sup>7</sup>

**Choose organic.** With all that being said, we don't want people to think that food cannot provide good nutrition. It absolutely does, but people need to be aware of current farming methods and choose the most nutritious foods. Also, we don't want people to reach for pills and powders to meet most of their nutritional requirements. Food is always the best way to receive nutrients because there is synergistic value in whole foods. Whole foods contain a much wider variety of nutrients and micronutrients that work together and can never be replicated in a pill or powder.<sup>9</sup>

A review of 343 peer-reviewed research studies has found that organically grown foods are higher in nutritional value than non-organic crops, especially for antioxidants. Antioxidants are very important in reducing risk of many chronic diseases including cardiovascular disease, neurodegenerative diseases, and certain cancers.<sup>10</sup> Pesticide residues were also found to be four times higher in conventional crops than in organically grown crops and significantly higher concentrations of the toxic metal Cadmium.<sup>10</sup> Proteins and amino acids were found to be lower in organic crops than in conventional crops primarily because of the added Nitrogen in chemical fertilizers, but this is not of particular concern since most European and North American diets have sufficient or excess proteins from other sources.<sup>10</sup> What is of concern is that there was higher NO<sub>2</sub> and NO<sub>3</sub> concentrations in conventional crops, also likely a result of chemical fertilizers. Health impacts of crop-based NO<sub>3</sub> is still unknown, but increased dietary intake of NO<sub>2</sub> has been linked to stomach cancer and methemoglobinemia, a type of anemia preventing adequate oxygenation of the blood.<sup>10,11</sup>

In addition to these benefits, organic and permaculture practices in farming are intended to build healthy soil naturally, do less harm to pollinating insects, and avoid pollution of the environment. The use of synthetic fertilizers and pesticides are not allowed in the production of organic crops.<sup>10</sup> Instead, crop rotation, nitrogen fixing with cover crops, use of mechanical and flame weeding, and biological disease and pest control, though the use of copper and sulfur are allowed in crop protection.<sup>10</sup>

More controlled research is needed to study the impact of conventional vs. organic farming methods on nutritional value of foods, but it is clear that organic methods provide superior quality

foods that promote health, do not introduce harmful toxins and compounds into the diet, and promote a sustainable environmental approach to farming.

### **Weight management**

Many health problems are associated with being overweight or obese. 75% of Americans today are overweight or obese and these numbers continue to climb.<sup>12</sup> Type 2 diabetes, which is closely tied to obesity, negatively affects blood vessels, nerves, and energy transportation, depriving muscles and other soft tissues of nutrients and oxygen. It not only predisposes people to RSI, it makes recovery much more difficult. Osteoarthritis (OA) is another chronic health problem closely related to RSI. It is generally caused from overuse. Extra body weight leads to increased wear and tear on the lower extremities leading to OA. Obesity and overweight also pose a major risk for cardiovascular disease, hypertension (high blood pressure) and stroke. These problems affect the health of the circulatory system, which in turn is a major factor in the development of RSI. Poor circulation and RSI are closely related. Drugs and surgery can help control some aspects of these diseases, but they do not get to the root of these health problems, which is often poor eating habits.

Being underweight is also stressful for the body and increases risk of RSI and other types of injury. Being underweight is often linked to malnutrition, overuse of alcohol or drugs, smoking, poor self-care, and poor mental health.<sup>13</sup> The body needs nutrition in order to maintain health and repair tissues and organs. Considering the much lower level of nutrients in most food today, eating too little is actually much worse than in previous generations.

The use of Body Mass Index (BMI) is an accepted way to determine if a person is within a healthy weight range. Body mass index is calculated by dividing body weight (in kilograms) by height (in meters), squared. We have an easy-to-use calculator on our website at <http://working-well.org/Website/bmi.html>

Underweight: less than 18.5 kg/m<sup>2</sup>

Desirable BMI: 18.5-24.9 kg/m<sup>2</sup>

Overweight: 25-29.9 kg/m<sup>2</sup>

Obese: over 30 kg/m<sup>2</sup>

Once you have determined your BMI, you can see if you should plan weight loss (or gain) in your future. If you find that you need to lose weight, we have an article on Overweight and Obesity that can help you: <http://working-well.org/articles/pdf/Overweight.pdf>.

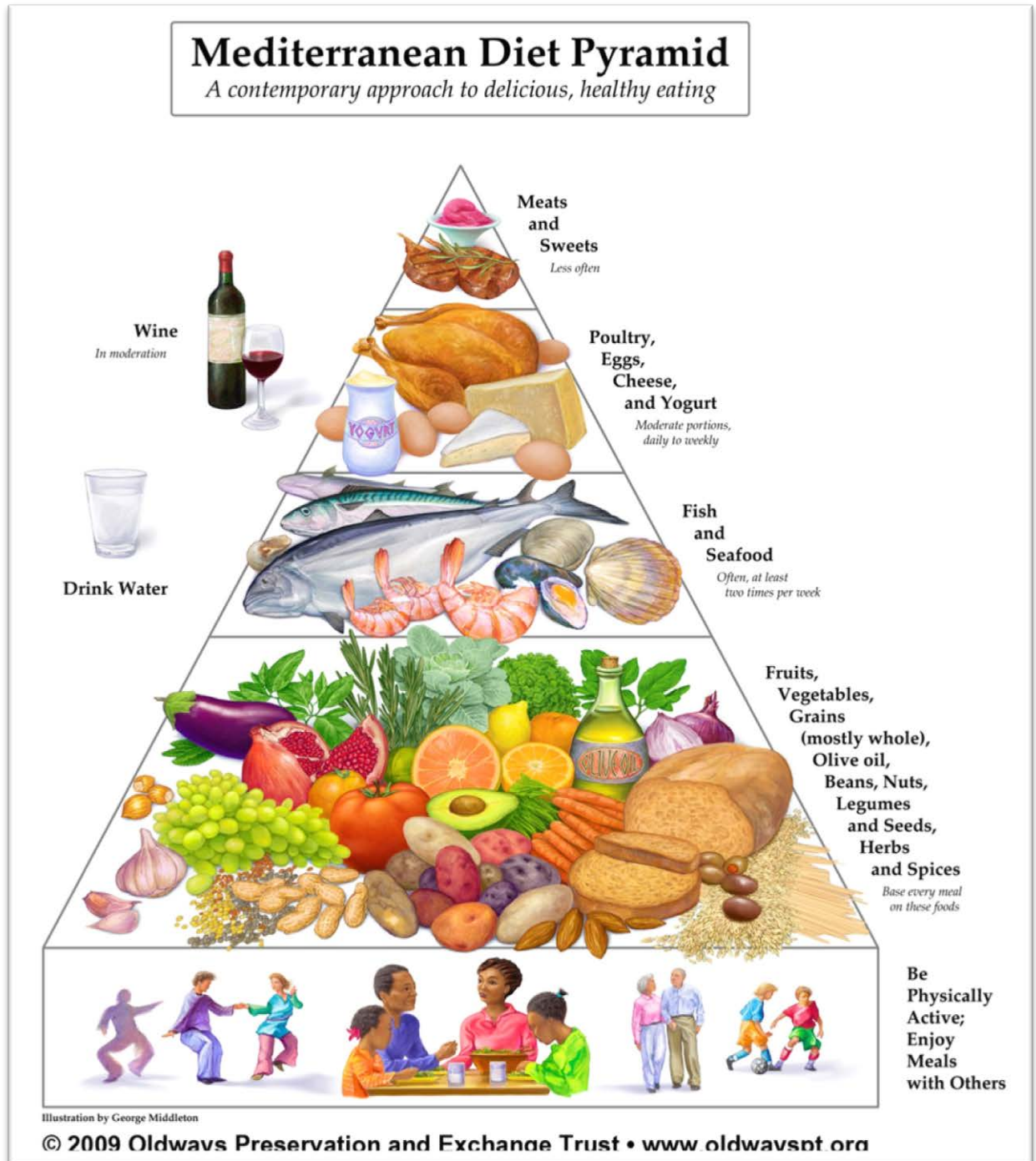
### **General Nutrition Guidelines**

Our recommendation for the most nutritious balance of foods in our article on Overweight was the Mediterranean diet backed by many research studies. Regardless of whether you need to lose weight or simply want to maintain your current weight and improve your health, there are no better nutritional guidelines to a healthy diet. Contrary to current Mediterranean eating habits, traditional ways of eating were healthy and not laden with refined starches, refined sugars, and saturated fats. In fact, almost any cuisine can be prepared using the guidelines of the Mediterranean Diet, so you don't have to eat Italian food all the time! One essential ingredient in all recipes, however, is extra-virgin olive oil. Other than that, it's up to you what exact foods you choose to consume as long as you stock your refrigerator and larder with the approved ingredients.

It is important to note that in addition to the actual foods consumed, being physically active and sharing meals with others is a key component to the Mediterranean diet.

To quickly understand the Mediterranean diet, we recommend reading:

- Oldways website - <http://oldwayspt.org/traditional-diets/mediterranean-diet>
- Book - The Mediterranean Prescription, by Acquista, A. and Vandermolten, L.A., ©2006 The Ascent Group, LLC, and Angelo Acquista, M.D. ISBN 0-345-47924-6



### Reducing Inflammation

When injury happens, there are several responses by the body. One is inflammation, which is generally a good thing if the injury is an acute, sudden injury or a sprain or strain because the influx of lymph, white blood cells, and other healing agents flood the wounded area and speed the

healing process. When injury is sustained over a long time, like during chronic stress, repetitive strain, and overuse, chronic inflammation can result....not a good thing. So we can look at things that will reduce chronic inflammation.

Chronic inflammation can go on for months or years leading to some serious and life-threatening diseases or conditions. Chronic inflammation destroys body tissues and can cause thickening or scarring of connective tissue and cell death. Reduction of chronic inflammation through diet and supplements is a safe and effective way to facilitate healing, promote lifelong health, and prevent related chronic diseases.

To learn about the many ways to control inflammation through diet and supplements, please read our in-depth article on inflammation:

<http://working-well.org/articles/pdf/Inflammation.pdf>

### **Macronutrients and Micronutrients**

When injury is severe enough to result in immobilization or “favoring” a particular body part, loss of muscle mass and reduced muscle strength and function may result. As we compensate, often another body part becomes overused and injured in the process to avoid the use of a painful part. We need to consider nutritional contributions that can be made to assist in the remodeling and rebuilding of damaged tissues.

Nutritional requirements during partial or complete immobilization and during healing is important to ensure that there are no deficiencies in energy, macronutrients and protein that would impair healing, increase loss of muscle and tendon mass, and reduce function.<sup>14</sup> The term nutraceutical is coined from the words nutrition and pharmaceutical. It is used to refer to food or the part of food that plays a significant role in treating illness and in maintaining health, though there is no universally accepted definition.<sup>15,16</sup> The food products that can be categorized as nutraceuticals are dietary fiber, prebiotics, probiotics, polyunsaturated fatty acids, antioxidants, and other herbal and/or natural foods.<sup>15</sup> Nutraceuticals are gaining much more attention in research as we recognize the importance of diet and dietary supplements rather than relying on synthetic drugs and all of their side effects. The three main branches of nutraceuticals are herbal/natural products, dietary supplements, and functional foods.<sup>15</sup> The goal is to prevent illness rather than to treat it, through proper lifestyle, consuming the correct foods, and the inclusion of foods that go beyond diet, but do not include pharmaceuticals.<sup>17</sup>

### ***Macronutrients***

Macronutrients are components of the diet that are required in larger quantities to promote growth, development, and to regulate body processes.<sup>18</sup> These include proteins, carbohydrates, and fats.

- ***Energy.*** Energy is supplied by simple and complex carbohydrates including sugars, starches, whole grains, starchy vegetables, and high-sugar fruits which are used quickly by the body.<sup>19</sup> Fats are broken down more slowly or stored by the body for later use, but they also provide energy over a longer time frame.<sup>19</sup> In the case of upper body injuries in office or lab settings, the reduction in energy expenditure during healing will likely be very little as opposed to an injury to the lower body that hinders walking or other exercise, so weight gain from inactivity is unlikely. Severe dieting and cutting back on energy sources and macronutrients while recovering from or suffering repetitive strain is counterproductive because the body requires significant energy to rebuild the damaged tissues.<sup>14</sup> Reducing energy intake will result in loss of muscle mass and it slows healing.<sup>14</sup> Overconsumption of fats, however, interferes with muscle synthesis, so the balance of foods should probably be shifted to more vegetables and proteins.<sup>14</sup> In addition, an intake of too much energy actually accelerates muscle loss during inactivity, most

likely through the activation of systemic inflammation.<sup>14</sup> It is important to watch the balance of foods that are eaten during periods of high activity requiring daily rebuilding of body tissues and during the healing process.

- **Proteins.** Consuming smaller amounts of protein throughout the day enables a continuous supply for rebuilding body tissues rather than consuming a lot of protein at one main meal.<sup>14</sup> There are 20 amino acids in protein. The human body can synthesize 10 of these, while the remaining 10 are termed “essential” because they must be consumed in food.<sup>20</sup> Unlike fat and carbohydrate, humans do not store excess amino acids in the body, so they must be consumed every day in food and as mentioned, it is important to provide a supply of protein throughout the day.<sup>14,20</sup> If activity level is reduced and food intake is also reduced to prevent weight gain, it is likely that protein consumption will be insufficient for healing.<sup>14</sup>

- **Fatty acids.** Our article on Inflammation covers the need for rebalancing the fats in most people’s diets so that Omega-6 fatty acids are reduced and Omega-3 fatty acids are increased. It is well documented that Omega-3 fatty acids, primarily derived from fish, krill, and the New Zealand green lipped mussel, play an important role in reducing and preventing chronic inflammation and associated pain.<sup>16</sup>

### ***Micronutrients***

Micronutrients are components of the diet that are required in small quantities to promote growth, development, and regulate body processes. These include vitamins, minerals, and trace elements.<sup>18</sup> We mention a few here that are of overall importance to the general health and healing. Some specific micronutrients will be included later in the discussion of the maintenance and healing of specific body tissues.

- **Calcium** is essential for healthy bone density. Calcium deficiency may increase the risk of stress fractures.<sup>21</sup> This is particularly important to athletes.

- **Iron** is essential for healthy muscles and soft tissues, though too much is not a good thing. You can usually get enough iron through diet cooking with cast-iron pans (which flakes off in minute quantities into the food), and by consuming Vitamin C with meals, which enhances iron absorption.<sup>22</sup>

Low blood-iron levels reduce the oxidative potential in the muscles, creating a higher potential for muscle injuries.<sup>21,22</sup> Low blood-iron may also decrease the rate of muscle and connective tissue repair which speeds the progression from minor to major injuries.<sup>22</sup>

Too much iron, may be linked to an increased risk of heart attack. It can inhibit the absorption of zinc, another important mineral.<sup>22</sup> In addition, iron interferes with the body’s natural antibiotic system. It turns out that when you have an infection, your body temperature rises and your blood-iron level drops.<sup>22</sup> Microorganisms are unable to grow when they are confronted with higher temperatures and reduced iron levels, so taking too much iron when you have an infection may actually be feeding the infection.<sup>22</sup>

- **Silicon.** Research is finding that dietary and supplemental silicon is essential to bone and connective tissue health.<sup>23</sup> It may also have a modulating effect on the immune and inflammatory response as well as affecting the absorption of other minerals.<sup>23</sup> Beer and (non-distilled) drinking water, especially mineral waters, are actually the most bioavailable forms of silica.<sup>24</sup> Barley and hops used to make beer are high in silica. Fruits and vegetables have a high level of silicon,

especially grasses that are sources of cereal grains and rice, however actual absorption of silicon from foods and bioavailability of these sources is not yet well understood.<sup>24</sup> The high fiber content of vegetables and whole grains reduces the dietary silicon is possibly one of the most significant facilitator of bone health, though one study found that it is only utilized effectively by the body in the presence of estrogen (estradiol).<sup>25</sup> The association of higher bone mineral density in the hip was found in one experiment only for high dietary levels of silicon, not for potassium, magnesium, or flavonoids, and only for premenopausal women or women on hormone replacement therapy.<sup>25</sup>

Experiments on humans and animals in real life and in the lab show that silicon is an important mineral in bone health, bone mineral density, and possibly in cartilage, collagen, and connective tissue synthesis as well.<sup>23,24</sup> More research is required to better understand the role of silicon and whether supplementation is required.

**Water.** Water is essential to good health. It keeps body temperatures normal, lubricates and cushions joints, protects the spinal cord and other tissues, and eliminates wastes through urination, perspiration, and bowel movements.<sup>26</sup> Your body needs more water when it is hot, you are physically active, you are running a fever, or you have diarrhea or vomiting.<sup>26</sup> It is possible to overdo water consumption. If you drink when you are thirsty and consume plenty of beverages and watery fruits and vegetables, you are likely consuming enough water. For a complete discussion of water requirements, please read our article on Hydration: <http://working-well.org/articles/pdf/Hydration.pdf>

### **Rebuilding nerves.**

There is a growing amount of research showing impressive results in therapeutic consumption of the nucleotide Uridine in combination with other micronutrients in rebuilding nerves.<sup>27,28,29,30</sup> One specific formulation of nutrients developed and researched called Fortasyn Connect is patented and sold under the name Souvenaid as a liquid beverage. It is not yet available for purchase in the U.S., but is available in Australia and the U.K. It is used in these countries for Alzheimer's patients and is also showing promise in regrowth of neural pathways and spinal cord tissue following injury.<sup>27,28</sup> One daily dose of Souvenaid contains:<sup>27,31</sup>

- Fish oil Omega-3 polyunsaturated fatty acids (PUFA) DHA (1200 mg) and EPA (300 mg)
- Choline (400 mg)
- Uridine monophosphate (UMP) (625 mg)
- Phospholipids (106 mg)
- Folic acid (400 µg)
- Vitamins B6 (1 mg)
- B12 (3 µg)
- C (80 mg)
- E (40 mg)
- Selenium (60 µg)

These nutrients have been known to enhance membrane formation and function, and they actually appear to have protective effects on brain membranes.<sup>27,28</sup> Uridine monophosphate is a nucleotide that works in conjunction with the Omega-3 fatty acid DHA and choline in the synthesis of neuronal membranes and synapses.<sup>32</sup> Uridine monophosphate has also been found to reduce pain and associated symptoms in a preliminary study of patients with peripheral nerve entrapment in a



formulation that included folic acid and Vitamin B12 for 2 months.<sup>29,30</sup> Patients with neuropathic pain for a variety of reasons, were given a daily dose for 60 days of:

- Uridine monophosphate (50 mg)
- Vitamin B12 (3 µg)
- Folic acid (400 µg)

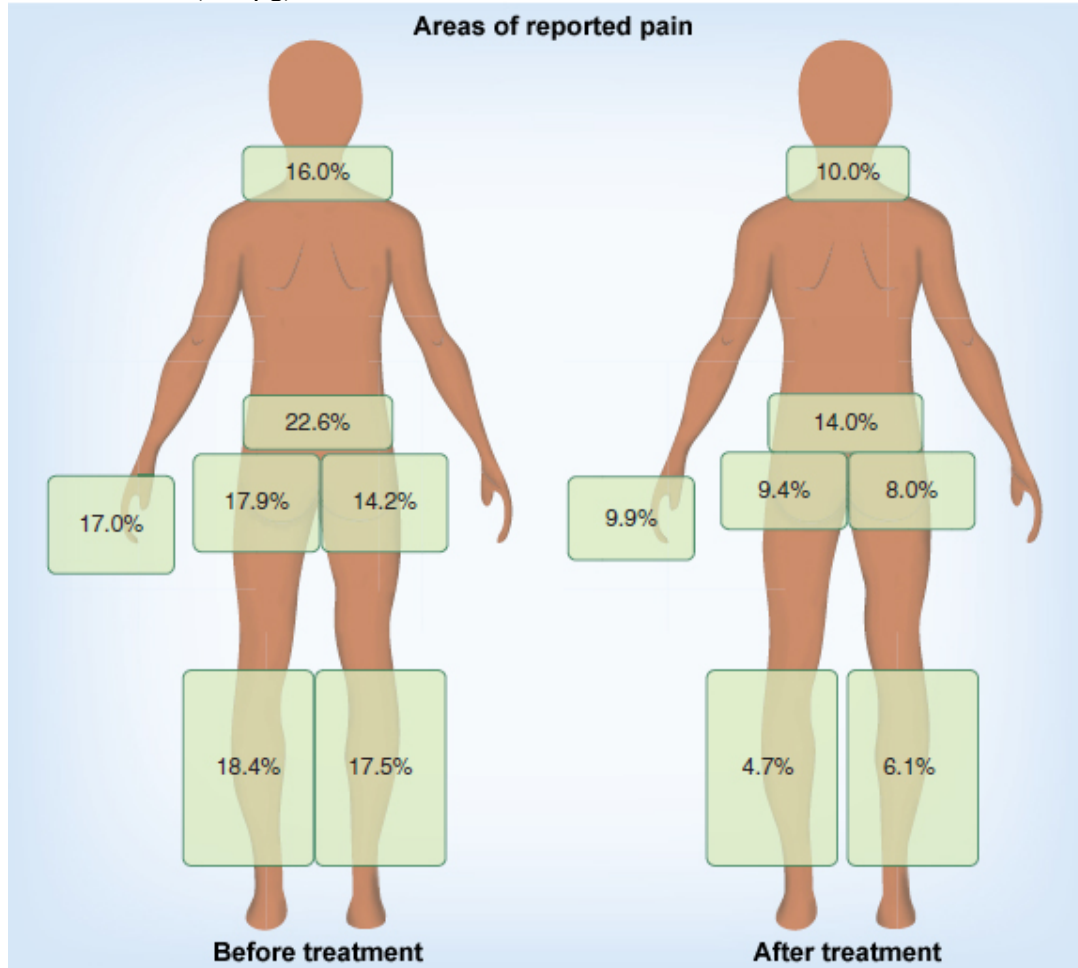


Illustration from Reference 30

Although the U.S. lags behind other countries in approving the use of Souvenaid for Alzheimer’s disease and it has not been released in any country for use in humans for general use with nerve trauma, damage, or pain, supplementation using these natural components may be quite beneficial as more research is conducted. If these micronutrients actually can help rebuild neural pathways, you will be nourishing your body. At least it is highly likely that you will experience much less pain from nerve damage or neuropathy allowing you to greatly reduce the use of other pain relievers and avoid the various side effects. By combining a quality source of Omega-3 PUFAs, a Uridine monophosphate supplement, and a quality multivitamin which contains all of the other ingredients, you can create your own formulation. Make sure you read the label of your multivitamin. Most do *not* contain choline, even high quality multivitamins. The supplements shown below contain all of the micronutrients used in all of the research to date. Be sure to check proper dosage.

		
<p>High quality Omega-3 PUFAs</p>	<p>Uridine</p>	<p>Multivitamin containing all the other ingredients of the formulation Fortasyn Connect</p>

**Protecting nerves from damage.** There are other areas of research pertaining to food and nutrient roles in protecting nerves from damage. In general, environmental toxins can lead to oxidative damage and degeneration of nerves. The formation of free radicals, oxidative stress, and the role of antioxidants in disorders such as Parkinson’s Disease, Alzheimer’s Disease, ALS, epilepsy, schizophrenia and other neurodegenerative diseases has led researchers to seek potent antioxidant nutrient sources.<sup>33</sup>

Pomegranates are one of the oldest known fruits and they have been used for thousands of years in the treatment of a wide variety of diseases and disorders.<sup>34</sup> It is exceedingly high in antioxidants, vitamins B6 and C, minerals, and fiber and current research is being conducted to verify and better understand the nature of its healing and protective qualities.<sup>34</sup> Research using four different tests to determine the antioxidant activity of various different beverages found that pomegranate juice had at least 20% greater potency than any of the other beverages tested.<sup>35</sup> Beverages tested included apple juice, acai juice, black cherry juice, blueberry juice, cranberry juice, concord grape juice, orange juice, red wines, iced teas (including black, green, and white tea), and commercially produced pomegranate juice.<sup>35</sup> Another study compared the effect of consuming whole pomegranates to figs, dates, and no special diet in the development of inflammation and neurodegenerative indicators. All fruits showed significant effect in reducing inflammation, but pomegranates were by far the most effective.<sup>36</sup> Antioxidant activity is higher in commercial juices available in the market than the juices used in most laboratory tests because it is extracted from the whole fruit, not just the arils, or interior juicy seed portions of the fruit.<sup>37</sup>



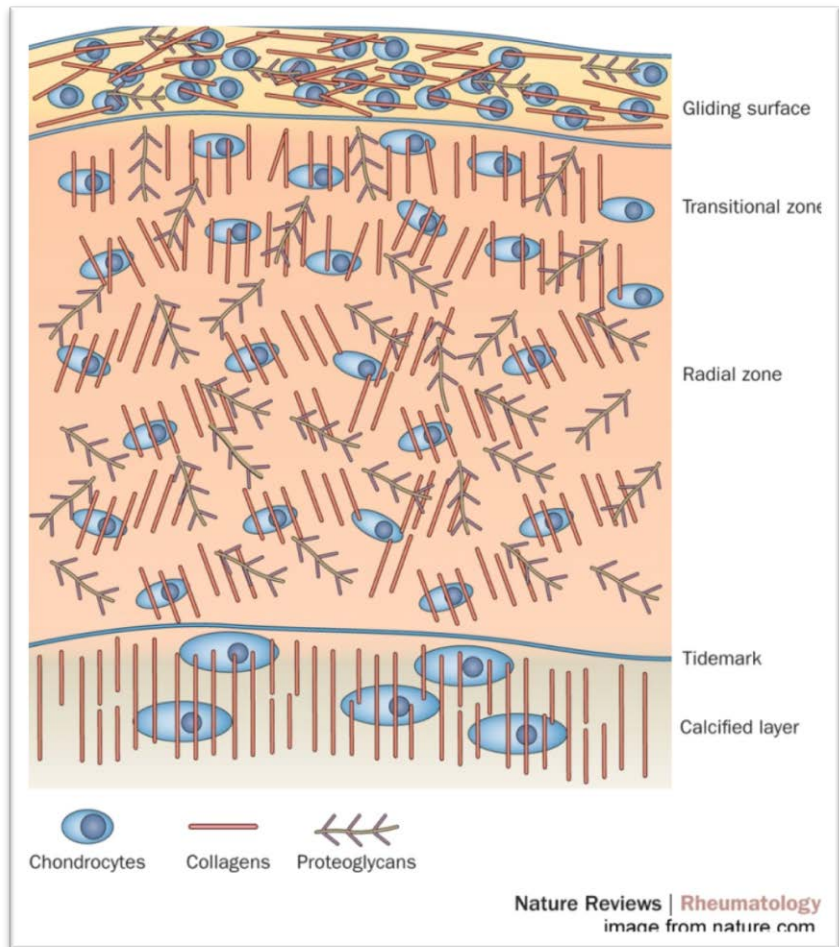
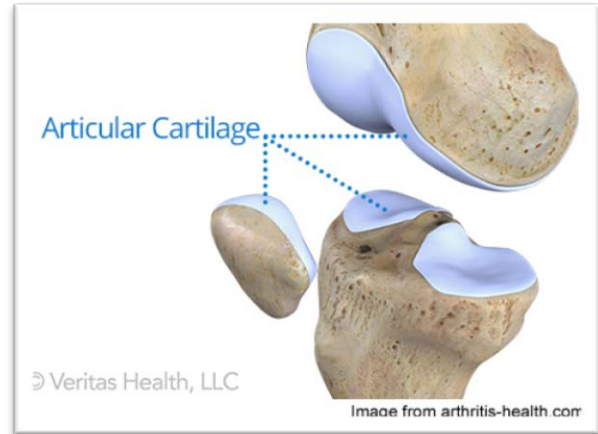
Pomegranate juice extract appears to provide protection against neurotoxins in laboratory studies, most likely because of the antioxidant and botanical phenolic constituents.<sup>33</sup> It has no toxic effect on human neurons and is likely therapeutically safe.<sup>33</sup> Some varieties of pomegranate have more potent properties, but in general, pomegranate fruit is a safe and powerful antioxidant with potential in protecting nerve damage from environmental oxidative damage.<sup>33</sup>

The indication that pomegranates have neuroprotective and anti-inflammatory properties does not mean that everyone should go overboard consuming them or their juice. A wide variety of fruits, vegetables, proteins, fats, and carbohydrates is always recommended to assure that a broad spectrum of nutrients is provided to the body. Pomegranates in the Western diet may be overlooked as a powerhouse of nutrition with special benefits, so consumption of a moderate amount of pomegranate juice daily is advisable.

### Rebuilding cartilage

Although it seems like cartilage is such a simple tissue compared to muscle, nerves, bone, tendons or ligaments, it has proven to be one part of the body that lacks the ability to repair once it is damaged. There are no blood vessels feeding cartilage and therefore, no way to provide nutrients or generate new cells.<sup>38</sup> Surgical intervention techniques such as marrow stimulation and grafts all result in cartilage of inferior quality, defects, lack of integration with the surrounding tissues, and risk of infection.<sup>38</sup> Bone regenerates quickly and integrates easily with a variety of materials, so integration of cartilage with bone is actually fairly successful because of the properties of the bone to integrate.<sup>38</sup> The problem is that cartilage almost never integrates successfully with adjacent cartilage.<sup>38</sup> Implantation of synthetic or natural cartilage patches is not highly successful for this reason.

Cartilage that articulates within a joint is called articular cartilage. It is organized in various layers or zones.<sup>39</sup> The top layer protects the deeper layers of cartilage and it consists of tightly packed collagen fibers aligned parallel to the moving surface.<sup>39</sup> A middle layer is loosely packed and organized at an angle to the surface providing some resistance to compressive forces.<sup>39</sup> The deepest zone of cartilage provides the greatest resistance to compressive forces with large diameter collagen fibers arranged perpendicular to the moving



surface of bone and the cells arranged in columnar fashion anchoring the cartilage to the bone.<sup>38,39</sup>

Cartilage has unique properties that protect joints from compressive forces, from friction during motion, and it has strength to endure a large range of motion. No other material can match all of these properties.<sup>38</sup> It has been possible to create tissues in the lab that have the compressive properties of natural cartilage.<sup>38</sup> The nearly frictionless properties of natural cartilage which provide lubrication of joint surfaces preventing wear and tear is unmatched by synthetic materials, but cartilage can be engineered with frictional properties similar to native tissue.<sup>38</sup> Research and technologies to repair cartilage is an ongoing effort, but has to date remained elusive.<sup>38</sup>

While we wait for technology to come up with a means to surgically repair cartilage, the field of nutrition is researching simple, safe, less expensive, and far less invasive dietary means for preventing and treating cartilage damage. Osteoarthritis (OA) is one of the main reasons that cartilage breaks down. Originally it was thought that OA was a result of simple wear and tear of the joints. We now understand that the development and progression of OA encompasses not only biomechanics, but other factors such as metabolism, genetics, and epigenetics...or the altered expression of genes based on external factors.<sup>40</sup> The interplay between pro and anti-inflammatory mediators, signaling within the cells regarding building and breaking down tissues, the cartilage matrix and synovial tissues and fluids themselves are all important in the health of the cartilage tissue.<sup>40</sup> Research has shown that, in adults, cartilage is primarily nourished by synovial fluids and to a lesser extent, bone marrow.<sup>41</sup>

- Omega 3's. Control of inflammation and the health of articular cartilage cells is very dependent upon a sufficient dietary supply of polyunsaturated fatty acids (PUFA's), specifically the Omega 3 Fatty Acids EPA and DHA found in dietary sources and supplements derived from marine sources such as oily fish, mussels, and krill.<sup>40</sup> The common over-consumption of Omega 6 Fatty Acids and under-consumption of Omega 3 Fatty Acids results in an imbalance that encourages chronic inflammation, promotes joint dysfunction and degeneration, and fails to provide nourishment to plasma membranes for repairing and remodeling damaged tissue and articular cartilage cells.<sup>40</sup> In a study of guinea pigs, dietary Omega 3 reduced disease in animals genetically prone to OA.<sup>40</sup>

- Pomegranate fruit is showing promising abilities to inhibit cartilage degradation in lab experiments and in live human and animal experiments.<sup>42,43</sup> In one experiment, people with knee OA who drank 200 ml of sugar and additive-free pomegranate juice for just 6 weeks significantly improved their total OA scores as well as stiffness and physical function. Pain was not significantly affected by the juice.<sup>43</sup> There was also a significant decrease in the enzymes responsible for cartilage breakdown and an increase in antioxidants compared to a control group.<sup>43</sup> Human studies are showing very promising effects of both pomegranate seed extract and pomegranate fruit extract in altering genetic expression of OA, inhibiting inflammation, and increasing bone mineral density.<sup>44</sup> Pomegranite peel extract has been shown to reduce reported pain and increase reported functionality of women with OA.<sup>45</sup> All parts of the pomegranate fruit have been shown to decrease inflammation and prevent bone loss in mice with laboratory-induced osteoarthritis.<sup>46</sup>



We covered the promising ability of pomegranates to help rebuild nerves and with its additional potential ability to protect cartilage and overall excellent anti-oxidant properties, we highly recommend that everyone start drinking a glass or two of unsweetened, whole pressed pomegranate juice daily or incorporating it into smoothies or using it in other dishes that do not require heating. Nothing in the world is magical on its own, but this often overlooked fruit does appear to have some impressive qualities and adding it to your arsenal of healthy foods seems prudent.

- **Glucosamine/chondroitin.** Unfortunately, although there have been years of research on glucosamine and chondroitin supplements, there is very conflicting evidence that these supplements help rebuild or maintain cartilage, reduce pain, or otherwise improve joint health.<sup>16,47,48,49</sup> As we discuss later, they are effective in rebuilding tendons and ligaments, however. There is pretty clear evidence that neither of these supplements alone provide significant help to warrant the expense, but together they might prevent continued damage and they might reduce pain enough to allow a person to reduce or discontinue the use of other pain relievers such as NSAIDS which have very undesirable effects on the body. This is true especially in the case of OA.<sup>48</sup> Use of glucosamine/chondroitin supplements is, therefore an individual choice, but many people find that they help and can be more effective than prescription drugs.<sup>50</sup> Glucosamine and chondroitin are found primarily in the shells of marine animals and animal cartilage. They are generally not found in foods that are commonly eaten, especially in dosages that would be effective, so supplements must be taken.<sup>51</sup> An adult weighing up to 200 lbs. should take 1,500 mg of glucosamine and 1,200 mg of chondroitin daily for at least two months to obtain results.<sup>51, 52</sup> If pain is not relieved and functionality is not improved, it is probably more effective to focus on other things that have been shown to help more.

- **Methylsulfonylmethane, or MSM,** is often combined with glucosamine because it has a synergistic effect and increases the effectiveness of glucosamine.<sup>53</sup> MSM is a naturally occurring form of sulfur that helps maintain healthy muscles, tendons, and cartilage.<sup>54</sup> Relatively little research has been done to determine its usefulness.<sup>16</sup> Studies of people with knee and/or hip OA have found that MSM provides significant improvement in physical function, as well as significant reduction in stiffness and pain compared to a people who received a placebo.<sup>55,56</sup> It is apparently more effective for arthritis in some parts of the body than others, but not enough research has been done. Since it is a form of sulfur, side effects are few. Taking this supplement may help symptoms and mobility, but it is unlikely that it provides protection from cartilage degeneration or that it helps to regenerate damaged cartilage. People should avoid taking it with blood thinners.<sup>57</sup> It is likely to be more effective than glucosamine/chondroitin, but if results are not felt within a couple of months, it is unlikely to be worth the cost.

- **Green tea.** Green tea appears to have some benefits as an anti-arthritis and protective effects on cartilage primarily through its ability to block inflammation.<sup>58</sup> Green tea's benefits are attributed to its catechin content, specifically epigallocatechin-3-O-gallate (EGCG).<sup>58</sup> There is enough research on the benefits of green tea to suggest that it should be a part of a healthy diet for most people.

- **Extra virgin olive oil.** The Mediterranean diet is recommended for its balance of healthy vegetables, fats, carbs, and proteins. Extra virgin olive oil is one of the cornerstones of the Mediterranean diet and it has been shown that it not only reduces the factors involved in inflammation, but it also promotes the synthesis of lubricin within the fluids and cartilage matrix itself.<sup>59</sup> Lubricin is a type of protein that protects cartilage surfaces and provides lubrication between the moving surfaces of cartilage in a joint.<sup>59</sup> Physical activity was also found to be

beneficial in the recovery of damaged cartilage, so it is recommended that both moderate physical activity and olive oil be used in the treatment and prevention of cartilage damage.

### **Rebuilding Muscle.**

Regeneration of muscle is hindered with disuse.<sup>14</sup> Just 14 days of reducing muscle activity results in a reduction in muscle synthesis from ingested proteins and amino acids.<sup>14</sup> This means that after just 2 weeks of muscle inactivity, our ability to build new muscle from the proteins we eat is actually impaired, so immobilizing is actually detrimental to muscle healing if it isn't required.

The body naturally rebuilds muscle tissue following damage, but research has studied dietary means for stimulating protein synthesis and inhibiting protein degradation in laboratory rats and humans.<sup>60,61,62</sup> The essential amino acid leucine is potentially important in the synthesis of skeletal muscle. There has also been considerable research on creatine supplements in rebuilding muscle tissue following exertion and for use with various muscle-related disorders. Both leucine and creatine have been researched quite a bit, but it is premature to suggest that supplements are needed or even helpful in healing muscles from repetitive strain injuries. In proper dosages, they cannot hurt and might help, but we are not recommending these supplements until further research is completed.<sup>14</sup>

- Leucine. It has been found that the role of the essential amino acid leucine in the presence of insulin is to switch on muscle protein synthesis.<sup>60</sup> Moderate levels of leucine and glucose, to stimulate insulin release, may help people with muscle injury and it reduces muscle atrophy during immobilization following injury, due to aging, or a sedentary lifestyle. It is important to note that leucine also enhances insulin sensitivity and prolonged very high intake of leucine may lead to insulin resistance, so we do not recommend high level supplementation of leucine for a long time.<sup>60</sup> At the same time, it is well known that muscle disuse leads to insulin insensitivity, so perhaps increasing insulin sensitivity is a good thing.<sup>14</sup> Not enough is known about to really understand or recommend anything with certainty. A study of sedentary older adults found that supplementation with 4 grams of leucine per meal, 3 meals per day for 12 days resulted in a marked increase in muscle synthesis.<sup>62</sup>

Many foods contain leucine and it follows that a diet consisting of high-leucine foods may be sufficient to promote the protein synthesis response. Many of the research studies have been funded by companies who produce whey protein supplements, but in reality many other legumes, lentils, egg yolks, dairy products, all meats and seafood contain generous amounts of leucine.<sup>63</sup> Which source of amino acids, and specifically leucine, are utilized best by the body is not yet known, but there are differences in how they are digested and metabolized. Milk proteins are absorbed more slowly than soy proteins and some research has found that because of this, milk may be a preferable food source for leucine than soy.<sup>64</sup> There is also some indication that a regular protein-rich diet based primarily on animal foods may be more effective for protein synthesis and maintenance of muscles than a long-term plant-based protein-rich diet, but there is not enough research to recommend this yet.<sup>64</sup> A variety of leucine-rich foods from many sources would be the best approach, since it takes all 10 essential amino acids for the body to create muscles and there are many other nutrients that are obtained by varying protein sources. If the diet is low in protein, supplementation with 2,000 to 5,000 mg. is advisable during times where muscles are healing, during times of intense muscle usage at work, competition, or exercise, or when a person is unable to be active to prevent muscle tissue deterioration.<sup>65</sup> Leucine is a bitter powder which is available as a powder to be added to drinks or smoothies, in premixed flavored protein powders, or as capsules, especially in combination with other branched-chain amino acids (BCAA), specifically Isoleucine and Valine. Research has shown that there is no benefit to taking all three types of branched-chain amino acids since Leucine has been specifically

identified to be the amino acid responsible for switching on protein synthesis in the body, though consumption of the other two BCAA will do no harm.<sup>60</sup> Look for products that are GMO-free and without added sugar.



- **Creatine.** Creatine facilitates muscle protein synthesis. Creatine is stored by the body, so it doesn't matter when it is taken with regard to meals or exercise.<sup>65</sup> For people recovering from repetitive strain injuries affecting the muscles, it may be beneficial, but there is no research on this at all. It may also help rebuild muscles that are fatigued due to overuse and repetitive use. It appears that creatine is safe for most people and has been researched extensively, especially with regard to sports performance and bodybuilding. It is a naturally occurring molecule that occurs in meat and fish, and it is made by the kidneys in humans.<sup>66</sup> Creatine monohydrate is the best form to take as a supplement in powder, tablet, or capsule form and the recommended dose is 0.3 grams/kilogram of bodyweight per day.<sup>65</sup> Take with plenty of water to avoid stomach cramping. Do not take too much at once to avoid diarrhea and nausea.<sup>65</sup> Caffeine may counteract the benefits of creatine though more research is needed to confirm this, but for the time being, it is probably wise to cut back on the caffeine while using creatine.<sup>67</sup>



### ***Rebuilding Ligaments and Tendons***

Nutraceuticals have been studied in their ability to repair damaged ligaments and tendons. Unfortunately much of the research is not conducted in a well-controlled manner and with confounding variables, but there are some promising indications that changes in diet or supplementation might help in rebuilding stronger, higher quality tendons and ligaments following injury than without.<sup>68</sup>

- **Glucosamine and Chondroitin sulphate.** Animal studies have found that tendon injuries and tendon-to-bone reattachment healing are affected positively by Glucosamine/Chondroitin Sulfate treatment.<sup>68</sup> Collagen synthesis in ligaments and tendons is increased, more organized collagen bundles with normal orientation of collagen fibrils were formed, greater tendon strength results, treated tendons returned to normal diameters with larger fibrils, and inflammation was less in various different studies.<sup>68</sup> Untreated subjects showed more random formation of collagen fibrils with disorganized scar tissue, weaker tendon strength, smaller diameter tendons with smaller fibrils upon healing, with weaker strength and greater likelihood for rupture, in addition to more inflammation.<sup>68</sup>

In addition to improved healing qualities, Glucosamine/Chondroitin Sulphate supplements seem to protect tendons from fatiguing during cycling and static loading in humans. This may possibly be due to better hydration.<sup>68</sup>

- Vitamin C. Animal research on tendon healing has shown that, although adequate levels of Vitamin C are critical to normal synthesis of collagen, it does not increase collagen synthesis alone.<sup>68</sup> It appears to possibly be part of a feedback mechanism that controls the supply of nutrients and the rates of collagen synthesis and secretion.<sup>68</sup> Vitamin C is an antioxidant and it appears to reduce oxidative stress, reduces the adhesion of tendons to surrounding tissues, and stimulates tendon healing.<sup>68</sup> Much more research is needed to understand the role of Vitamin C in tendon healing, but dietary intake and probably supplementation of Vitamin C appears to be critical to proper healing of tendons.

- Hydrolyzed Type I Collagen. Hydrolyzed collagen is derived from cow bones and cartilage and through processing. It is broken down into small, undamaged, amino acids.<sup>69</sup> It is available in the form of Knox gelatin, beverages, powders, and tablets. One study found that high doses may improve the mechanical properties in the Achilles tendon of rabbits, but that is not strong enough evidence to suggest that it will improve the health or healing of tendons or ligaments in humans. It has been known to improve hair strength and quality, improve skin tone, and promote overall health and healing through providing available amino acids.<sup>69</sup> Until further research is conducted, we do not advise spending money on these supplements to improve tendon and ligament health, and many are needlessly expensive. If you wish to increase dietary consumption of collagen, gelatin is a natural source. Pressure cooking or long, slow cooking of bones, muscle fascia, tendons, and other meat products that are generally wasted will result in a gelatin that contains collagen and it is a delicious soup base known as consommé.<sup>70,71</sup> Consommé differs significantly from simple broth. It gels when cooled, adds body to soups, and can be used for cooking a variety of foods such as rice.<sup>70</sup>



- L-arginine. The formation of nitric oxide by the body has been found to be a key factor in tendon healing. Inhibition results in chronic inflammation, development of fibrosis, and changes in the body chemistry during the repair process.<sup>68,72,73</sup> Nitric Oxide is formed by the body from the amino acid L-arginine.<sup>73</sup> Not much research has focused specifically on dietary L-arginine in ligament healing, though it has been shown that it can be beneficial to other healing processes such as wound and burn healing.<sup>72</sup> A diet rich in nuts, legumes, meat, and seafood likely supplies all the L-arginine required by the body.<sup>74</sup> Currently a dosage of 30g/day of arginine has been proposed.<sup>75</sup> People with diabetes, pregnant or nursing women, or people who have suffered a heart attack should not use L-arginine supplements without a doctor's approval.<sup>76</sup>

- Curcumin. Curcumin (in turmeric), has been found to be beneficial to tendon health and healing in several ways. It helps to reduce oxidative stress and reduces inflammation, it reduces unhealthy accumulation of substances that degrade connective tissue, it reduces the growth of



new blood vessels in tendinopathy, it helps to restore healthy organized tendon tissues, and it reduces cross-linking of collagen fibrils in aging and damaged collagen and tendons.<sup>68,77</sup>

- Bromelain. Bromelain is an enzyme derived from the stem of the pineapple plant. Several animal studies comparing tendon healing using various parts of the pineapple plant.<sup>78,79,80</sup> Results are preliminary, but it appears that the flesh of the pineapple plant and bromelain, improve healing of injured tendons and stimulate tenocyte (immature tendon cell) proliferation in comparison to no treatment or treatment with pineapple juice, or treatment with extracts from the core, leaves, or bark.<sup>78,79,80</sup> Eating fresh pineapple flesh or taking a bromelain supplement may aid in healing injured tendons.

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This article and all of our articles are intended for your information and education. We are not experts in the diagnosis and treatment of specific medical or mental problems. When dealing with a severe problem, please consult your healthcare or mental health professional and research the alternatives available for your particular diagnosis prior to embarking on a treatment plan. You are ultimately responsible for your health and treatment!  
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