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THE ROLE OF NUTRITION IN THE MANAGEMENT OF DEVELOPMENTAL ORTHOPEDIC DISEASE

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Nutrition may play an important role in the pathogenesis of developmental orthopedic disease in horses. Deficiencies, excesses, and imbalances of nutrients may result in an increase in both the incidence and severity of physitis, angular limb deformity, wobbler syndrome (wobbles), and osteochondritis dissecans (OCD).

Nutritional Factors as a Cause of Developmental Orthopedic Disease

MINERAL DEFICIENCIES

A deficiency of minerals, including calcium, phosphorus, copper, and zinc, may lead to developmental orthopedic disease. The ration of a growing horse should be properly fortified because most commonly fed cereal grains and forages contain insufficient quantities of several minerals. A ration of grass hay and oats would only supply about 40% and 70% of a weanling's calcium and phosphorus requirement, respectively, and less than 40% of its requirement for copper and zinc (Table 1). The best method of diagnosing mineral deficiencies is through ration evaluation. Blood, hair, and hoof analysis is of limited usefulness.

Table 1. Mineral requirements for weanlings.

	Nutrient concentration required in total diet (90% dry basis)						
	Moderate growth	*Rapid growth*	*Grass hay*	*Alfalfa hay*	*Oats*	*Corn*	*Barley*
Calcium (%)	0.62	0.70	0.35	1.25	0.08	0.05	0.05
Phosphorus (%)	0.40	0.45	0.20	0.22	0.34	0.27	0.34
Zinc (ppm)	65	65	9	16	6	4	8
Copper (ppm)	22	22	17	28	35	19	17

MINERAL EXCESSES

Horses can tolerate fairly high levels of mineral intake, but excesses of calcium, phosphorus, zinc, iodine, fluoride, and certain heavy metals such as lead and cadmium may lead to developmental orthopedic disease.

Mineral excesses occur because of overfortification or environmental contamination. Massive oversupplementation of calcium (>300% of required) may lead to a secondary mineral deficiency by interfering with the absorption of other minerals such as phosphorus, zinc, and iodine. Excessive calcium intake may be compounded by the use of legume hays as the primary forage source. Iodine and selenium oversupplementation occurs if supplements are fed at inappropriate levels. A ration evaluation is the best way to identify this type of mineral imbalance.

Environmental contamination is a more likely cause of developmental orthopedic disease because contamination may result in extremely high intakes of potentially toxic minerals. If a farm is experiencing an unusually high incidence of developmental orthopedic disease or if the location and severity of skeletal lesions are abnormal, environmental contamination should be investigated. Blood, feed, and water analysis should be performed. In addition, chemical analysis of hoof and hair samples may reveal valuable information in such a situation. Farms that are located near factories or smelters are the most likely candidates for this type of contamination, although OCD from a zinc-induced copper deficiency has been reported on farms using fence paint containing zinc or galvanized water pipes.

Table 2. Toxic mineral levels (NRC, 1989; Cunha, 1997).

Mineral	*Level of mineral needed by young horse (ppm)*	*Level at which mineral is toxic (ppm)*
Iodine	0.2-0.3	5.0
Fluoride	–	50
Lead	–	80
Selenium	0.2-0.3	5.0
Manganese	60-70	4000
Copper	20-30	300-500
Cobalt	0.1	400

MINERAL IMBALANCES

The ratio of minerals may be as important as the actual amount of individual minerals in the ration. High levels of phosphorus in the ration will inhibit the absorption of calcium and will lead to a deficiency, even if the amount of calcium present was normally adequate. The ratio of calcium to phosphorus in the ration of young horses should never dip below 1:1 and ideally it should be 1.5:1. Too much calcium may affect phosphorus status, particularly if the level of phosphorus in the ration is marginal. Calcium to phosphorus ratios greater than 2.5:1 should be avoided if possible. Forage diets with high calcium levels should be supplemented with phosphorus. The ratio of zinc to copper should be 3:1 to 4:1.

DIETARY ENERGY EXCESS

Excessive energy intake can lead to rapid growth and increased body fat, which may predispose young horses to developmental orthopedic disease. A recent Kentucky study showed that growth rate and body size may increase the incidence of certain types of developmental orthopedic disease in Thoroughbred foals (Pagan et al., 1996). Yearlings that showed osteochondrosis of the hock and stifle were large at birth, grew rapidly from 3 to 8 months of age, and were heavier than the average population as weanlings.

The source of calories for young horses may also be important, as hyperglycemia or hyperinsulinemia have been implicated in the pathogenesis of osteochondrosis (Glade et al., 1984; Ralston, 1995). Foals that experience an exaggerated and sustained increase in circulating glucose or insulin in response to a carbohydrate (grain) meal may be predisposed to development of osteochondrosis. In vitro studies with fetal and foal chondrocytes suggest that the role of insulin in growth cartilage may be to promote chondrocyte survival or to suppress differentiation and that hyperinsulinemia may be a contributory factor to equine osteochondrosis (Henson et al., 1997).

Recent research from Kentucky Equine Research (Pagan et al., 2001) suggests that hyperinsulinemia may influence the incidence of OCD in Thoroughbred weanlings. In a large field trial, 218 Thoroughbred weanlings (average age 300 ± 40 days, average body weight 300 kg ± 43 kg) were studied. A glycemic response test was conducted by feeding a meal that consisted of the weanling's normal concentrate at a level of intake equal to 1.4 g nonstructural carbohydrate (NSC) per kilogram body weight. A single blood sample was taken 120 minutes post feeding for the determination of glucose and insulin.

In this study, a high glucose and insulin response to a concentrate meal was associated with an increased incidence of OCD. Glycemic responses measured in the weanlings were highly correlated with each feed's glycemic index (GI), suggesting that the GI of a farm's feed may play a role in the pathogenesis of OCD. Glycemic index characterizes the rate of carbohydrate absorption after a meal and is defined as the area under the glucose response curve after consumption of a measured amount of carbohydrate from a test feed divided by the area under the curve after consumption of a reference meal (Jenkins et al., 1981). In rats, prolonged feeding of high GI feed results in basal hyperinsulinemia and an elevated insulin response to an intravenous glucose tolerance test (Pawlak et al., 2001). Hyperinsulinemia may affect chondrocyte maturation, leading to altered matrix metabolism and faulty mineralization or altered cartilage growth by influencing other hormones such as thyroxine (Pagan et al., 1996; Jeffcott and Henson, 1998).

Based on the results of this study, it would be prudent to feed foals concentrates that produce low glycemic responses. More research is needed to determine if the incidence of OCD can be reduced through this type of dietary management.

Ration Evaluations

In almost every circumstance of developmental orthopedic disease, the surest way of determining if nutrition is a contributing factor is to perform a ration evaluation, which compares the intake of several essential nutrients with the requirements of the horse. Gross deficiencies or excesses of key nutrients can then be identified and corrected.

TYPES OF EVALUATIONS

Ration evaluations can be approached in two ways. One way is to add up what is being fed and compare it to the horse's requirements. This is actually more difficult than it may first appear since most horsemen do not actually know exactly what their horses are eating. There are a number of checks that can be used to more accurately estimate feed intakes, and these checks will be reviewed later. Alternatively, a new ration may be developed.

THE PROTOCOL

Every nutrition evaluation should include a description of the horse, definition of nutrient requirements, determination of nutrients in feedstuffs, determination of intake of feedstuffs, calculation of nutrient intake, comparison of intake with requirements, and adjustments of the ration to correct deficiencies or excesses.

Describe the horse. Different classes of horses have different nutrient requirements, and each class may eat different amounts of forage and grain. Within each class of horse, it is important to know the horse's current body weight, its age and mature body weight if growing, and its rate of body weight gain or loss.

Define nutrient requirements. Ration evaluations are intended to compare a horse's daily nutrient intake to a set of requirements to determine how well the feeding program meets the horse's nutritional needs. This would seem to be a straightforward accounting exercise, but what nutrient requirements should be used? The National Research Council (NRC) publishes a set of requirements for horses, but NRC values represent minimum requirements for most nutrients. These are the levels of intake that are required to prevent frank deficiency symptoms. No allowances are included to account for factors that may increase the requirement of a nutrient. The bioavailability of nutrients may be different, and other substances within a ration may interfere with the digestibility or use of a nutrient.

Kentucky Equine Research has developed its own set of nutrient recommendations for young growing horses. These requirements are based on a combination of NRC numbers, research that has been conducted since publication of the most recent NRC recommendations, and experience in the field. Digestible energy and protein are two NRC requirements that fairly accurately describe the needs of horses maintained under practical management conditions. These two requirements were primarily developed from direct measurements of growth response and energy balance in a number of different experiments. Other requirements, such as those for calcium and phosphorus, were developed using more theoretical calculations involving estimates of endogenous losses and digestibility. Still others were based on values developed for other species or from single experiments that were far from conclusive. For most of the vitamins and minerals, KER requirements use values ranging from 1.25 to 3.0 times those recommended by NRC. All of these nutrient requirements are far from absolute, and they will continue to evolve as more data become available. For now, though, it is assumed that these requirements adequately reflect what is needed by the horse under a wide range of conditions.

Determine nutrients in feedstuffs. The accuracy of evaluating the diet depends on proper sampling of feedstuffs. The feeds should be thoroughly mixed and a representative sample taken. Pelleted feeds are fairly uniform, but sampling is more critical for textured feeds and home mixes. If an odd nutrient value is encountered, look to sampling error as a likely cause.

A hay core can be used to obtain a representative hay sample for analysis. Pasture analysis is more difficult. Should the entire pasture be systematically sampled or only those areas heavily grazed? Horses tend to be spot grazers; therefore sampling the heavily grazed areas is probably best.

When expressing feed intakes and nutrient composition, air dry values for hay and grain and 100% dry matter values for pasture are used. This is because hay and grain intakes are actually measured as fed and pasture intakes tend to be estimated. The moisture content of the pasture is not relevant to the evaluation and only complicates intake calculations.

A number of commercial laboratories analyze forages and feeds. For a typical ration evaluation for young growing horses, the following nutrients should be either analyzed or calculated for each forage and concentrate: digestible energy (megacalories [Mcal] or megajoule [MJ], typically estimated), crude protein (percent), lysine (percent, typically estimated), acid or neutral detergent fiber (percent), calcium (percent), phosphorus (percent), zinc (percent), copper (percent), and manganese (percent).

These nutrients are usually included on a standard panel analysis at a reasonable cost. Other minerals, such as selenium and iodine, are usually analyzed separately, and analysis can be quite expensive. Selenium and iodine are not essential for most evaluations that focus on identifying nutritional causes of developmental orthopedic disease.

Determine intake of feedstuffs. A common flaw in many ration evaluations is measuring intake inaccurately. A scale should be used to measure the amount of grain and hay offered. A certain degree of hay wastage usually occurs, and this should be taken into account when calculating intake. Table 4 lists expected feed consumption by various classes of horses. The amount of forage and grain consumed by a young horse can vary tremendously depending on its geographic location and forage availability. Typically, horses that are raised in more tropical environments will depend more heavily on grain in their ration. Yearlings raised in temperate areas with abundant forage eat rations that contain 80% forage.

Table 3. Expected feed consumption by horses.

Horse	*% of body weight*		*% of diet*	
	Forage	*Concentrate*	*Forage*	*Concentrate*
Maintenance	1.0-2.0	0-1.0	50-100	0-50
Pregnant mare	1.0-2.0	0.3-1.0	50-85	15-50
Lactating mare (early)	1.0-2.5	0.5-2.0	33-85	15-66
Lactating mare (late)	1.0-2.0	0.5-1.5	40-80	20-60
Weanling	0.5-1.8	1.0-2.5	30-65	35-70
Yearling	1.0-2.5	0.5-2.0	33-80	20-66
Performance horse	1.0-2.0	0.5-2.0	33-80	20-66

Calculate nutrient intake. Determining pasture intake is the most difficult part of conducting a ration evaluation. Two methods usually are employed to estimate pasture intake. The simplest method is to arbitrarily estimate intake at about 1% to 1.5% of a young horse's body weight. The obtained value is only fairly accurate, but it is representative of most young horses on pasture the majority of the day. A second and more accurate method is to calculate pasture intake energetically by subtracting the digestible energy intake from all other feedstuffs from the horse's daily energy requirement. Dividing this number by the pasture's calculated energy density yields daily dry matter intake. For example, a yearling that weighs 330 kg with an average daily gain of 0.55 kg/day should require 20.4 Mcal of digestible energy per day. If that yearling is eating 3.65 kg of sweet feed (10.8 Mcal digestible energy) and 2 kg of mature alfalfa hay (3.6 Mcal digestible energy), then it must be consuming around 6 Mcal of digestible energy from pasture. Most grass pastures contain about 2.2 Mcal of digestible energy per kilogram, so this yearling must consume about 2.73 kg of pasture dry matter per day. These intakes can then be used to evaluate the adequacy of the ration for other nutrients in addition to energy. This method of calculating pasture energy intake works well provided the horse is actually consuming the intakes of other feedstuffs and the correct energy requirements were selected.

Using the method described above for estimating pasture intake often yields a negative number. If this occurs, then either the digestible energy intake of the other feeds was too high or the calculated energy consumption was too low. Sometimes horse owners report higher intakes of feeds than are actually eaten. This is particularly true for forages because hay is rarely weighed and large quantities are often wasted. Grain intake can also be overestimated. At other times the hay and grain intake may be correct, but the horse may be consuming more energy than calculated. Increased energy intake can occur if the horse is expending extra energy to work or to keep warm in cold weather, or a young horse may be growing faster than assumed. For example, a yearling needs about 5 kg of additional grain (16.1 Mcal of digestible energy) per kilogram of gain. If average daily gain is higher than assumed, then the horse may be eating significantly more digestible energy than calculated.

Compare intake to requirements. Rarely will the nutrients supplied by a ration exactly match the horse's requirements, and it is unnecessary to balance rations with this type of precision. Instead, the key to interpreting a ration evaluation is to identify deficiencies, excesses, or imbalances of nutrients that may affect growth and skeletal soundness. For most nutrients, a level of intake in excess of 90% of required is not considered deficient. What is interpreted as excessive varies tremendously among nutrients. For instance, potassium plays only a minor role in skeletal development; a young horse at pasture may consume greater than 300% of its potassium requirement. Most of this potassium comes from the pasture and is perfectly harmless. Even small excesses of other nutrients, such as energy, may play a significant role in the development of skeletal disease. Energy intakes that are 115% of required might trigger mild developmental orthopedic disease, and levels above 130% almost certainly will cause problems in rapidly growing horses.

Feeding Practices that Contribute to Developmental Orthopedic Disease

Several feeding scenarios may contribute to developmental orthopedic disease. Once identified, most can be easily corrected through adjustments in feed type and intake. Several of the most common mistakes made in feeding young growing horses are explained.

OVERFEEDING

One of the most common problems of feeding young horses is excessive intake that results in accelerated growth rate or fattening. Both conditions may contribute to developmental orthopedic disease. Unfortunately, there are no simple rules about how much grain is too much, because total intake of both forage and grain determines caloric consumption. Large intakes of grain are appropriate if the forage is sparse or poor quality, as often is the case in tropical environments. For example, grain intakes as high as 2% to 2.5% of body weight may be necessary to sustain reasonable growth in weanlings that have access to no forage other than tropic pasture. Conversely, grain intakes higher than 1% body weight may be considered excessive when weanlings are raised on lush temperate pasture or have access to high-quality alfalfa hay.

Table 4. Growth rates of fillies and colts in central Kentucky.

Average days of age	*Colts BW (kg)*	*Fillies BW (kg)*	*Colts ADG (kg/d)*	*Fillies ADG (kg/d)*	*Colts HT* (cm)*	*Fillies HT* (cm)*	*Colts BCS***	*Fillies BCS***
14	77.7	76.1	-	-	107.3	106.3	5.7	6.0
43	116.3	115.1	1.38	1.34	115.7	115.5	6.2	6.4
72	149.5	148.5	1.20	1.19	122.6	121.8	6.2	6.3
99	182.1	178.6	1.14	1.11	127.3	127.1	6.0	6.5
127	208.8	207.9	1.01	1.01	129.8	130.3	5.8	5.9
155	233.6	230.2	0.89	0.84	133.5	132.5	5.5	5.7
183	255.9	250.7	0.80	0.75	135.8	134.7	5.4	5.6
212	277.1	271.0	0.75	0.71	138.2	137.4	5.5	5.5
240	295.1	287.3	0.68	0.60	140.0	139.4	5.4	5.5
267	309.1	300.6	0.55	0.48	141.8	140.7	5.4	5.4
296	322.0	311.0	0.43	0.40	144.2	142.5	5.3	5.4
323	335.1	322.5	0.40	0.35	145.4	144.0	5.4	5.4
350	349.2	335.2	0.43	0.39	147.0	145.5	5.3	5.4
378	362.5	350.1	0.45	0.51	148.3	146.7	5.4	5.5
406	378.9	367.9	0.52	0.60	150.2	148.2	5.5	5.7
435	396.2	388.9	0.62	0.65	150.8	149.6	5.5	5.8
462	414.2	407.9	0.59	0.60	152.5	151.5	5.6	5.8
490	427.8	418.0	0.55	0.54	153.4	151.8	5.7	5.8

**Height, **Body condition score*

The surest way to document excessive intake is by weighing and using condition scoring in the growing horse. Growth rates and condition scores for Thoroughbred foals can be compared to the data presented in Table 3. Based on a system developed by Henneke et al. (1981), condition scoring measures fat deposition. Horses are scored from 1 to 9 with 1 denoting extreme thinness and 9 indicating obesity. In a Kentucky study, fillies tended to have higher condition scores than colts, and the difference was greatest at 4 months of age (fillies 6.48; colts 6.0). These condition scores are considered moderate to fleshy according to the Henneke scoring system. By 12 months of age, the condition scores of the colts and fillies had dropped to 5.3 and 5.4, respectively. Both sexes increased condition score slightly from 14 to 18 months.

If growth rate cannot be measured, excessive intake can often be assessed by ration evaluation. For example, a six-month-old Thoroughbred weanling (250 kg body weight, 500 kg mature body weight) was being fed 4 kg/day of a 16% protein sweet feed and 2 kg of alfalfa hay and had access to high-quality fall Kentucky pasture. To support a reasonable rate of growth (0.80 kg/d), this weanling required about 17 Mcal of digestible energy per day. The hay and grain intake of this foal alone would supply about 17.5 Mcal of digestible energy, which is slightly above the weanling's requirement. If a reasonable level of pasture intake is included (1% of body weight or 2.5 kg dry matter), this weanling would be consuming 135% of its digestible energy requirement, a level likely to cause problems.

To reduce intake, the alfalfa hay should be eliminated, if the pasture is indeed adequate. If hay were needed when the weanling is stalled, grass hay would be more appropriate. Secondly, grain intake should be reduced to a level of about 3 kg/d. At this level of grain intake, the weanling would need to consume about 3.3 kg of pasture dry matter to support a growth rate of 0.80 kg/d, and the ration would be nicely balanced.

INAPPROPRIATE GRAIN FOR FORAGE BEING FED

Occasionally, the concentrate offered to a growing horse is incorrectly fortified to complement the forage that is being fed. The problem occurs particularly when the forage is mostly alfalfa or clover. Most concentrates for young horses are formulated with levels of minerals and protein needed to balance grass forage.

For example, a 12-month-old yearling (315 kg body weight, 500 kg mature body weight, 0.50 kg/d ADG) is raised without access to pasture and the only forage available is alfalfa hay, which is fed at a level of intake equal to 1.5% of the yearling's body weight (4.72 kg/d). At this level of forage intake, the yearling would only require about 2.5 kg of grain per day. If a typical 14% protein sweet feed that was formulated to balance grass forage is used, the ration would be inappropriate for a number of reasons. Calcium would be 183% of the yearling's requirement, with a calcium to phosphorus ratio of 2.9:1. This would not be a problem except that phosphorus and zinc are marginal in the ration. Because calcium may interfere with the absorption of both of these minerals, the yearling may be at risk of developmental orthopedic disease from a zinc or phosphorus deficiency. The solution is to feed a concentrate that is more appropriately balanced for legume hay. For example, a 12% protein feed with 0.4% calcium, 0.9% phosphorus, and 180 ppm zinc would be more suitable.

INADEQUATE FORTIFICATION IN GRAIN

The most common reasons for inadequate fortification are using unfortified or underfortified grain mixes, using correctly fortified feeds at levels of intake that are below the manufacturer's recommendation, or using fortified feeds diluted with straight cereal grains. These errors in feeding can be corrected by the incorporation of a highly fortified grain balancer supplement.

For example, a 6-month-old weanling (200 kg body weight, 400 kg mature body weight, 0.60 kg/d ADG) is fed 3 kg/d of a 10% protein sweet feed that is intended for adult horses. To compound matters, the weanling is also fed grass hay with an estimated intake of 2.3 kg/d. This ration is deficient in protein, calcium, phosphorus, zinc, and copper. This foal would be prone to a rough hair coat and physitis. There are two ways to correct this problem. A properly formulated 14% to 16% protein grain mix with adequate mineral fortification could be used, or 1 kg of a grain balancer pellet can be substituted for 1 kg of the 10% sweet feed. This type of supplement is typically fortified with 25% to 30% protein, 2.5% to 3.0% calcium, 1.75% to 2.0% phosphorus, 125 to 175 ppm copper, and 375 to 475 ppm zinc. This is an extremely useful type of supplement to correct underfortified rations.

Feeding Systems to Prevent Developmental Orthopedic Disease

BROODMARES

The nutritional requirements of a broodmare can be divided into three stages. Stage one is early pregnancy, from conception through the first 7 months of gestation. Barren mares and pregnant mares without sucklings by their sides fit into this nutritional category. Stage two encompasses the last trimester of pregnancy, which is from around 7 months of pregnancy through foaling. Stage three is lactation, which generally lasts 5 to 6 months after foaling. The most common mistakes made in feeding broodmares are overfeeding during early pregnancy and underfeeding during lactation.

Early pregnancy. Proper feeding during pregnancy requires an understanding of how the fetus develops during gestation. Contrary to popular belief, the fetus does not grow at a constant rate throughout the entire 11 months of pregnancy. Figure 3 illustrates a typical growth curve for a fetus expressed as a percent of birth weight. As is plainly visible, the fetus is small during the first 5 months of pregnancy. Even at 7 months of pregnancy, the fetus equals only about 20% of its weight at birth. At this stage in pregnancy, the fetus equals less than 2% of the mare's weight, and its nutrient requirements are minuscule compared with the mare's own maintenance requirements. Therefore, the mare can be fed essentially the same as if she were not pregnant. Mare owners often increase feed intake after the mare is pronounced in foal, reasoning that she is now "eating for two." Increased feeding is unnecessary and may lead to obesity and foaling difficulties, especially if the mare has access to high-quality pasture during early pregnancy.

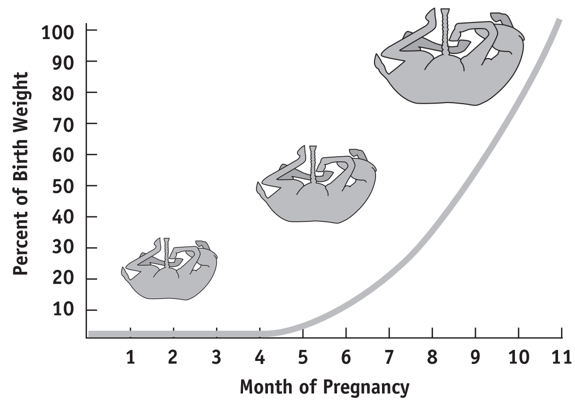

Figure 1. Typical growth curve for a fetus expressed as a percentage of birth weight.

Late pregnancy. The fetus begins to develop rapidly after 7 months of pregnancy, and its nutrient requirements become significantly greater than the mare's maintenance requirements; therefore adjustments should be made in the mare's diet. Digestible energy requirements only increase about 15 percent over early pregnancy. Protein and mineral requirements increase to a greater extent. This is because the fetal tissue being synthesized during this time is quite high in protein, calcium, and phosphorus. During the last four months of pregnancy, the fetus and placenta retain about 77 grams of protein, 7.5 grams of calcium, and 4 grams of phosphorus per day. Trace mineral supplementation is also very important during this period because the fetus stores iron, zinc, copper, and manganese in its liver for use during the first few months after it is born. The fetus has developed this nutritional strategy of storing trace minerals during pregnancy because mare's milk is quite low in these elements.

New Zealand researchers studied the effect of copper supplementation on the incidence of developmental orthopedic disease in Thoroughbred foals. Pregnant Thoroughbred mares were divided into either copper-supplemented or control groups. Live foals born to each group of mares were also divided into copper-supplemented or control groups. Copper supplementation of mares was associated with a significant reduction in the physitis (inflammation of the bone growth plates) scores of the foals at 150 days of age. Foals from mares that received no supplementation had a mean physitis score of 6, whereas foals out of supplemented mares had a mean score of 3.7. A lower score means less physitis. Copper supplementation of foals had no effect on physitis scores. A significantly lower incidence of articular cartilage lesions occurred in foals from supplemented mares.

However, copper supplementation of the foals had no significant effect on articular and physeal cartilage lesions. Mares in late pregnancy are often overfed energy in an attempt to supply adequate protein and minerals to the developing foal. If the pregnant mare becomes fat during late pregnancy, she should be switched to a feed that is more concentrated in protein and minerals so that less can be fed per day. This will restrict her energy intake while ensuring that she receives adequate quantities of other key nutrients.

Lactation. A mare's nutrient requirements increase significantly after foaling. During the first 3 months of lactation, mares produce milk at a rate equal to about 3% of their body weight per day. This milk is rich in energy, protein, calcium, phosphorus, and vitamins. Therefore, the mare should be fed enough grain to meet her greatly increased nutrient requirements. Mares in early lactation usually require from 4.5-6.5 kg of grain per day depending upon the type and quality of forage they are consuming. This grain mix should be fortified with additional protein, minerals, and vitamins to meet the lactating mare's needs. Trace mineral fortification is not extremely important for lactating mares because milk contains low levels of these nutrients and research has shown that adding more to the lactating mare's diet does not increase the trace mineral content of the milk. Calcium and phosphorus are the minerals that should be of primary concern during lactation. Grain intake should be increased gradually during the last few weeks of pregnancy so that the mare is consuming nearly the amount that she will require for milk production at the time that she foals. A rapid increase in grain should be avoided at foaling because this may lead to colic or founder. Milk production begins to decline after about 3 months of lactation, and grain intake can be reduced to keep the mare in a desirable condition.

SUCKLINGS

If the broodmare has been fed properly during late pregnancy, it is unnecessary to supplement the suckling with minerals until it reaches 90 days of age. At 90 days, moderate amounts of a well-fortified foal feed can be introduced and gradually increased until the suckling is consuming around 0.5 kg feed per month of age. It is critical that the suckling be accustomed to eating grain before it is weaned. If it is not, there is a very good chance that there will be a dramatic decrease in growth rate at weaning. When the weanling finally starts eating grain, a compensatory growth spurt will occur that may result in developmental orthopedic disease.

WEANLINGS

The most critical stage of growth for preventing developmental orthopedic disease is from weaning to 12 months of age, when the skeleton is most vulnerable to disease and nutrient intake and balance is most important. Weanlings should be grown at a moderate rate with adequate mineral supplementation. In temperate regions, the contribution of pasture is often underestimated, leading to excessive growth rates and developmental orthopedic disease.

YEARLINGS

Once a horse reaches 12 months of age, it is much less likely to develop several forms of developmental orthopedic disease than a younger horse. Many of the lesions that become clinically relevant after this age are typically formed at a younger age. Still, proper nutrient balance remains important for the yearling. It is best to delay the increased energy intakes that are required for sales prepping as long as possible because the skeleton is less vulnerable to developmental orthopedic disease as the yearling ages. Normally, increasing energy intake 90 days before a sale is enough time to add the extra body condition that is often expected in a sales yearling.

Physitis in the carpus is often a major concern with sales yearlings. To reduce the incidence of physitis in these horses, the level of trace mineral supplementation should remain high and a significant portion of the energy normally supplied from grain should be replaced with fat and fermentable fiber. Sales preparation grain mixes can contain as much as 10% fat. Sources of fermentable fiber include beet pulp and soy hulls.

Nutritional Management of Developmental Orthopedic Disease

The goal of a feeding program for young horses is to reduce or eliminate the incidence of developmental orthopedic disease. Unfortunately, developmental orthopedic disease will still occur in some foals. Nutritional intervention can help reduce the severity of many forms of developmental orthopedic disease, but not all of the damage resulting from developmental orthopedic disease is reversible. However, it is important to alter the feeding programs of foals with developmental orthopedic disease. The type of alteration will follow a similar pattern but will depend on the foal's age and the type of developmental orthopedic disease. In almost every instance, energy intake should be reduced while maintaining adequate levels of protein and minerals. The rationale for this type of modification is that skeletal growth should be slowed, but adequate substrate should be available to promote healthy bone development.

PHYSITIS

Grain intake should be restricted to a level supplying around 75% of the foal's normal energy requirement. This restriction, however, should not compromise protein and mineral intake, so a different type of feed formulation may be required. For instance, a six-month-old weanling (250 kg body weight, 500 kg mature body weight, 0.8 kg average daily growth) on a decent fall pasture would normally consume around 3.5 kg of a 16% protein foal feed. If this foal developed physitis, it would be confined and fed grass hay (3 kg/d). Reducing the grain intake to a level that was 75% of the foal's normal digestible energy would result in shortages of protein, lysine, calcium, and phosphorus. These shortfalls could be overcome by replacing 1 kg of the 16% percent sweet feed with a grain balancer pellet. This ration would supply 90% of the foal's normal protein requirement alone with a good supply of minerals. As the physitis resolves, intake of the 16% grain mix can be slowly increased and the supplement pellet intake slowly decreased until the foal returns to its normal ration.

WOBBLER SYNDROME

A feeding program like the one described previously is also appropriate for the horse with wobbler syndrome except that the degree of exercise and energy restriction may be more severe. In this case, a feeding program that combined grass hay (2 kg/d) with a moderate amount of alfalfa hay (2 kg/d) and 1 kg/d of balancer pellet would result in a reduction in energy intake equal to 65% of normal intake while maintaining adequate levels of protein and mineral intake.

OSTEOCHONDRITIS DISSECANS

Once a foal develops osteochondritis dissecans that is severe enough to produce clinical signs, the effect of diet is going to be minimal in solving the existing lesion. Again, reducing energy intake and body weight while maintaining adequate protein and mineral intake is advised. Conservative management of shoulder (humeral head) and stifle (lateral trochlear ridge) OCD lesions has been successful. Complete stall rest is recommended along with intra-articular hyaluronan and intramuscular Adequan. There have been anecdotal reports of improvement in lesions identified radiographically through the use of oral joint supplements containing glucosamine and chondroitin sulfate, but these findings have not been validated in a controlled study.

Summary

Nutrition may play a role in the pathogenesis of developmental orthopedic disease. Mineral deficiencies, excesses, or imbalances may be involved along with excesses in energy or carbohydrate intake. A computerized ration evaluation is the best method to identify potential problems. The feeding errors that most often cause developmental orthopedic disease are excessive grain intake, an inappropriate grain mix for the forage being fed, and inadequate fortification in the grain. Each of these can easily be corrected by selecting an appropriate grain mix and feeding it at the correct level of intake. Foals that already have developmental orthopedic disease should have their energy intakes reduced while maintaining adequate levels of protein and mineral intake.

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