Principles of Sound Growth

BY L. A. LAWRENCE, PH.D.

Growth Management Challenge

Few animals are as precocious as the horse. Within 20 minutes of birth a foal may stand and within hours can be ready to run at speeds no human athlete will ever achieve. At this early stage of life, even with this exceptionally early development, horses have only 17% of their mature bone mineral content, but they also have only 10% of their ultimate body weight. The relationships between growth, nutrition, bone strength and development, body weight, and the forces applied to bone are all orchestrated in a careful balance when optimal growth is achieved.

The selection and breeding of horses for desirable traits have been practiced for over 2000 years. However, most of what we have learned about the growth of horses has been recorded in the past 20-30 years. In 1979 Dr. Harold Hintz reported Windfields Farm's growth data for 1,992 foals from birth to 22 months of age. The records illustrate how quickly foals grow. Thoroughbreds and other light horse breeds will reach 84% of their mature height at six months of age. Assuming a mature Thoroughbred will be 16 hands, the six-month-old weanling will be approximately 13.2 hands. At 12 months that horse will have reached 94% of its adult height or around 15 hands, and at 22 months it has almost finished growing in height, reaching 97% of its full height at approximately 15.2 hands. Mature weight is reached at a slower rate; during the first six months of life, the foal will gain 46% of its mature weight. Assuming a mature weight of 1100 pounds, the six-month-old will weigh approximately 506 pounds. At 12 months it will have reached 65% of its mature weight (715 pounds), and at 22 months it should be 90% of its adult weight (990 pounds). Average daily gains described by Hintz are the same as those recommended by the National Research Council (NRC) for moderate growth. The NRC reports that six-month-old weanlings with a projected adult weight of 1100 pounds gained 1.43 pounds per day. Twelve-month-old yearlings gained 1.1 pounds per day, and 18-month-old long yearlings gained 0.77 pounds per day.

Photos by Mark Llewellyn

Radiographic studies on the acquisition of bone mineral in horses from one day of age to 27 years have shown that maximum bone mineral content (BMC) is not achieved until the horse is six years old. If the rate of mineralization of the cannon bone and age are compared, a pattern emerges that is more similar to that of weight gain than height. At six months of age horses have attained 68.5% of the mineral content of an adult horse, and by one year of age they have reached 76% of maximal BMC. Bone is a much more dynamic

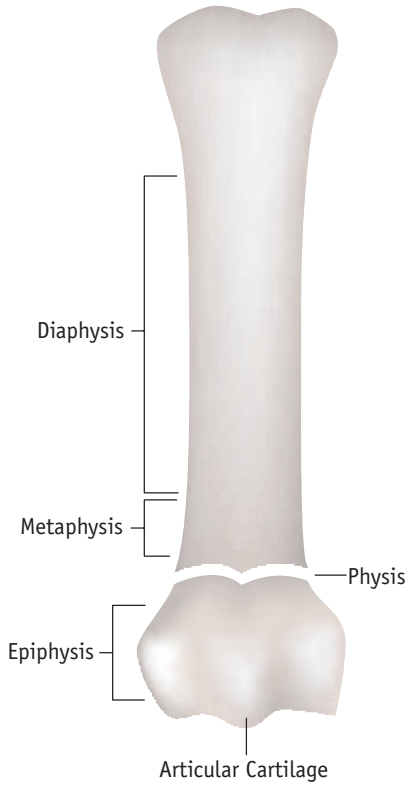
Projected Growth Parameters for a Young Horse

Age	Height	% Mature Height*	Weight	% Mature Weight*
6 months	13.2 h	84%	506 lb	46%
12 months	15.0 h	94%	715 lb	65%
22 months	15.2 h	97%	990 lb	90%

**Estimates based on 16-hand, 1100-lb mature horse.*

tissue than it appears to be upon casual observation; however, complete bone mineralization lags behind growth in height and weight.

Height or long bone growth is the developmental priority for young horses. Energy, protein, minerals, and vitamins are first directed to maintenance requirements, and any additional nutrients are used for skeletal growth, specifically long bones (limbs for locomotion) and flat bones (skull, ribs, etc. for protection). Additional nutrients above those needed for optimal bone development are used to fuel more rapid growth, first developing muscle and then producing a heavier and more well-developed young horse. Optimal growth rates may vary somewhat between breeds, but all young horses have several critical considerations for bone growth and development. Extremely rapid growth caused by overfeeding (particularly energy) has been implicated in developmental orthopedic disorders (DOD) and unsoundness. Periods of slow or decreased growth followed by rapid growth are particularly dangerous. Imbalanced levels of calcium, phosphorus, and trace minerals have been linked to DOD. Forced exercise also seems to cause bone development problems.



Managing Growth

The Rural Industries Research and Development Corporation of Australia recently published a list of suggestions for minimizing the risk of DOD in young growing horses.

1. Promote a moderate, steady growth rate.
2. Diets should contain adequate but never excess energy.
3. Calcium and phosphorus ratios should be maintained between 3:1 and 1:1.
4. Maintain adequate intakes of minerals including calcium, phosphorus, copper, zinc, manganese, magnesium, selenium, etc.
5. Provide an opportunity for sufficient exercise.
6. Avoid breeding mares and stallions that have produced a number of foals with DOD.

Nutrition and Growth

Optimal bone development is greatly influenced by nutrition. During the first two months of life, the mare's milk contains enough energy, protein, and other essential nutrients to meet the needs for growth. Work in Australia has shown that a horse maturing to1100 pounds requires approximately nine pounds of milk for each pound of gain at seven days of age, 13 pounds at one month of age, and 15 pounds at two months of age. Thoroughbred foals may consume up to 40 pounds of milk per day. The foals require around 16 pounds of milk per pound of gain, so they should be gaining just over two pounds per day. Beyond two months of age, there is a decrease in milk production and additional nutrients must be supplied by creep feeding until weaning.

Bone development begins before birth and continues beyond 18 months of age. The period between three and nine months of age appears to be the most precarious for the foal in terms of DOD. During this time serious conditions can develop that might restrict the athletic potential of a horse. It is important to monitor growth rates and evaluate the foal's skeletal development. (See sidebar titled Developmental Orthopedic Disorders in Growing Horses.) Steady, moderate growth along a typical growth curve appears to provide the best method of reducing developmental problems. Kentucky Equine Research has been weighing and measuring foals, weanlings, and yearlings monthly in central Kentucky for over 10 years. Those records combined with numbers from universities and Windfields Farm in Canada have resulted in a tremendous vault of comparative growth data. These data have been formulated into software designed to track growth and make comparisons with databases containing thousands of foals. In addition, the program creates an organized system for recording issues that a particular foal might be experiencing and also saves digital images of the foal as a reference tool.

Foals begin to nibble grass soon after birth, but they do not develop a functional hindgut that will allow them to extract significant nutrients from forages for months. In contrast, their efficiency of grain utilization is high at three weeks of age.

Researchers in Australia, New Zealand, and the United States have recently focused on the contribution of pastures to the nutrition of growing horses. Variability in pastures is considerable across regions and seasons of the

Developmental Orthopedic Disorders in Growing Horses

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Photo by Mark Llewellyn

Developmental orthopedic disease refers to several growth abnormalities that affect young horses. The most prevalent forms of developmental orthopedic disease are defined here:

- Osteochondritis dissecans (OCD) results when a cartilage flap or a free-floating piece of cartilage invades a joint. Common sites for OCD lesions are the stifle and hock.
- Subchondral cysts are osteochondrotic lesions that result from the infolding of thickened joint cartilage. Subchondral bone cysts appear in areas of high compression and occur most frequently in the femur and less usually in the forearm, gaskin, knee, hock, and cannon bones.
- Cervical vertebral malformation (wobbler syndrome) is thought to be caused by osteochondrosis and includes malarticulations and degenerative changes of intervertebral joints. Developmental changes can lead to narrowing of the vertebral column and compression of the spinal cord.
- Physitis occurs when osteochondrotic lesions in growth plates lead to enlargement of the epiphysis above the knee, hock, and fetlocks. The affected bones would therefore be the forearm, gaskin, and cannon bones, respectively.
- Angular limb deformities are deviations in limb alignment in relation to the midline of the limb. The deformities are considered valgus (rotation away from the midline) or varus (deviation toward the midline). Valgus deformities of the carpus are the most prevalent angular limb deformity among young horses.
- Cuboidal bone malformation results from the collapse or injury of carpal and tarsal bones, and can occur in premature foals that have delayed ossification. Cuboidal bone malformation typically leads to severe angular deformities.
- Acquired forelimb contracture is the result of joint pain caused by physitis, OCD, septic wounds, or hoof infections. Any pain within the limb can initiate flexion-withdrawal reflex, which culminates in flexor muscle contraction and an altered position of the joint.

year. When pastures were analyzed across seasons, researchers at Virginia Tech found that the amount of hydrolyzable and rapidly fermentable carbohydrates could be as much as five times higher during the spring and fall as opposed to winter and summer for cool season forages. While many professional horsemen recognize the importance of pastures to growth and development, pasture care is not often given the attention it requires.

Pastures basically fall into the categories of cool season or warm season and grass or legume. What species are found in a particular area is dependent on the annual rainfall and seasonal variations in temperature. For example, a common pasture for a temperate climate might include bluegrass, orchard grass, and white clover. Pastures subjected to adequate fertilization and rainfall during early spring and fall may produce forage that can support gains in weanlings of up to two pounds per day, although vitamin and mineral supplementation would be necessary. Studies at Virginia Tech have confirmed that even under the best conditions pasture will fall short of some key mineral and vitamin requirements and may vary depending on the location of the farm. However, these same pastures during typically hot and dry July and August weather will not provide enough nutrients to support maintenance needs. To avoid the deleterious effects of these drastic swings in available nutrients, producers supply nutrition through carefully fortified rations.

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Pasture is one variable of feeding young horses that is constantly changing and must be accounted for to control growth. Changes in weather patterns, for example, may cause a flush of pasture growth and subsequent weight gain, or a drought may leave pastures barren and unable to fulfill nutritional requirements for growth. The effects of undernutrition followed by overnutrition were illustrat-

ed by researchers at Cornell University. Dr. Hintz fed one group of Standardbred weanlings free-choice feed for eight months, and a second group was given restricted feed for four months and then free-choice feed for four months. Two-thirds of the foals in the restricted-feed group developed contracted tendons within one to four months of being switched to free-access feed.

Several studies of young horses on pasture demonstrate the effects of undernutrition followed by overnutrition. In one project, six-month-old Danish warmblood colts were fed to gain either 1.75 or 0.97 pounds per day until they were 12 months old. Then, all foals were put in the same pasture to graze. During the first six months of grazing, the colts fed for slow growth rebounded by gaining 304 pounds, and colts fed for fast growth gained an average of only 165 pounds. This divergence in growth rates describes the compensatory growth expected to increase the incidence of DOD. The authors also noted that the horses fed for higher gains were significantly heavier and taller with greater cannon bone circumference, even after compensatory growth. The researchers continued the project for two more years. While all the horses were essentially the same height as three-year-olds, the horses fed for more consistent and steady gains were reported to be more vigorous and aggressive.

In a study at the University of Queensland Veterinary Science School, 15 Australian Stock Horse weanlings were divided into three groups. One group was fed a nutritionally complete pellet diet, a second group was rotationally grazed through three paddocks every three weeks, and the third group grazed the same paddock throughout the 60-week study. The mean body weight gains of the completely hand-fed group, the rotationally grazed group, and the group that remained on the same pasture were 1.12, 0.81 and 0.74 pounds per day, respectively. At the end of the experiment, the horses in the hand-fed group were significantly heavier and had higher body condition scores (system of evaluating the level of fatness of horses) than the horses in the other two groups. The authors indicate height and muscle mass were similar; however, the hand-fed group had more compact (harder or denser) bone between six and 12 months of age. The chemical analysis of the pastures revealed that some had mean crude protein concentrations below those recommended for growing horses, and a high proportion of the pastures were deficient in calcium, copper, and zinc. The pastures with low calcium concentrations also had inverted calcium-to-phosphorus ratios (below 1:1). Diets containing an inverted calcium-to-phosphorus ratio and low zinc and copper concentrations are associated with the development of DOD.

Exercise and Bone Remodeling and Development

While these studies illustrate that there are potential problems with pastures, with careful management the advantages of exercise outweigh the disadvantages. Bone responds to exercise. For example, bone will not grow and remodel when subjected to a certain level of inactivity. C.A. Porr and coworkers in Virginia placed 12 conditioned Arabians in stalls for 12 weeks. During the study, they were placed on a mechanical walker for two 30-minute exercise sessions per day and then returned to their stalls. Bone mineral content decreased 0.45% per week over the 12-week study. The authors stated that confinement may weaken bones, increasing the risk of skeletal injuries when training or free exercise is resumed. At the opposite end of the spectrum, researchers at Texas A&M and Michigan State University have repeatedly shown that standard training practices result in a bone remodeling process that, if not monitored, can result in the weakening of bone and the development of bucked shins over a period of 60 days in long yearlings and two-year-olds. Anecdotal evidence suggests young halter horses fed for rapid growth and overexercised may also develop skeletal injuries.

Controlling Growth by Pasture Supplementation

Concentrate or grain supplementation should be designed to provide nutrients that are not found in adequate amounts in the forage. Several of the key nutrients of concern have already been mentioned. Optimal concentrations of calcium, phosphorus, copper, zinc, manganese, magnesium, vitamin A, vitamin D, protein, and energy ensure proper growth.

Protein plays a vital role in development. Diets low in protein or with low protein-to-energy ratios have resulted in failure to reach potential mature heights and reduction in bone mineral content including smaller cortical area of the cannon bone. Commercial feeds are fortified with enough protein to meet the needs of specific phases of growth. For example, weanlings require higher concentrations of protein than yearlings. Oversupplementation with protein has not been proven to unquestionably cause bone growth problems. However, there is an optimal ratio of protein to energy that appears to enhance proper growth.

The combination of rich pastures and oversupplementation with concentrates may be one of the most common causes of DOD. Numerous studies have shown that when energy levels of 120 to 130% of the NRC recommendations are fed the incidence of DOD is increased.

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