MINERAL REQUIREMENTS OF JUVENILE HORSES IN TRAINING

Gary D. Potter, PhD, PAS, Dipl.ACAN
Professor, Leader Equine Sciences
Department of Animal Science
Texas A&M University
College Station, TX 77845

Presented at the 2005 Nutrition Conference sponsored by Department of Animal Science, UT Extension and University Professional and Personal Development The University of Tennessee.

Introduction

Many young horses in training experience an injury during training, and many of those are injuries to the skeletal system. Those injuries result in lost training days, and too often can lead to catastrophic bone failure and breakdown—frequently in front of the grandstand and large crowds of people. Surveys indicate that up to 80% of young horses in training experience an injury, and 80% of the causes for euthanizing racehorses in one survey was because of skeletal injury. This is a huge problem for the horse industry. Not only does it result in negative perceptions of the horse industry, but it is also very expensive for horse owners costing the U.S. horse industry billions of dollars annually. Some have argued that this problem could be reduced or even eliminated by delaying training and competitions for horses until they are mature. There are at least two reasons to avoid relying on that approach to the problem—1) for economic and political reasons, eliminating age restricted competitions for immature horses is not going to happen, and 2) immature horses have more capability to adapt to the stress and strain placed on the skeletal system than mature horses that have not been trained. Therefore, it behooves everyone to learn how to feed and manage young horses to prepare them for the rigor of competition, and do it in a manner that doesn't injure them. That has been the focus of our research since 1985. This paper is the result of a part of that research.

The Research Approach

Others have been focusing on joint injuries in young horses, and too little research has been directed at understanding bone quality in young horses. Therefore, we chose to study nutritional and management factors that affect bone quality in juvenile, athletic horses. We chose to study the third metacarpal (MCIII) or cannon bone because 1) juvenile horses in training experience injuries to MCIII frequently, and 2) access to MCIII for noninvasive measurements is comparatively straightforward.

Initial experiments were conducted to characterize what happens to MCIII when young horses are put into training. Nielsen et al. (1997) found that MCIII undergoes a period of demineralization and remineralization following the onset of training (Figure 1).

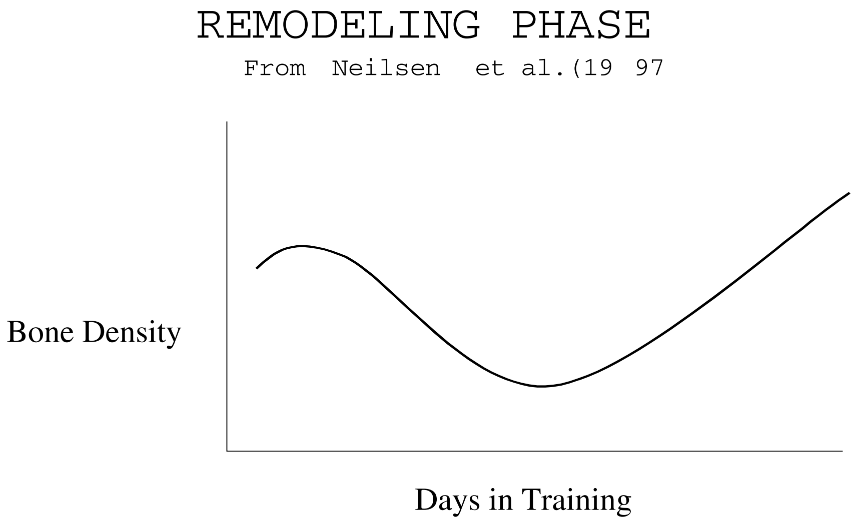
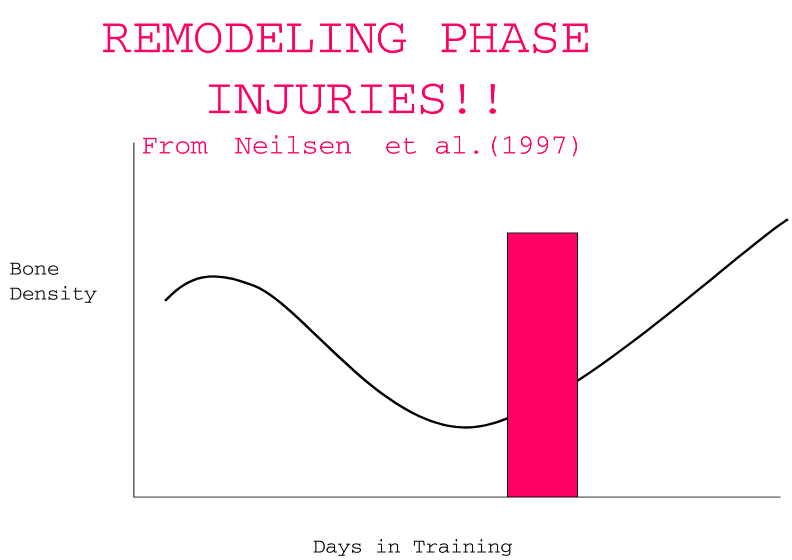


Figure 1. Bone remodeling curve

This process is due to the requirement for young horses to model and remodel MCIII in response to the strain placed on it due to training. The timing of the demineralization of MCIII is problematic because the time at which the bone is the most demineralized and thus, the weakest, was about 60 days following the onset of training. That corresponds to the time that young horses in training may be first required to run hard. That is a prescription for bone injury! Bone injuries occurred mostly at 60-70 days after the onset of training, which was the time when the bone was weakest (Figure 2). So, attention the bone density curve and modification of training regimens accordingly offers good promise to reduce the frequency and severity of bone injuries in juvenile athletic horse

The characterization of the bone demineralization/remineralization curve led to suspicion that this process would likely affect the mineral needs of young horses in training. As seen in Figure 3, the regulation of calcium balance in these horses is affected
by whether calcium is being deposited into bone or being removed from bone.



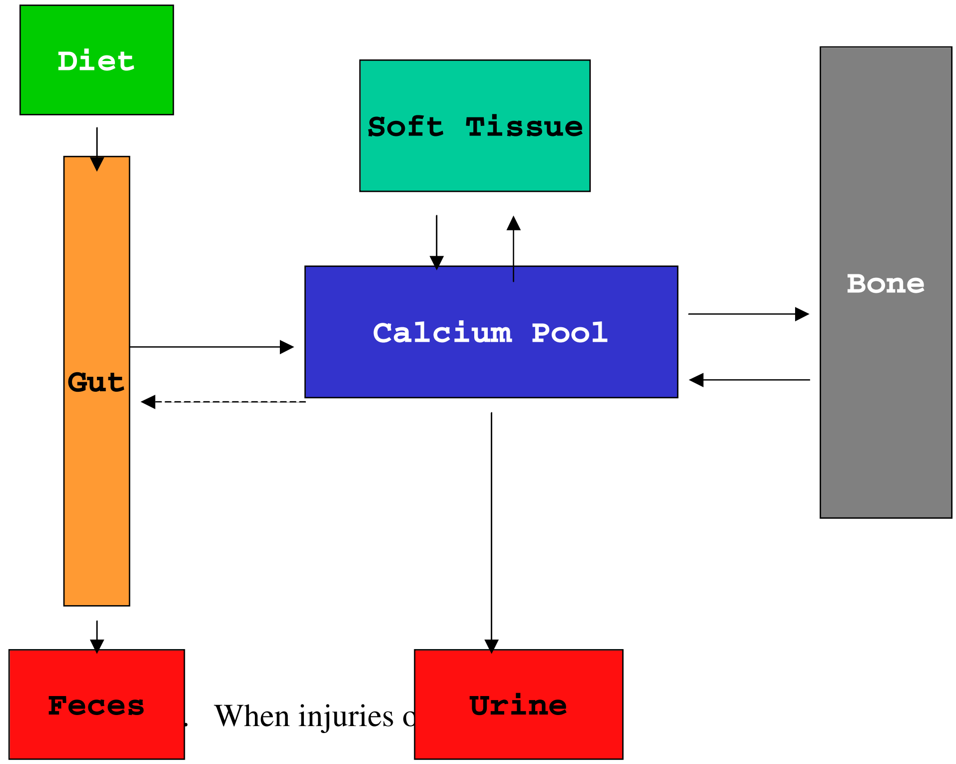


Figure 3. The mechanism of calcium regulation

When calcium is being removed from bone, some of it can be lost in the urine, which would affect the dietary requirement for calcium to keep the horse in calcium balance and promote new bone formation.

Experiments were conducted to determine the effects of training on mineral balances and bone quality. As seen in Figure 4, 5 and 6, Stephens et al. (2004) found that training affected the absorption, urinary excretion and retention of calcium. Following 64 days of training, which corresponds to the period when bone is being demineralized, calcium absorption was reduced and urinary excretion of calcium was increased. That resulted in reduced retention of calcium. Then, after 128 days of training when new bone was being formed, calcium absorption was increased, urinary calcium loss was reduced and calcium retention was increased. Clearly, calcium balance was affected by training, and that finding precipitated questions on how training might influence the dietary requirement for calcium and other minerals.

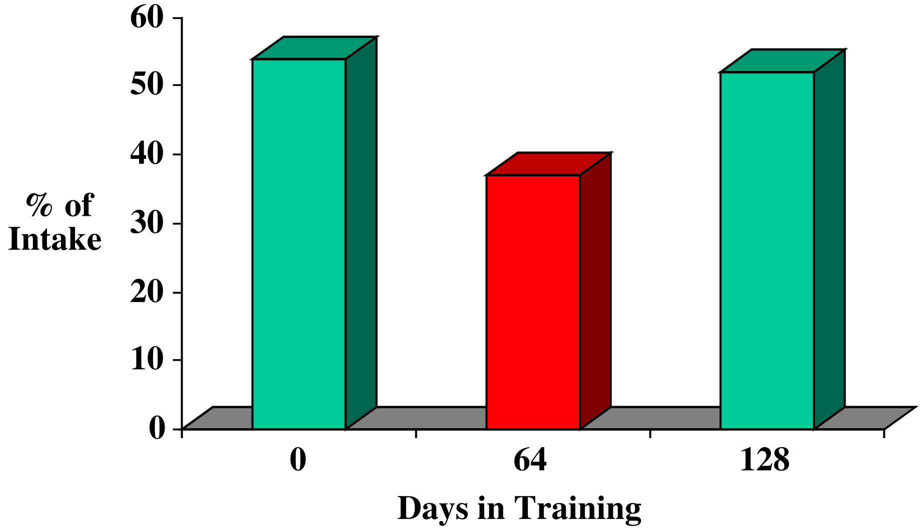


Figure 4. Calcium absorption during training
(From Stephens et al., 2004)

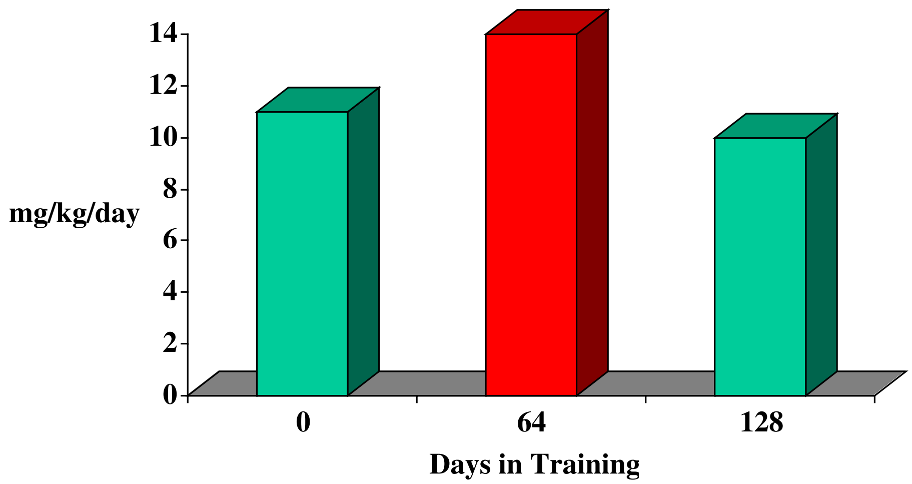


Figure 5. Calcium lost in the urine during training
(From Stephens et al., 2004

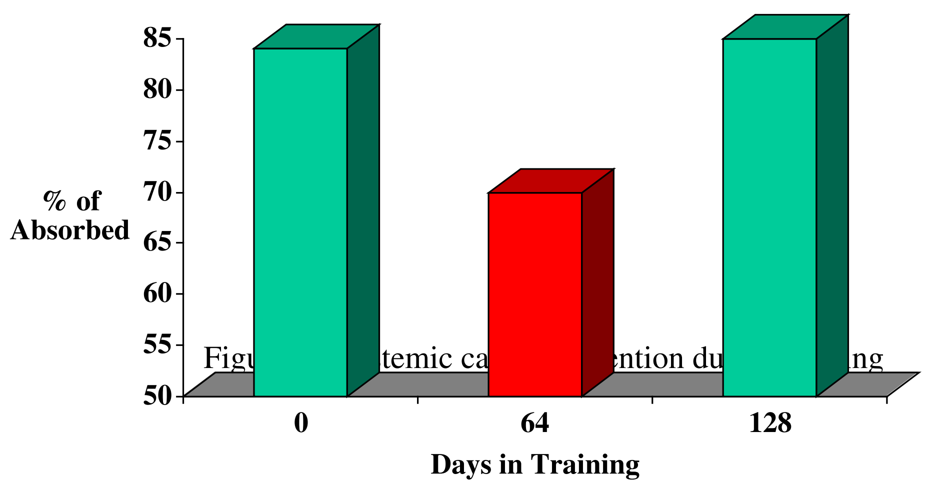


Figure 6. Systemic calcium retention during training
(From Stephens et al., 2004)

Stephens et al. (2004) conducted subsequent experiments to determine the requirements for calcium, phosphorus and magnesium during a period of bone demineralization and a following period of new bone formation (Figures 7-11). Young horses in training were fed varying amounts of calcium, and calcium balance was determined. Calcium retention as a function of intake at day 64 is shown in Figure 7. The intake data are presented as a percentage of current NRC (1989) recommendations. At day 64, calcium retention was not maximized even at 175% of the current recommendation. This means that when the horses were in state of bone demineralization with reduced calcium absorption and increased urinary loss of calcium, their dietary calcium requirements were increased dramatically due to the inefficiency of calcium absorption and increased losses in the urine.

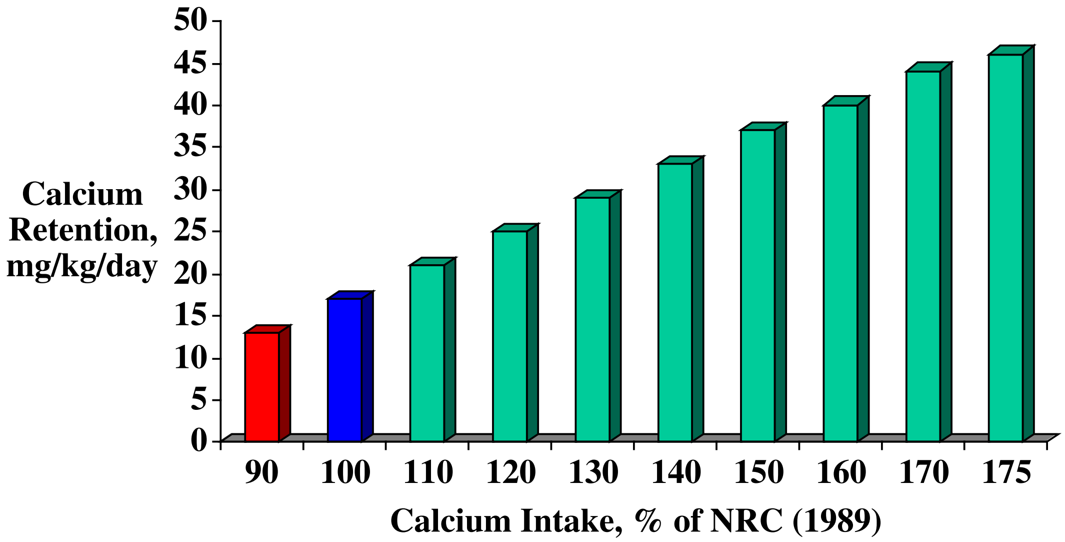


Figure 7. Calcium retention at varying intake after 64 days of training (From Stephens et al., 2004)

At day 128, when the efficiency of calcium absorption was restored and urinary losses of calcium were reduced, calcium retention was maximized at 130% of current recommendations (Figure 8). Even though the horses were more efficient at absorbing and retaining available calcium, the dietary requirement to maximize calcium retention was increased significantly over current recommendations. These data reveal that the process of new bone formation during the remineralization phase of bone modeling/remodeling requires more calcium that previously recommended. Therefore, diets should be formulated to reflect the increased need for calcium to offset calcium losses during bone demineralization and promote new bone growth during the remineralization phase in young horses in training.

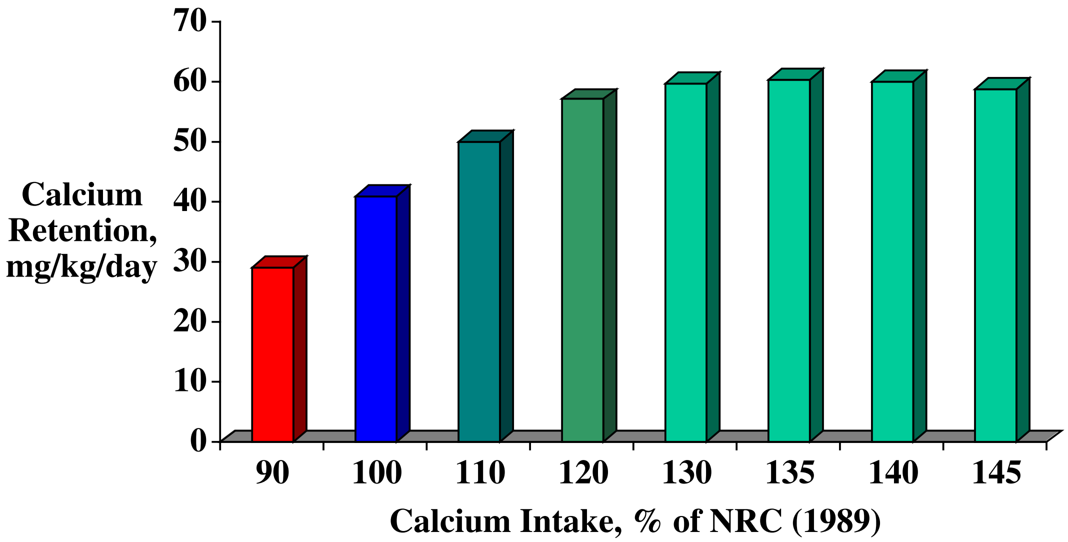


Figure 8. Calcium retention at varying intake after 128 days of training (From Stephens et al., 2004)

Similarly, phosphorus requirements were affected by training. Phosphorus intake in this study did not range as high relative to NRC (1989) recommendations as calcium, and was not sufficient to maximize phosphorus retention. Even so, as seen in Figure 9, phosphorus retention increased with intake at both day 64 and day 128 of training, and was not maximized at 120% of current recommendations. While exact phosphorus requirements cannot be determined from this study, by maintaining workable ratios of calcium-to-phosphorus, it can be reasonably assumed that phosphorus requirements increased similar to calcium requirements due to training.

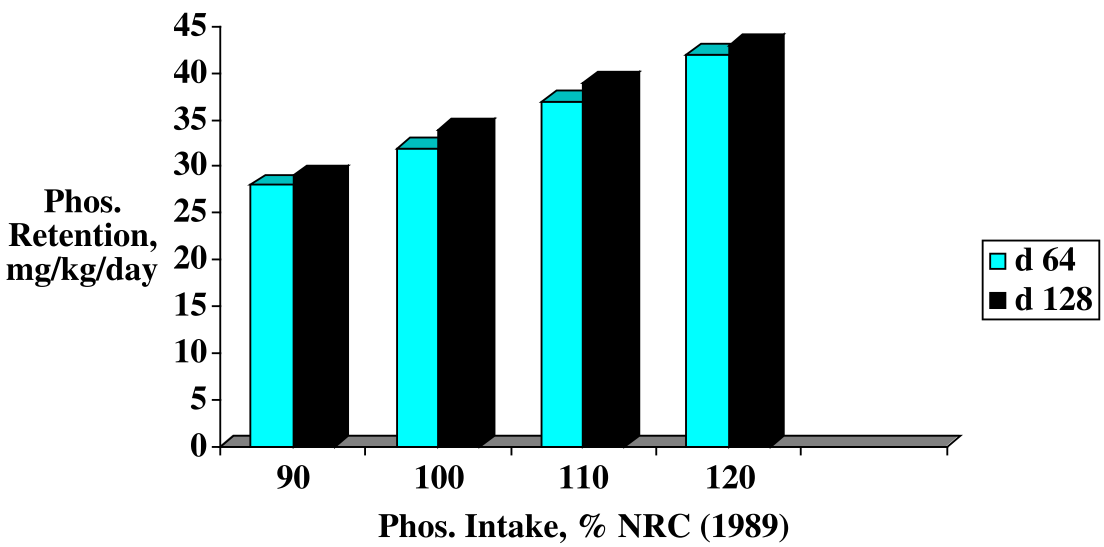


Figure 9. Phosphorus retention at varying intake after 64 and 128 days of training (From Stephens et al., 2004)

Perhaps the most dramatic effect of training was on magnesium requirements. As seen in Figure 10, magnesium retention was maximized, at day 64, at 160% of NRC (1989) recommendations. While the horses were in a state of bone demineralization, demand for magnesium was increased, but not as much as when they were in the remineralization phase. As seen in Figure 11, magnesium retention not maximized during the bone formation phase, even when the horses were fed 200% of the current recommendation for magnesium. Clearly, the requirements for magnesium during bone modeling/remodeling are increased dramatically relative to NRC (1989) recommendations.

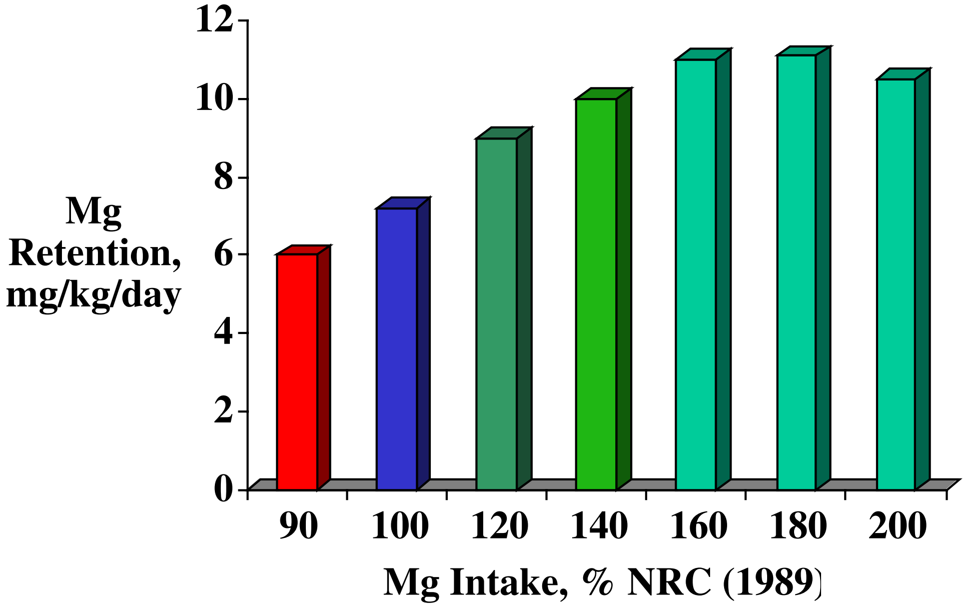


Figure 10. Magnesium retention at varying intake after 64 days of training (From Stephens et al., 2004)

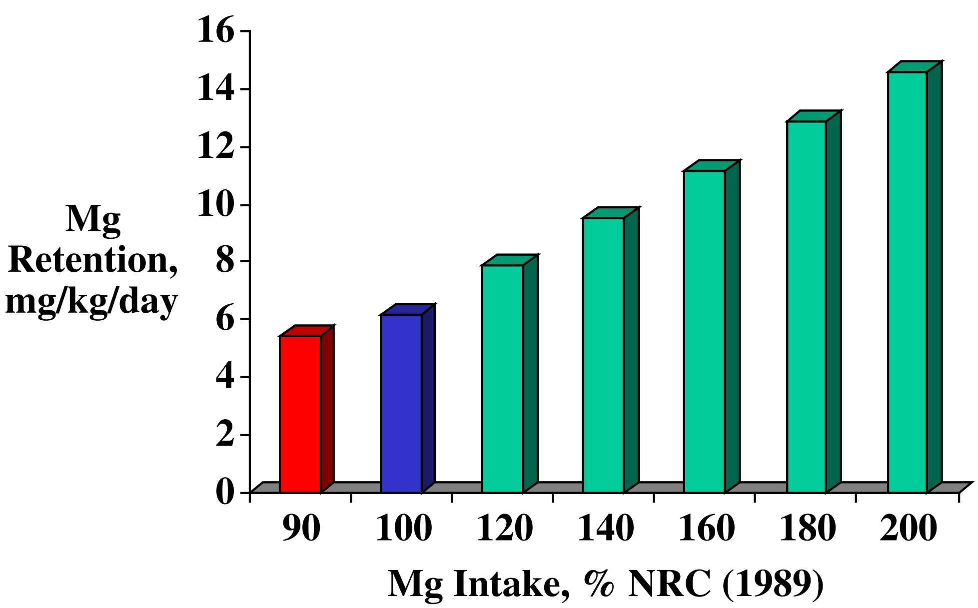


Figure 11. Magnesium retention at varying intake after 128 days of training (From Stephens et al., 2004)

Previously, Nielsen et al. (1996) found that providing supplemental calcium to young horses in training actually increased bone density (Figure 12). That observation combined with the results of Stephens et al. (2004) indicate clearly that the mineral requirements of juvenile horses are affected by the training process that results in bone demineralization and remineralization.

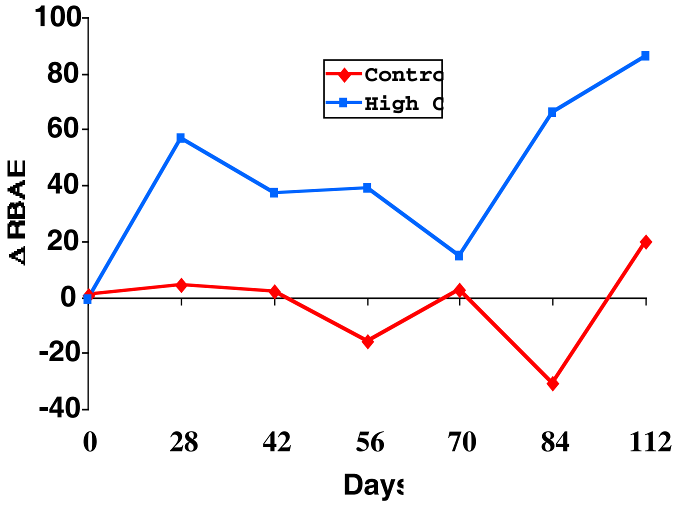


Figure 12. Bone density during training of young horses fed supplemental minerals (From Nielsen et al., 1996)

Implications and Recommendations

To ensure adequate mineral supply for bone modeling/remodeling in the juvenile horse in training, particular attention should be paid to the mineral concentration in diets during the first 6 months of training. Data from these experiments indicate that the daily requirements for calcium, phosphorus and magnesium, during the initial period of bone demineralization are approximately 160, 80, and 35 mg/kg BW. Then during the remineralization phase of bone remodeling, those requirements are approximately 125, 60 and 40 mg/kgBW/day for calcium, phosphorus and magnesium, respectively. These data are transformed in Table 1 assuming body weight of 400 kg (880 lbs) and daily, total feed intake of 10 kg (22 lbs). Please note that the diet concentrations are in the total diet.

Table 1. Approximate Calcium, Phosphorus and Magnesium Requirements of Young Horses In Training—1st 6 months

	Calcium		Phosphorus		Magnesium	
	g/d	% of diet	g/d	% of diet	g/d	% of diet
1st 3 mos	65	0.65	35	0.35	15	0.15
4-6 mos	50	0.50	25	0.25	15	0.15

References

Nielsen, B. D., G. D. Potter, E. L. Morris, T. W. Odom, D. M. Senor, J. A. Reynolds, W. B. Smith and M. T. Martin. 1997. Changes in the third metacarpal bone and frequency of bone injuries in young Quarter Horses during race training -- observations and theoretical considerations. J. Equine Vet. Sci. 17(10): 541-549.

Nielsen, B. D., G. D. Potter, L. W. Greene, E. L. Morris, M. Murray-Gerzik, W. B. Smith and M. T. Martin. 1998. Response of young horses in training to varying concentrations of dietary calcium and phosphorous. J. Equine Vet. Sci. 18(6): 397-404.

Nutrient Requirements of Horses, 4^{th} Ed. National Research Council, National Academy of Sciences. National Academy Press. Washington, D.C.

Potter, G.D., P.G. Gibbs and B.D. Scott. 2003. Feeding race prospects and racehorses in training. Tex. Coop. Ext. Bulletin.

Potter, G.D., P.G. Gibbs and B.D. Scott. 2003. Feeding the arena performance horse. Tex. Coop. Ext. Bulletin.

Stephens, T.L., G.D. Potter, P.G. Gibbs and D.M. Hood. 2004. Mineral balance in juvenile horses in race training. J. Equine Vet. Sci. 24(10): 438-450.