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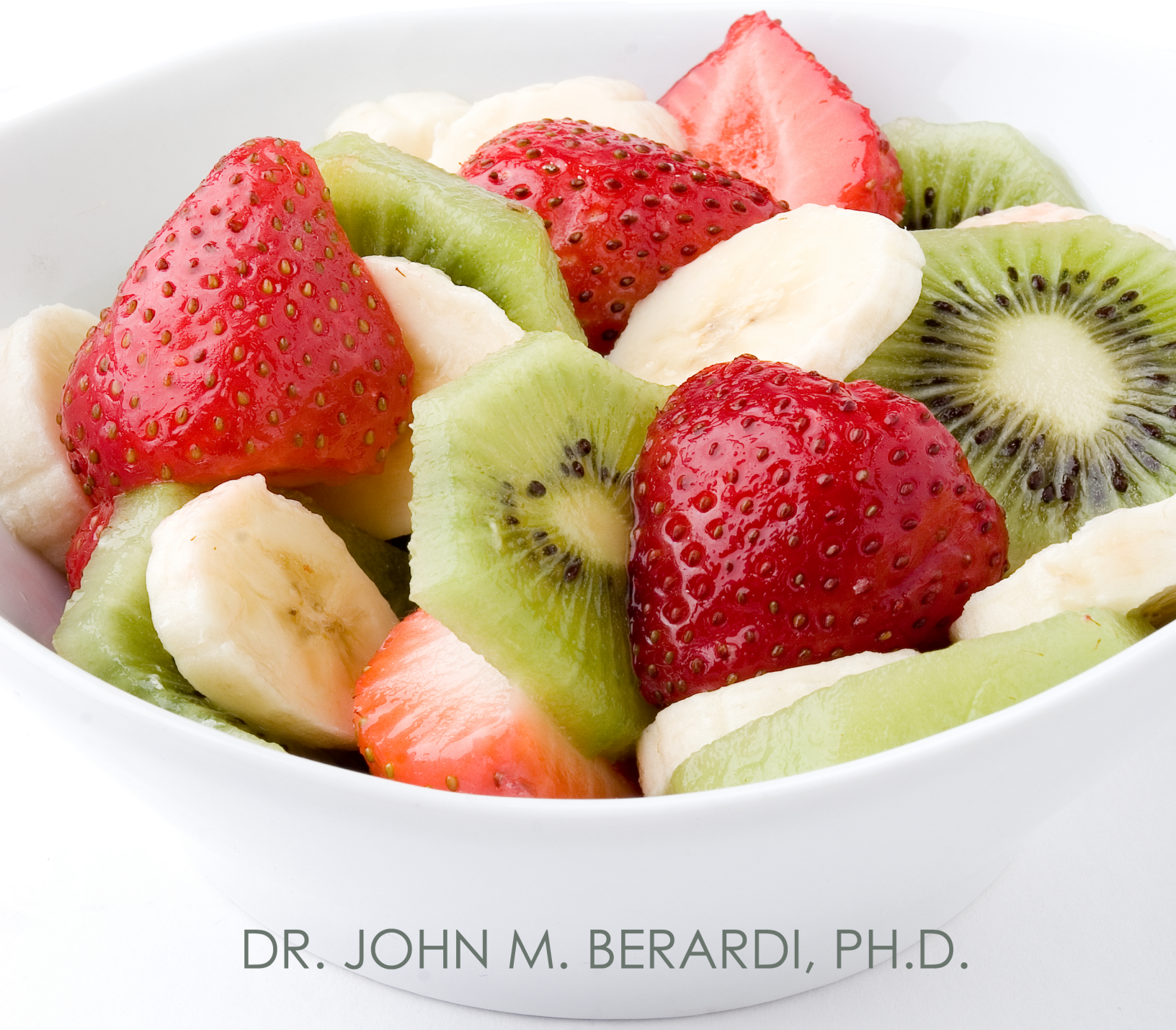

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Nutritional Strategies for the Management of Sports Injuries

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Soft Tissue Repair
When talking nutrition/supplements for sports injury repair (specifically soft tissue injury), it's important to understand what's happening during the injury repair process.

For starters, although we may perceive injury as chaotic with the pain, swelling, dysfunction, etc, when we look at things biologically we see that injury does lead to an organized, consistent pattern of repair. Researchers and clinicians typically break this pattern down into 3 defined stages.

Stage 1: Inflammation (lasts up to ~4 days post-injury) Regardless of the injury, muscle, bone, and vascular damage likely occurs. As a result, the injured tissues are deprived of their normal flow of oxygen and nutrient-rich blood. This reduction in blood flow, as well as the actual physical damage suffered, leads to cell death.

In an attempt to clear out the damaged/dead cells and help lay down new cells, the body initiates the inflammatory process.

Inflammation itself is stimulated by the increased movement of inflammatory/immune chemicals (leukocytes, neutrophils, macrophages, phagocytes, etc) into the injured areas. These chemicals take care of the cellular debris as well as attract plasma (fluid from the blood) and blood proteins to the site of injury. The result of this biochemical process - injured tissues are removed and the process of repair is initiated.

Throughout the inflammatory process, the following can be expected:

A) Pain - believed to be a function of two things. First, certain chemicals involved in injury repair (substance P, calcitonin, histamines, cytokines) may interact with local pain receptors to cause the pain associated with inflammation. Further, as inflammation proceeds, pain may also result from the swelling/pressure placed on the nerve endings.

B) Swelling - a result of fluid seeping through damaged and now hyper permeable vessels into the damaged tissues. These vessels can be damaged

by the initial trauma. Further, they can be altered chemically during the inflammatory process.

C) Redness and Heat - additional blood is shunted to the area of injury, resulting in increased heat. This is due to vasodilation up-stream of the injury and constriction downstream. The upstream vasodilation is thought to be related to nitric oxide activity.

Now here's an important note. Although painful and irritating, the inflammatory process is *necessary* for repair. Without inflammation, injuries would not heal. So any attempt at eliminating inflammation is a mistake, especially in acute injury.

Chronic injury is altogether different. Excessive inflammation, especially if it's prolonged, can lead to other problems including excessive macrophage activity at the site of inflammation and continued tissue destruction. This is why inflammation management is an important concept in injury recovery and why anti-inflammatory agents are often prescribed by physicians during chronic pain.

Step 2: The Proliferative Phase (from ~4 days to ~21 days) Once the inflammation begins to subside, most of the damaged tissues will have been removed from the site of injury and new vasculature will have developed.

This restoration of oxygen and nutrient flow to the damaged area allows for fibroblast proliferation/multiplication. Once this occurs, collagen and fibronectin are laid down; forming what is commonly called "scar tissue."

Importantly, scar tissue will lay down in alignment with the forces being placed on the area. Further, this scar tissue will contract/shorten as it matures (due to fibroblast differentiation into myoblasts, which are similar to smooth muscle cells) to reduce the size of the injury.

Step 3: Remodeling Phase of Injury (from ~21 days to ~2 yrs) Eventually, the scar tissue formed above (typically made up of type II collagen) will be degraded and type I collagen (much stronger) will be laid down in its place. Although this new tissue will never likely be 100% normal, it can become ~80% as strong as uninjured tissue.

Further, as this tissue is aligned along tension lines, it's important to recovery that the tissue be used in normal functional activity throughout the recovery process. This will help maintain the length of the scar tissue as well as help arrange the tissue in an organized pattern in line with adjacent soft tissue fibers.

Hopefully this helps describe the injury repair process. In the end, this predictable pattern of soft tissue healing can give us clues as to how injuries can be managed using physical therapy, manual therapy, nutritional strategies, and drug interventions.

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Bone Repair
Bone healing, on the other hand, undergoes a similar yet unique regeneration process vs the one described for soft tissues above.

> **Stage 1: Reactive Phase Inflammation (up to ~2-3 weeks)** Bleeding from the fractured bone and surrounding tissue causes the fractured area to swell. This phase is similar to the inflammation phase experienced in soft tissue injury.
>
> **Stage 2: Soft callus (from ~2-3 weeks post-injury to ~4-8 weeks post injury)** At this point, the pain and swelling will decrease. The site of the fracture will stiffen, with new bone forming. The new bone is weaker and incomplete and therefore cannot be seen on x-rays.
>
> **Stage 3: Hard callus (from ~4-8 weeks post-injury to ~8-12 weeks post injury)** During this phase, new bone begins to bridge the fracture, covering the soft callus. This bony bridge can be seen on x-rays.
>
> **Stage 4: Bone remodeling (from ~8-12 weeks post-injury to several years)** The fracture site remodels itself, correcting any deformities that may remain as a result of the injury. This final stage of fracture healing can last up to several years.

As you can see, similar to soft tissue injuries, bone injuries go through an early inflammation phase. This attracts plasma and inflammatory cells to the site of injury. These cells help clear out the damaged tissue as well as help revascularize the area.

After this occurs, other cells (in this case, periosteal cells) proliferate and differentiate into chondroblasts and osteoblasts to form new tissue (cartilage and woven bone). This ends up forming the callus.

Again, as with soft tissue injury, this early tissue is eventually replaced again. This time, the cartilage and woven bone forums first lamellar bone and this occurs after a collagen matrix becomes mineralized.

With bone, the process continues though, with lamellar bone becoming trabecular bone, which is nearly a strong as the original bone. Yet during the last phase, this trabecular bone is resorbed and compact bone takes its place. This compact bone closely duplicates the original bone's shape and strength.

Nutritional Approaches for Injury Management and Healing
Once we understand the healing process above, we can better understand how different therapies can impact this process.

From the information presented above, we believe it's important to target three different nutritional angles in the support of injury recover:

> 1) Nutritional strategies that support, yet manage, acute inflammation

2) Nutritional strategies for supporting immune function

3) Nutritional strategies that support long term tissue healing and regeneration

As with the posts above, let's start by talking inflammation. One goal of any treatment plan for acute injury should be to support (but manage) the inflammatory process. As the inflammatory process is critical in stage 1 of injury repair, any modality designed to eliminate inflammation or blood flow to the injured area should be avoided. However, pro-inflammatory agents should also be avoided as excessive inflammation could increase total tissue damage, slowing down the repair process. Further, a secondary goal of managing inflammation is to reduce pain as pain can cause biomechanical compensations/changes that can lead to secondary injury. However, again, strategies that eliminate pain often target inflammation. And in this case, the elimination of inflammation (and pain) may also reduce healing.

Dietary Fat

A diet high in trans-fats, omega 6 rich vegetable oils, and saturated fat will be pro-inflammatory while a diet high in monounsaturated fats and omega 3 fats will be anti-inflammatory. So it's clear that the ratio of omega 6 to omega 3 in the diet is important for overall inflammation in the body - especially during normal periods of healthy living when we definitely want to keep inflammation under control. In these circumstances, the omega 6 to 3 ratio should be anywhere from 3:1 to 1:1 and this should lead to a balanced inflammatory profile.

Of course, beyond 3s and 6s, overall fat balance is also important here. With a good balance of saturated, monounsaturated, and polyunsaturated fats (about 1/3 of total fat intake each), the body's inflammatory profile should also achieve a healthy balance.

However, during acute injury, an intentional decrease in omega 6 that goes along with a similar increase in omega 3 (specifically fish oil) is recommended. Studies have shown that high omega 6:3 ratios reduce collagen production while a low 3:6 ratio is supportive of healing. It appears that even though this scenario leads to an anti-inflammatory response in the body, this response isn't enough to reduce healing - rather, it only helps with injury healing and collagen deposition.

Unfortunately, neither the exact omega 6:3 ratio, nor the amount of fish oil supplementation required to manage inflammation during injury has been determined. Studies with low dose fish oil (~450mg - 1g/day) have shown no effect on inflammatory or immune markers while other studies have shown that high dose fish oil (12-15g/day) may reduce immune cell function in certain populations. As a result, some authors have recommended anywhere from 3-9 grams of fish oil (salmon oil, sardine oil, menhaden oil, krill oil, etc.) per day and we would extend these recommendations to both normal healthy conditions and injury repair.

In addition to the omega 6:3 ratio, research has shown that increased nut and seed consumption, as well as olive oil consumption, can mildly reduce inflammatory

biomarkers. Nuts, seeds, and olive oil likely share a common mechanism as the monounsaturated fats found in all three contain compounds that can mildly reduce COX enzymes activity (something that these foods share with ibuprofen). But again, be careful, too high a dose of any anti-inflammatory may reduce acute healing.

In the end, athletes should focus on improving their omega 6:3 ratio while adding in healthy monounsaturated fats and balancing out their saturated, polyunsaturated, and monounsaturated fats both during healthy competitive periods as well as during times of injury repair. While this may seem like a tall order, the following simple strategies should go a long way:

1) To balance your fats:
Increase intake of olive oil, mixed nuts, avocados, flax oil, ground flax and other seeds, etc - getting some of each fat source each day. By eating these foods, you'll likely balance out the saturated fats naturally present in your protein sources, leading to a healthy profile without breaking out the calculator.

2) To balance your 6:3 ratio:
Add 3-9g of fish oil each day while reducing omega 6 fats like vegetable oils such as corn oil, sunflower oil, safflower oil, cottonseed oil, and soybean oil, etc. This strategy should take care of your omega 6:3 ratio.

Dietary Herbs and Phytochemicals
Beyond healthy fat balance, certain dietary herbs can be very beneficial in the management of inflammation.

Turmeric (a flowering plant in the ginger family) has long been used as an anti-inflammatory agent and in wound healing. Current research is showing that the active ingredient, curcumin, is responsible for some of the benefits noted above. While adding curry powder to the diet during recovery from injury is likely a good strategy, 400-600mg of turmeric extract 3x per day (or as described on the product label) will likely lead to measurable reductions in inflammation.

Garlic has also been shown to inhibit the activity of the inflammatory enzymes cyclooxygenase and lipoxygenase as well as impact macrophage function. Again, though, while eating additional garlic during injury is likely a good strategy, garlic extracts may be required for more measurable anti-inflammatory effects. Typically recommended dosing is 2-4g of whole garlic clove each day (each clove is 1g) or 600-1200mg of aged garlic extract.

Bromelain is another anti-inflammatory plant extract, coming from pineapple. While best known for its digestive properties, Bromelain is an excellent anti-inflammatory and analgesic compound although it's mechanism of action is poorly understood. Typically Bromelain is given in doses of 500-1000mg/day for the management of inflammation.

Boswellia is a type of tree that also has anti-inflammatory uses and has been shown to

offer benefit through the inhibition of 5-lipoxygenase and potentially other cytokines. Typically Boswellia is taken in 300mg doses 3x per day.

Finally, although flavanoids (such as those found in cocoa, tea, red wine, fruits, vegetables, and legumes) can help manage inflammation through their antioxidant actions, these powerful compounds likely act in other beneficial ways by impacting cell signaling.

While an increase in consumption of flavanoid foods would likely be of benefit during times of acute injury, nutritional supplements containing blueberry or grape extracts, green tea extracts, citrus extracts (hesperedin, naringin, etc), and bioflavonoid supplements containing quercetin/dihydroquercetin and rutin may lead to more marked anti-inflammatory effects.

Again, with all of these nutrients, caution is warranted as wholesale suppression of the inflammatory response in the body is contraindicated during the acute phases of injury. The idea here is to control inflammation from getting out of control, not stop it from happening.

So, in the end, the key is not to load up on all of these anti-inflammatory supplements at once. Rather, focus on foods rich in natural inflammation modulating agents such as these below, only supplementing if inflammation becomes a major/chronic problem (this would likely be discussed with your physician first).

1) Curry powder/turmeric
2) Garlic
3) Pineapple
4) Cocoa
5) Tea
6) Blueberries

What About NSAIDs?

In sport, it's very common for NSAIDs (ibuprofen, naproxen sodium, celecoxib, etc) to act as the first line of defense in the case of acute injury, pain, and inflammation. They come over the counter, docs prescribe them, and they work to reduce pain.

Yet new research suggests that NSAIDs, in some cases, might actually hinder injury healing in the mid-term. Celebrex, for example, reduced ligament strength in rats recovering from injury by about 32%. In another study, the same thing happened with both Celebrex and indocin. Not all studies show these effects, but enough of them do to cause some concern and to moderate our NSAID use in acute injury or muscle pain.

Beyond interfering with ligament healing, NSAIDs also may interfere with the healing of muscle strains, adaptations to weight training, and bone healing in the mid-term. Of course, there are also the side effects (GI bleed, etc with non-selective NSAIDS). Yet again, the data are mixed.

In the end, I believe the take-home message is that caution should be exercised when using NSAIDs or any other anti-inflammatories for pain management during acute injury. In some cases the risks (GI problems, reduced healing rates, incomplete healing prognosis) may outweigh the benefits (pain management).

Inflammatory Questions

This discussion of the cost/benefit ratio of NSAIDs raises the question of whether or not any inflammation strategy is beneficial during acute injury. After all, we want the inflammation process to occur. And NSAIDs may negatively impact healing because they block a big step in the recovery process.

So why even use NSAIDs, fish oil, turmeric, garlic, and other anti-inflammatory nutrients? Well, for starters, if used in moderation at the right time, they get results, helping reduce pain, reduce excessive inflammation (which can damage local, non injured tissues), and help with later stages of injury repair.

As discussed above, the goal here is to manage inflammation during injury, not eliminate it. And that's why very moderate use of NSAIDs (if at all) and healthy use of nutraceuticals is recommended.

Of course, another issue that arises is timeline. The acute phase of inflammation during soft tissue and bone injury can last from the time of injury to 4 days (soft tissue) or 14-21 days (bone). During this time inflammation is what we want and expect. So perhaps more aggressive anti-inflammatory strategies are best reserved for after the acute inflammatory phase. During the proliferative and maturation stages, these agents may help keep excessive, chronic inflammation at bay, speeding up the healing process.

Unfortunately this approach is not the one used currently. Rather, at the onset of injury, athletes are loaded up with NSAIDs. And this may lead to reduced injury recovery rates.

Calorie and Macronutrient Needs During Injury Recovery

To continue the discussion of nutritional strategies for injury repair, I'd like to address the biggest permissive & supportive factors in stage 2 and 3 injury recovery, adequate calorie and micronutrient intake.

It should be no surprise that energy needs during sport are increased and this is due to the energy cost of activity. As a result, some athletes, especially females, intentionally (to lose body weight) or unintentionally (due to improper nutrition education) under eat. This can lead to an increased incidence of stress fractures, ligamentous injury, etc. So, on the one hand, too few calories when healthy can lead to injury. On the other hand, too few calories during recovery from injury can prevent an athlete from getting healthy.

During acute injury, energy needs are increased. In fact, BMR may increase by 15 - 50% based on the severity of the trauma. For example, sports injury and minor surgery may increase BMR by 15-20% while major surgery and burn injury may lead to a 50%

increase in BMR. When trying to determine energy needs during recovery from injury, it's important to consider this increase in energy requirement.

Of course, comparatively speaking, an athlete will have to eat less during injury recovery than during training and competition. Yet if they return to baseline intake, they may be under eating.

Let's take the example of a young athlete here.

Example Athlete
Male - 14y
5'6", 140 lbs

Basal Metabolic Rate
1611 kcal/day (based on the mean of 3 predictive equations)

Energy needs when sedentary
1933 kcal/day (based on activity factor of 1.2)

Energy needs with daily training/competition
2739kcal/day (based on activity factor of 1.7)

Energy needs during injury recovery
2319kcal/day (based on activity factor of 1.2 and a 20% increase in metabolism due to injury)

As you can see, although energy intake should decrease (relative to training and competition) during periods of injury repair, returning to baseline intake will lead to underfeeding.

And not only is this an important clinical note, it's an important practical one! Reduced physical activity leads to reduced appetite. Therefore if an athlete is eating based on hunger only, it's quite likely that he or she may under eat during recovery, leading to losses of lean mass, poor healing and slow progress.

In the end, while it's important for injured athletes to reduce energy intake during periods of injury, they should still be cognizant of eating as they would (or perhaps SHOULD based on what their eating habits actually look like) for sport. This includes frequent feedings, sufficient protein intake, adequate macronutrient intake, etc.

When it comes to the macronutrients, increased dietary protein is recommended for injury repair. Now, these increases are based on increasing the clinical recommendations from the usual 0.8g/kg to 1.5-2.0g/kg. Since many athletes will already be hitting this 1.5-2.0g/kg mark, these needs should be covered. So, if a rapid return to normal function is desired, this is one area that should not be neglected. Injured athletes should absolutely strive for 1g of protein per pound of body weight as a minimum.

Dietary fat has already been discussed and to recap, the idea is to balance out dietary fat by getting about 1/3 of total fat intake from each of the three types of fat. Further, the omega 6:3 ratio should come down to anywhere from 3:1 to 1:1.

As far as dietary carbohydrate, while glucose is necessary for athletic injury healing, no specific carbohydrate recommendations have been established for injury periods. However, dietary carbohydrate should likely be included in sufficient amounts to ensure adequate micronutrient intake as well as stable insulin concentrations (which, as an anabolic hormone, may impact wound healing).

Translating these recommendations above into practical strategies, the following habits should help athletes ensure adequate calorie and macronutrient intake for both sport and injury recovery:

1) Frequency
Eat every 2-4 hours.

2) Protein
Each meal/snack should contain complete protein including lean meats, lean dairy, eggs, or protein supplements (if whole food is unavailable).

3) Vegetables and Fruit
Each meal/snack should contain 1-2 servings veggies and/or fruit (1/2 - 1 1/2 cups or 1-2 pieces) with a greater focus on veggies.

4) Starches
Additional carbohydrates should come from whole grain, minimally processed sources like whole oats, yams, beans, whole grain rice, quinoa, etc. The athlete should eat fewer starches when not training (such as during injury recovery), and more when training (unless fat loss is a goal). Although a no carbohydrate or no starch diet is unwarranted.

5) Fats
The athlete should eat each of the following good fats each day - avocadoes, olive oil, mixed nuts, flax seeds, and flax oil. In addition 3-9g of fish oil should be added to the diet.

Micronutrient Needs During Injury Recovery
Vitamins and minerals are nutrients required in small amounts for metabolic reactions in the body. They can act as catalysts (bound to enzymes to facilitate their actions in the body), they can act as coenzymes (to further help out enzymes), or can act as substrates in which they're directly metabolized themselves.

When it comes to injury, vitamins A, B, C, and D as well as calcium, copper, iron, magnesium, manganese, and zinc can all play important roles. (Interestingly, vitamin E

may slow healing so it's recommended to avoid vitamin E supplements during injury). However, the role that each vitamin and mineral plays is not well understood.

Until further research confirms these roles, there's controversy as to whether it's simply the prevention of vitamin/mineral deficiency we're after or whether the ingestion of additional vitamins and minerals can be of additional benefit. So rather than discussing each vitamin and mineral that may impact injury recovery, let's discuss only those that may require additional supplementation.

Vitamin A acts to enhance and support early inflammation during injury, reverse post-injury immune suppression, and assist in collagen formation via collagenase modulation. Studies have shown that collagen cross-linkage is stronger with vitamin A supplementation and repair is quicker. Typically 25,000IU daily is recommended during short periods of time surrounding serious trauma and surgery. With sports injuries, supplementation with 10,000IU daily for the first 1-2 weeks post-injury is likely a safe approach although beyond that, assuming dietary vitamin A intake is sufficient, the supplement can be removed in order to avoid potential vitamin A toxicity.

Vitamin C enhances neutrophil and lymphocyte activity during phase 1 of acute injury. It also plays an important role in collagen synthesis as it assists in the formation of bonds between strands of collagen fiber. With vitamin C deficiencies, collagen fibers are formed abnormally and fibrous tissue is weak with poor adhesion. As vitamin C acts as a powerful antioxidant and immune system modulator as well, it's an important supplement for injury repair. Indeed, research suggests that supplemental vitamin C can be beneficial in subjects recovering from surgery, injury, and ulcers. Vitamin C supplementation of 1g-2g/day is recommended during periods of injury repair.

Copper is a mineral that assists in the formation of red blood cells and acts in concert with vitamin C to form elastin and to strengthen connective tissue. 2-4mg/day is recommended during the first few weeks of injury repair.

Zinc is required for over 300 enzymes in the body and plays roles in DNA synthesis, cell division, and protein synthesis. These are all necessary for tissue regeneration and repair. Zinc deficiency has been associated with poor wound healing and as zinc deficiency is one of the most common micronutrient deficiencies, supplementation of 15-30mg per day is recommended, especially during the initial stages of healing.

Note: Calcium and iron deficiencies are, like zinc deficiencies, quite common. Due to their roles in bone health, deficiencies in these two minerals can actually increase the risk of stress fractures in athletes. So, while these two minerals may not play direct roles in injury healing, they play a large role in prevention. So ensuring adequate intake of these two minerals when healthy, preferably coming from food sources, is important.

In the end, it appears that the following vitamins and mineral supplements would benefit those with acute injuries:

1) Vitamin A – 10,000IU/day for 2-4 weeks post-injury

2) Vitamin C – 1000-2000mg/day for 2-4 weeks post-injury

3) Copper – 2-4mg/day for 2-4 weeks post-injury

4) Zinc – 15-30mg/day for 2-4 weeks post-injury

Additional Nutrients That May Impact Injury Recovery

Supplemental amino acids have been shown to exert powerful effects on injury healing. When the body is under stress, arginine and glutamine become conditionally essential amino acids and these as well as the following amino acids, have been shown to speed up healing process in the body:

1) Arginine

This amino acid may act in a number of ways to speed up injury repair. First, it may stimulate insulin release and IGF action. These powerful anabolic hormones may stimulate protein synthesis and collagen deposition. Further, its role in stimulating nitric oxide production may increase blood flow to the injured area as well as activate macrophages for tissue clean-up. These macrophages also help produce and activate growth factors, cytokines, bioactive lipids, and proteolytic enzymes necessary for healing. Finally, arginine may promote the conversion of ornithine to proline.

Studies using arginine in rodents and humans have demonstrated the potential of high dose arginine supplementation to increase collagen accumulation, reduce lean body mass loss, reduce nitrogen excretion, and accelerate wound healing. Human doses have been in the range of 15-30g per day with higher doses having the largest effect.

2) Ornithine

As supplemental arginine has shown benefit in wound healing and ornithine is the main metabolite of arginine, researchers have speculated that ornithine might also show similar benefits.

The mechanisms of action for ornithine in wound healing somewhat overlap those of arginine. Ornithine can be converted to the amino acid proline, which is essential in collagen deposition. Further, studies have shown that ornithine supplementation can improve protein metabolism in burn/trauma patients.

Studies using ornithine in trauma/injury situations have shown that ornithine can shorten healing time, increase healing strength, and increase nitrogen retention. Human doses in these studies have been in the 20-30g/day range (10g 2-3x per day) with larger doses having the greatest effect.

3) Glutamine

This amino acid is essential for the metabolism of rapidly turning-over cells such as lymphocytes and enterocytes. During starvation, trauma, and sepsis, glutamine needs dramatically increase and indeed, in trauma situations, glutamine supplementation can reduce morbidity, mortality, and length of hospital stay. As a result it's been speculated that glutamine may help speed up wound healing yet glutamine alone has not been shown to do so.

However, in one study, the combined administration of 14g arginine, 3g HMB, and 14g glutamine in two divided doses (two doses of 7g arginine, 1.5g HMB, 7g glutamine per day) for 14 days significantly increased collagen synthesis in adults.

4) HMB

HMB, a metabolite of the amino acid leucine, has been shown in numerous studies to inhibit muscle protein breakdown as well as increase net protein balance, leading to potential increases in muscle mass.

In addition, research has shown that HMB increases collagen deposition in rodents as well as improves nitrogen balance in critically injured adult patients.

Again, in one study, the combined administration of 14g arginine, 3g HMB, and 14g glutamine in two divided doses (two doses of 7g arginine, 1.5g HMB, 7g glutamine per day) for 14 days significantly increased collagen synthesis in adults.

Interestingly, local application of amino acids and other nutrients (directly to injured sites vs. orally) has been shown to offer unique benefits. In one study, cylindrical sponges implanted near wound areas in rodents were regularly infused with amino acids, salts, glucose, B-vitamins, and vitamin C. The group receiving the treatment had superior healing vs. placebo while using smaller doses than required with oral treatment. These localized therapies, go beyond the scope of this review.

At this point, before loading up on amino acids, it's important to note that many of the studies discussed in this section were performed in either the elderly or in hospitalized patients. In both cases malnourishment is common. In hospitalized patients (urban areas), cross-sectional analysis has shown that nearly 50% show signs of malnutrition. Further, another study showed that 42% of patients receiving hip replacements were malnourished. And between 40-85% of nursing home residents are malnourished.

In each case, not only do micronutrient deficiencies exist, these individuals may also be ingesting too few calories, too little protein, and too little healthy fat. Therefore it's likely that the amino acid supplements above were eliminating relative deficiencies rather than being added to a healthy diet that's already adequate in dietary amino acids.

Of course, this point doesn't necessarily disqualify amino acid supplementation as a viable option for an athlete experiencing a sports injury. Indeed, many athletes may be

poorly nourished as well, under eating both total calories and protein. Micronutrient deficiencies have also been found in athletes. As a result, in such cases, the first priority is to increase calorie and protein intake during recovery as discussed above (including about 1g of protein per pound of body weight). In addition, a diverse nutrient-dense diet should be encouraged in order to meet micronutrient needs.

Further, even in well-nourished individuals, it is likely still prudent during sports injury to supplement with amino acids in order to stimulate collagen deposition and injury healing. The combination of arginine (7g 2x per day), HMB (1.5g 2x per day), and glutamine (7g 2x per day) will likely preserve lean body mass while recovering from injury. At the same time, this approach may accelerate collagen synthesis and injury repair.

Glucosamine and chondroiton are two additional supplements that are discussed with respect to joint injury, although much of the supportive research on glucosamine and chondroiton has been in the area of treating osteoarthritis. Hyaluronic acid is another compound discussed in the same vein.

With all three compounds, the research is promising for managing long-term pain and inflammation, as well as reducing joint degeneration, yet not all researchers are in agreement that the evidence is entirely supportive. Meta-Analyses in the Journal of the American Medical Association have concluded that while research suggests these agents probably offer benefit, mixed data and publication bias may lead to overestimates of the effects. (And, of course, "more research is needed...")

Nevertheless, for acute sports injury, it is unlikely that these compounds offer significant benefit as their onset of action is delayed (typically 1 month or more before marked improvement is seen). Further, although these compounds have been hypothesized to assist in wound-healing, there is little evidence to support this claim. Therefore these compounds may be best reserved for use in long-term degenerative conditions rather than acute injury repair.

Note: While some believe that creatine supplementation may cause cramping or increased risk of injury, the research is fairly clear - creatine doesn't seem to contribute to sports/exercise injury. However, coaches and athletes would be wise to take note that there are a few anecdotal reports from elite athletes suggesting that in some speed/power athletes, hamstring strains may be occur during creatine supplementation. This is by no means common yet it has been reported to the authors often enough to be mentioned here.

Summary

In summary, sports injury recovery is characterized by an organized response to the acute trauma. First inflammation is provoked to remove damaged tissues. Next cells proliferate to replace the damaged tissue. And finally new cells replace the intermediary cells to strengthen the repair process and lead to injury resolution. During each step of the repair process, specific nutritional strategies can be employed to both support and enhance this repair process.

One major priority during this repair process is ensuring adequate calorie and protein nutrition. These steps can assist in the process:

1) Frequency
Eat every 2-4 hours.

2) Protein
Each meal/snack should contain complete protein including lean meats, lean dairy, eggs, or protein supplements (if whole food is unavailable).

3) Vegetables and Fruit
Each meal/snack should contain 1-2 servings veggies and/or fruit (1/2 - 1 1/2 cups or 1-2 pieces) with a greater focus on veggies.

4) Starches
Additional carbohydrates should come from whole grain, minimally processed sources like whole oats, yams, beans, whole grain rice, quinoa, etc. The athlete should eat fewer starches when not training (such as during injury recovery), and more when training (unless fat loss is a goal). Although a no carbohydrate or no starch diet is unwarranted.

5) Fats
The athlete should eat each of the following good fats each day - avocadoes, olive oil, mixed nuts, flax seeds, and flax oil. In addition 3-9g of fish oil should be added to the diet.

Although these steps above should lead to adequate micronutrition during normal conditions, during injury repair the following vitamin and supplements are useful:

1) Vitamin A – 10,000IU/day for 2-4 weeks post-injury

2) Vitamin C – 1000-2000mg/day for 2-4 weeks post-injury

3) Copper – 2-4mg/day for 2-4 weeks post-injury

4) Zinc – 15-30mg/day for 2-4 weeks post-injury

Beyond these supplements, the management of inflammation can be accomplished by:

1) Balancing your fats:
Increase intake of olive oil, mixed nuts, avocados, flax oil, ground flax and other seeds, etc - getting some of each fat source each day. By eating these foods, you'll likely balance out the saturated fats naturally present in your protein sources, leading to a healthy profile without breaking out the calculator.

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2) Balancing your 6:3 ratio:
Add 3-9g of fish oil each day while reducing omega 6 fats like vegetable oils such as corn oil, sunflower oil, safflower oil, cottonseed oil, and soybean oil, etc. This strategy should take care of your omega 6:3 ratio.

3) Including anti-inflammatory foods:
These foods include curry powder/turmeric, garlic, pineapple, cocoa, tea, blueberries, wine.

Finally, even in well-nourished individuals, it is likely still prudent during sports injury to supplement with the following amino acids in order to stimulate collagen deposition and injury healing.

1) Arginine (7g 2x per day)

2) HMB (1.5g 2x per day)

3) Glutamine (7g 2x per day)

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