Supplementing for Bone and Connective Tissue Health

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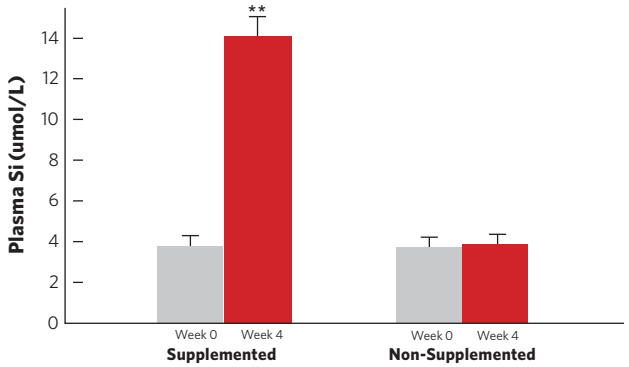
Connective tissues (e.g., cartilage, ligaments, tendons, and bone) are critical components of body structure. They are vital for the overall health and performance of all horses whether they are used for pleasure riding or competition. Many nutrients are required for normal development and maintenance of connective tissues, including silicon and other minerals, omega-3 fatty acids, and several vitamins.

Silicon

Although traditionally considered a nonessential nutrient for animals, silicon is now known to play a significant role in the development, growth and maturation of bones and other connective tissues. Several studies indicate that an insufficient amount of silicon in the diet is associated with poor growth rates, developmental abnormalities, and a reduction in bone collagen and mineral content.[1-4] Conversely, supplementation with silicon stimulates an increase in bone mineral content and formation,[5,6] possibly by increasing calcium incorporation into bones.[7] This effect may be particularly important during late pregnancy and lactation as bone mineral density may decrease in the dam at these times, as noted by research in a rodent model.[8] Pregnant mares supplemented with a synthetic silicon demonstrated a trend towards increased blood osteocalcin,[9] a marker associated with bone formation. Furthermore, foals that nursed from the supplemented mares showed a significant increase in their serum silicon. In addition to bone, silicon has been identified in glycosaminoglycans (e.g., chondroitin sulfate, hyaluronic acid),[10] which provide resistance to compression forces in connective tissue by attracting water.[11] Silicon supplementation can be positively correlated with increased cartilage collagen content in animals.[12]

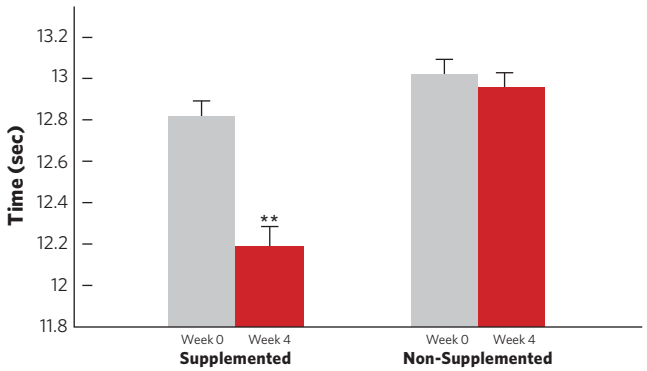
It is very likely that horses require a dietary source of silicon. Although grains and forage may be naturally high in silicon, this form of the element may not be easily absorbed. A bioavailable source of silicon is zeolite, which, when ingested, increases plasma concentrations of silicon and improves exercise performance in horses. For example, plasma silicon concentrations increased in training Thoroughbreds supplemented with a product containing natural

Figure 1. **Plasma Silicon Concentrations among Silicon-Supplemented* and Non-Supplemented Thoroughbreds**



**Significantly greater than Week 0 and corresponding Non-Supplemented Week ($p < 0.05$)

Figure 2. **201 Meter Run Times for Silicon-Supplemented* versus Non-Supplemented Thoroughbreds**



**Significantly greater than Week 0 and corresponding Non-Supplemented Week ($p < 0.05$)

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zeolite* (Figure 1). Performance improvements over a 4-week period were also noted in these Thoroughbred horses in 201-meter runs when compared to non-supplemented horses (Figure 2). In another study,[13] Quarter Horses supplemented with a synthetic zeolite had faster middle distance race times, ran nearly twice as far during training before any injury occurred, and had fewer injuries than non-supplemented controls. These authors concluded that silicon supplementation may allow horses to train at faster speeds for longer periods of time without incurring injury.

More on Minerals

In addition to silicon and the well-recognized calcium, other elements are important to maintain healthy bones and other connective tissues. Magnesium converts vitamin D to its active form and, therefore, plays an indirect role in calcium balance.[14] Magnesium also directly impacts calcium status because it is a cofactor in enzymes involved in calcium homeostasis.[14] Boron helps maintain calcium status and bone mineral density and is documented as necessary for healthy bone growth and maintenance.[15,16] Boron has a variety of biochemical activities, but the primary one related to bone health is likely through its support of steroid hormone formation and activity.[14] Zinc stimulates bone formation and is needed for collagen synthesis.[14] Copper also plays a role in collagen synthesis by activating the enzyme lysyl oxidase and subsequent lysine cross-link formation typical of collagen and other connective tissue.[14] Sulfur is another key mineral for connective tissue health, although sulfur intake and status is often influenced by amino acid (e.g., methionine, cysteine, taurine) and B vitamin (e.g., thiamine and biotin) intake. Sulfur is a component of most glycosaminoglycans and, therefore, is needed for the compression-resistance of cartilage as well as the structural integrity of tendons and ligaments.[17]

When considering mineral supplements, owners and vets should take into account the form of mineral provided. Inorganic mineral forms, such as oxides, are relatively inexpensive and often the preferential mineral source for many supplements. In general, inorganic minerals are not the ideal source because they tend to have a lower bioavailability to the horse when compared to most organic minerals. Organic minerals, or chelates, exist when a mineral has been linked to an amino acid or other carbon-containing compound. Organic minerals do not dissociate in the digestive tract and, therefore, remain protected for absorption across the intestinal wall.

Omega-3 Fatty Acids

Omega-3 fatty acids are important for normal bone mineral content, density, strength, and growth.[18,19] These effects may be due, in part, to omega-3's inhibition of strong inflammatory factors implicated in bone loss.[20] Omega-3 fatty acids have also been shown in other animals to decrease calcium loss in the urine, increase absorption of calcium through the intestine, and increase calcium concentration in bones.[18,21,22] Because omega-3 fatty acids cannot be either synthesized at all or in adequate quantities by most animals, they must be consumed in the diet. While pasture grasses and hay generally have a more favorable ratio of low/anti-inflammatory omega-3 to pro-inflammatory omega-6 fatty acids, cereal grains, including corn and oats, provide much higher concentrations of omega-6 fatty acids. In addition, environmental factors may alter the nutrient composition of hays. For example, a commercial laboratory determined that fresh alfalfa hay contains a higher percentage of omega-3 fatty acids than bailed alfalfa hay. In fact, the omega-3 content was decreased by 36% six weeks after bailing and by 83% after ten weeks of bailing when compared with fresh alfalfa hay (Figure 3). Due to the detrimental effects of processing and storage on the concentration of omega-3 fatty acids in forage, the best way to add omega-3 fatty acids to the diet is through direct supplementation.

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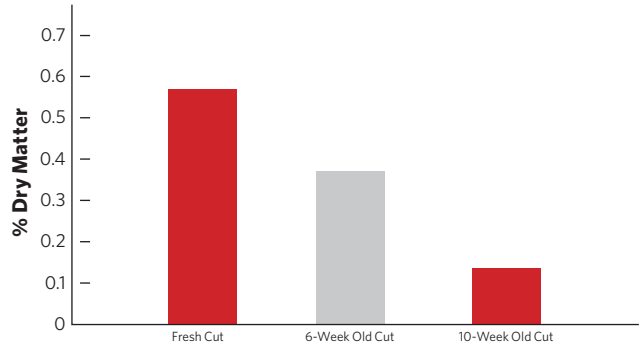
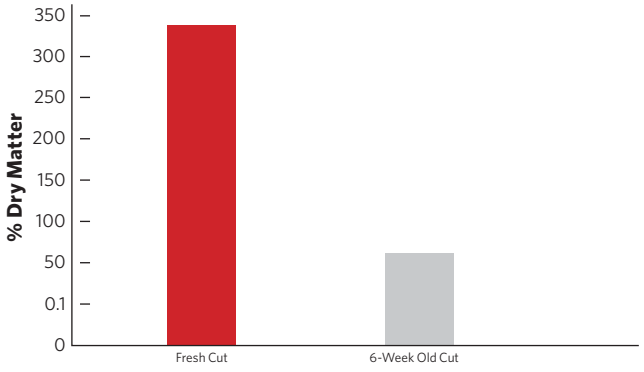
Figure 3. **Total Omega-3 Content in Alfalfa from Different Times of Cut**



Vitamins D, A and C

Vitamins D, A and C are critical for the health of connective tissues. Vitamin D is well-recognized for its role in maintaining calcium uptake, body calcium status, and healthy bones. Although vitamin D is synthesized naturally by most animals, horses that are stabled or that live in northern climates may require supplemental vitamin D.[23] Furthermore, the stress of exercise, whether it be the pounding of hooves on a track or extra weight from a rider, can stimulate bone remodeling and increase the need for vitamin D to support adequate bone mineral availability.[24] In addition to sunlight, fresh hay or pasture grass offers a good natural source of vitamin D to the horse, but stored or poor quality forage may be deficient. As evidence of this, analysis of alfalfa hay revealed that the vitamin D content was nearly 80% lower six weeks after bailing when compared to fresh alfalfa (Figure 4).

Figure 4. **Vitamin D Content in Fresh and 6-Week Old Bailed Alfalfa**



The role of vitamin A in bone health is recognized but not fully understood. It has been shown that vitamin A deficiency is linked to a reduction in blood makers associated with bone and other connective tissue formation.[25] Vitamin A is obtained by the horse predominantly through the consumption of green forage. However, environmental factors such as sunlight, feed processing, exposure to air, and moisture can significantly decrease the activity of vitamin A in feeds.[26] Research has previously shown that only two months on a hay and vitamin A-free concentrate may be enough time to fully deplete a horse's vitamin A stores.[27] Therefore, attention must be paid to maintaining adequate vitamin A in a horse's ration while avoiding over-supplementation because Vitamin A toxicity can occur. Horses are capable of synthesizing vitamin C from glucose, which means vitamin C is not technically an essential nutrient. However, vitamin C's role in collagen and bone matrix formation[16] do make it a popular supplement and important nutrient for young, rapidly growing horses. In addition, vitamin C supplementation has been recommended for horses with arthritis or soft tissue injuries.[28]

Developmental Orthopedic Diseases

Developmental orthopedic diseases include several conditions that occur as a result of alterations in endochondral ossification, i.e., the process by which bones grow.[29] Disturbances in bone growth can result from trauma, genetic predisposition, unusually rapid growth, and nutritional imbalances such as excessive calories, high-starch diets, calcium and phosphorus imbalances, and mineral deficiencies. Supplemental administration of trace minerals has been associated with an increase in bone density in Thoroughbred yearlings, especially when mineral intake is suboptimal.[30,31] Furthermore, mineral supplementation is generally recommended for growing horses.[29]

Conclusion

Dietary supplementation of young and adult horses is a key component to ensuring optimal growth, development, and maintenance of connective tissues, such as bones, ligaments, tendons and

cartilage. Providing appropriate amounts of key vitamins and minerals, including silicon, as well as omega-3 fatty acids is one way to best support growth and health of connective tissue. Not only does healthy connective tissue play a role in optimizing exercise performance, but it also is critical to the general well-being of all horses.

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