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NUTRIENT REQUIREMENTS OF THE YOUNG EQUINE ATHLETE

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In many segments of the horse industry, horses enter training in their yearling or two-year-old year. This creates a situation for the owner or trainer that is quite different than what is experienced by many other stockmen or horsemen. Not only does the individual who is feeding this young animal have to worry about providing the correct ration for optimal growth, but he also has to be concerned about providing the correct balance of nutrients for exercise as well. In the past, much research has focused on feeding the growing horse. Additionally, there have been plenty of nutritional studies that have centered on the adult athlete. Unfortunately, the amount of research that has centered directly on the young athlete is quite limited. And when one searches for studies focused on young horses at the time they first enter training, the amount of information is even more limited. The reason for this is twofold. First, the process of training young horses is very labor intensive. Hence, to put enough horses in training for a controlled study proves to be quite challenging. Second, because of limited resources, researchers are forced to use animals that have not been very competitive in their respective events. It is rather uncommon for researchers to be able to put a horse into training before it is tested to determine how competitive it will be. Therefore, in order to examine the nutrient requirements of the young equine athlete, we are often forced to draw conclusions from adult horses in training and combine them with growth studies conducted with young horses.

Energy

The energy requirements of young horses entering training, and the relationship of the energy requirements to other nutrients, is one of the first items that needs to be addressed. A horse can meet its energy requirements through the consumption of both carbohydrates and lipids. Whereas carbohydrates have typically been the main energy source for horses, the addition of fat to the equine diet is now quite commonplace. Fat can be used to increase the energy of the diet without greatly increasing total intake. Studies have shown that fat can be as much as 20% of the diet with no harmful effects on the animal (Duren et al., 1987). This can provide a very useful means of meeting the increased energy demands of exercising animals. However, as energy is the most obvious metabolic factor that differs between the resting and exercising state, we need to ask whether the requirements for other nutrients vary in direct proportion to energy demand (Frape, 1988). In essence, as we increase the energy requirements of the horse as it begins training, it is yet to be fully determined as to whether the requirements of other nutrients (i.e. protein, Ca, P) should be based on a percentage of the total diet, grams of nutrient per day or on the basis of a nutrient to calorie ratio. To explore this issue, research in the young exercising horse needs to focus on two questions. First, does a difference in physiological response to exercise or growth exist as the nutrient to calorie ratio changes, and second, does voluntary food intake increase in proportion to an increased energy demand, thus increasing intake of all other dietary nutrients (Frape, 1988). With little research having been done in the young horse in training, we can only speculate as to whether there is a difference in physiological response when the nutrient to calorie ratio increases or decreases. At this point, if one is increasing the caloric density of the diet, it may be advisable to increase the other nutrients in the diet so that the ratio remains the same. Above average weight gains have been associated with the onset of bone abnormalities (Thompson et al., 1987). In addition, it has been reported that inadequate concentrations of protein and minerals relative to the energy concentration of the diet can result in skeletal problems (Potter, 1982). However, when growing horses are fed high energy diets, no adverse effects have been reported as long as diets provided suitable nutrient to calorie ratios (Hansen et al., 1987; Scott et al., 1987). Of course, this becomes a moot point if a horse is able to consume sufficient quantities of the feedstuff to meet its energy requirements without having to change the caloric density of the feed.

It is when lipids are used to increase energy density that care needs to be taken to balance the ration for the rest of the nutrients unless one is using a manufactured feed that already contains added fat and has been balanced to take this into account. By top-dressing a commercially prepared feed with fat, one is diluting the total nutrient balance. Hence, it becomes necessary to rebalance the ration. Does this mean one should avoid using fat in the diet of young performance horses? Definitely not. While carbohydrates serve as the main source of energy for high-intensity, short-duration activity, lipids serve as the predominant fuel for low-intensity, long-duration activity (Snow, 1992). As a result, there are obvious benefits in feeding fat to horses involved in endurance or aerobic activities, but there are also many benefits to horses competing anaerobically. This includes a possible glycogen-sparing effect (Pagan et al., 1987; Meyers et al., 1987). This effect would allow fats to be used preferentially, instead of glycogen, during non-anaerobic activity so that more glycogen is available for anaerobic activity. Other beneficial effects include an increase in muscle glycogen content (Oldham et al., 1989; Hughes et al., 1995), a decreased thermal load (Scott et al., 1993) and a reduction in performance times (Oldham et al., 1989). Because of its numerous beneficial effects, it is fortunate that horses can adapt to a fat-supplemented diet rather quickly. Thoroughbred horses in training have demonstrated a digestive adaptation to fat within one week of supplementation and increasing muscle glycogen concentration was seen within 21 days of receiving an added-fat diet (Hughes et al., 1995). Therefore, though the benefits are seen rapidly, it is important that the athletic horse receives the added fat early enough to be of full benefit in competition.

Protein

Protein requirements of young horses always generates a lot of interest due to the perceived notion that protein requirements for the athlete are much higher than for the idle animal. However, this is not necessarily true (Patterson et al., 1985). Additionally, there are negative effects associated with feeding an excess of protein. The first is expense. Protein tends to be an expensive nutrient, so the feeding of excess protein is usually a waste of money. Many feeds formulated for athletic horses tend to have large amounts of both energy and protein. While the extra energy is usually needed, one should determine whether the extra protein is beneficial. One reason for the misconception that feeds containing higher concentrations of protein are better for the athletic horse is that they tend to be more expensive. Most people naturally assume that items that are more expensive are better and since most people would like to feed the best feed available to their performance horses, they tend to feed the high protein feeds, regardless of whether there is an actual need for it. One study that looked specifically at feeding two concentrations of protein (10% and 20%) to two-year-old horses in training found no consistent benefits or detrimental effects in feeding the higher concentration of protein (Frank et al., 1987). The researchers reported that the extra cost of the high protein ration was not justifiable based on the performance of the horses. Another problem with feeding too much protein is that in order to get rid of the extra nitrogen, there will be an increase in urine production to help remove extra ammonia that is produced. The increased urine production leads to increased water intake (Hintz et al., 1980; Ralston, 1988), wetter stalls and an increased cost for bedding materials. Additionally, the increase in ammonia has potentially negative effects for horses housed in stalls with poor ventilation. It is believed that the decreased air quality resulting from the additional ammonia may increase respiratory problems for the athletic horse.

Despite the potentially negative consequences of feeding extra protein, the total protein requirement of the young horse entering training is slightly increased from maintenance. Freeman et al. (1988) found an increase in nitrogen retention, presumably resulting from increased muscle hypertrophy, when mature horses entered a training program and became conditioned. However, it is felt that if a DE:CP ratio is maintained, the additional DE intake needed for work will result in consumption of enough additional protein to meet the exercising horse's protein requirement (Freeman et al., 1988; Hinkle et al., 1981).

Minerals

Much work has been done on Ca balance in mature, idle horses and growing horses (Hintz et al., 1986). However, there appears to be little work conducted on 18- to 24-month old horses entering training to determine changes in mineral balance. It has been presumed that any increase in Ca requirements due to exercise would be met by increased Ca intake associated with increased dry matter intake (NRC, 1989). However, this has not been documented in young horses entering training. A study with 53 yearling Quarter Horses placed into race training demonstrated a substantial decrease in optical density of the third metacarpal during the first two months of training (Nielsen et al., 1997). This was followed by an increase that continued through the duration of the study. In a subsequent project, 10 untrained Quarter Horse geldings were put into race training and were fed a diet balanced to meet NRC recommendations to further investigate the influence of early training on bone metabolism (Nielsen et al., 1998a). A similar decrease in the mineral content of the third metacarpal was observed during the first two months of the project. The study also indicated a potential deficiency in dietary Ca in the young horses as they entered training. A follow-up study was conducted to investigate feeding different concentrations of Ca and P to two different groups of two-year-olds placed into training for the first time (Nielsen et al., 1998b). While the NRC (1989) recommends 0.32% Ca in the total diet for long yearlings in training, and 0.31% Ca for two-year-old horses in training on an as-fed basis, after completing this study (Nielsen et al., 1998b), it appears that the recommendation is too low when formulating diets for young horses entering intense training. It is probable that the ideal concentration of Ca is 0.40% as Schryver et al. (1978) found no additional benefit from feeding 0.60% Ca compared to 0.40% Ca to yearling Standardbreds in training. Though no additional benefit was seen by feeding the higher concentration of Ca (Schryver et al., 1978), the exercise being performed by horses in that study may not have been loading the skeletal system sufficiently to initiate a strong remodeling response (Nunamaker et al., 1991). However, there was definitely a benefit in feeding 0.38% Ca compared to 0.31% Ca as demonstrated by an increase in mineral content of the third metacarpal and an increased Ca retention in horses on the high mineral diet (Nielsen et al., 1998b). However, this experiment used NRC guidelines for Ca concentration in the diet, rather than the total intake of Ca in grams per day. When total Ca intake (g/d) is considered, the control diet provided only 80 to 85% of the requirement and the high mineral diet provided about 100%. When the adequacy of the NRC recommendation is considered from this perspective, it is arguable as to whether the data can be used to support a contention that the current recommendation is too low. Hence, one needs to decide whether it is more appropriate to base mineral requirements on a given quantity per day or whether it is more appropriate to feed as a percent of total intake.

Interestingly, a study was conducted examining factors associated with shin soreness in human athletes (Myburgh et al., 1988). The study contained 25 athletes that developed shin soreness and 25 control athletes who matched the injured athletes in age, sex and sport. Only three athletes who developed shin soreness consumed the recommended dietary allowance (RDA) of Ca, whereas 15 control athletes met the requirement. Additionally, only two of the control athletes consumed under half the RDA of Ca compared to ten of the injured athletes. As a result, it was reported that low Ca intake was significantly ($P < .005$) related to shin soreness. This seems to indicate that inadequate Ca intake may play a role in skeletal injuries.

The recommended concentration of P in the diet as suggested by the NRC appears to be adequate. No differences between treatments or days were seen in P retention in the study by Nielsen et al. (1998b). Hence, there appeared to be no benefit in feeding additional P above what the NRC recommends, other than to maintain a constant Ca:P ratio. Based on the Ca and P concentrations investigated in that study, it appears that the equine is quite capable of regulating P retention.

It is difficult to draw definite conclusions from the Mg balance results in the study by Nielsen et al. (1998b), as Mg concentrations were greater than what the NRC recommends. Additionally, once the feed was analyzed, it was discovered that the Mg concentration was not uniform throughout the project. Furthermore, there were no major differences in the amount of Mg fed to the control horses and the high mineral treatment group. However, additional supplementation of Mg may be greater than NRC (1989) recommendations. There was an increase in Mg retention in the latter part of the study in the high mineral group. This was the result of decreased urinary Mg, despite increased Mg intake. Since this is when the biggest increase in mineral content of the third metacarpal occurred in the high treatment group, there exists a potential benefit of feeding additional Mg during periods of high bone formation. This, however, is speculative at best. Additionally, the fact that the horses were in a negative Mg balance when fed Mg concentrations averaging 0.15% of the diet indicates that the currently recommended concentrations of Mg are inadequate.

Besides a potential increase in dietary mineral need for changes in bone metabolism, the additional sweating that accompanies exercise can cause an increased need for some minerals. Schryver et al. (1978) found that the total excretion of Ca and P in the sweat of mature polo horses ranged from 80 to 145 mg of Ca and 11 to 17 mg of P in a 20-min exercise period. Hoyt et al. (1995a) estimated sweat loss of Ca to be 8.5 mg per Mcal DE consumed above maintenance for work and sweat loss of P to be 10.7 mg per Mcal DE consumed above maintenance for work. Thus, it does not appear that sweating greatly increases the need for Ca and P. In contrast, an increased need for Na, Cl and K to replace that lost in sweat has been reported (Hoyt et al., 1995a; Meyer, 1987). For horses that are exercising hard and producing a lot of sweat, electrolytes should be provided.

Copper is another mineral that plays an important role in proper bone and cartilage development of young horses. A low Cu concentration in the diet appears to have links to osteochondrosis. A negative correlation between Cu concentration and perceived affliction of metabolic bone disease has been reported by Knight et al. (1985). Knight et al. (1990) also reported a reduction in prevalence and severity of osteochondrosis and other developmental cartilage lesions in foals fed elevated amounts of Cu. Gunson et al. (1982) reported several cases of foals with severe generalized osteochondrosis. The foals were suspected of having chronic zinc/cadmium toxicosis as lesions of their joint cartilage were similar to those seen experimentally in animals fed diets high in zinc. This may be partially due to the high levels of zinc interfering with normal copper absorption as similar cartilaginous lesions were also seen in foals fed a copper deficient diet (Bridges and Harris, 1988).

In addition to osteochondrosis, low Cu concentrations have been linked to epiphysitis in the fetlock joint of weanlings (Asai et al., 1993). In a study conducted by Hurtig et al. (1990), foals fed a diet containing 7 ppm copper had greater incidence and severity of angular limb deformities, mild flexural deformities, epiphysitis, intermittent lameness and osteochondrosis lesions than weanlings fed 30 ppm of copper. Hence, it appears that the NRC (1989) recommendation of 10 ppm is minimal and that by increasing the concentration, a reduction may be seen in the incidence of developmental orthopedic disorders.

One other mineral that may need special attention is selenium. Depending on the part of the country in which feedstuffs are grown, there may be a need for selenium supplementation. Forages and grains grown in the northeastern United States are often low in Se (Kubota et al., 1967). Hence, if one lives in this part of the country, it is advisable to evaluate the Se concentrations in the rations of their horses to ensure that they are adequate.

Vitamins

Research has not been able to demonstrate any drastic need for changes in vitamin requirements for the young exercising horse, with one possible exception. Horses undergoing heavy training may develop a lethargic, depressed condition described as "track sour" in the racing industry. Often these horses lose their appetite. As they are often receiving large quantities of energy in their diets, there is a chance that these horses are deficient in B-vitamins, particularly thiamin, which are necessary for utilizing extra dietary energy. Thiamin is needed for the metabolism of pyruvate. If the absorption of microbially synthesized thiamin in the intestine is not adequate, there may be a dietary requirement (Carroll et al., 1949). Topliff et al. (1981) reported that supplementation of thiamin is necessary in hard working horses receiving a traditional diet. Hence, one should be aware of the signs of a horse becoming "track sour" and supplement the diet if needed.

Water

The importance of a good, clean water supply to young horses in training is obvious. As horses increase their workload, there is also an increase in sweating rates. This is especially true during hot weather or when horses are performing endurance-type activities. While being ridden 9.6 km daily, Thoroughbreds have been reported to have sweat losses of 15.6 g/kg of body weight (Hoyt et al., 1995b), while almost 40 liters of water have been reported to have been lost during an 80-km endurance ride (Snow et al., 1982). Hence, there is an additional need in exercising horses for water to replace that lost as sweat. If electrolytes are added to the water, it is recommended that additional water also be available to the animal. Some horses will refuse to drink enough water if it is supplemented with electrolytes and this could leave the horse prone to dehydration.

Other Tips

As previously stated, the energy needs of a horse can increase greatly upon entering training. Though part of this increased demand can be made up through the addition of fat to the diet, it will usually become necessary to increase the carbohydrate portion of the diet as well. When increasing carbohydrates in the diet, it is recommended that the total daily intake be divided into as many feedings as possible. Increasing the intake without increasing the number of times fed will increase the likelihood of digestive problems such as colic.

Despite all of the recommendations being set forth on how to achieve optimum performance, one last item should be mentioned. Though there is an increased nutritional demand placed upon the young horse as it enters training, one management practice used by some in the industry is to choose to ignore that increase in demand, and for good reason. Often when a young horse is being "broken" to ride, the trainer will not increase the intake of the animal until after four to six weeks of training. This is to make the animal easier to control. One saying used by some horse trainers is "work the mental through the physical." A horse that is "full of energy" will be more difficult to control and train during the early stages of training. As a result, it is not uncommon to wait until the horse has made sufficient progress in its training before making large increases in its feed. This would tend to make the nutritional requirements of that young horse even more complicated. Despite that problem, this practice will continue and is one that many recommend.

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