Effects of Exercise on Bone Density, Growth Parameters and Biochemical Markers of Bone Metabolism in Yearling Quarter Horses

J.C. Henry, S.R Cooper, D.W. Freeman, and J.R. Kropp

Story in Brief

Sixteen yearling Quarter Horses were used in a split plot designed experiment to determine the effect of exercise on bone metabolism. Horses were blocked by age and weight, and then randomly assigned to either the exercised (EX) or non-exercised (NEX) treatment. Diets were formulated to meet or exceed NRC requirements for yearlings in moderate growth. Diets consisted of a pelleted concentrate, prairie grass hay, and alfalfa cubes fed in a 50:30:20 ratio at 2.5% of body weight. The 90-d trial consisted of three 72-h collection periods on d 0 (period I), d 45 (period II), and d 90 (period III) during which total fecal collections were performed. Radiographs of the third metacarpal were also taken at this time. Body weight and skeletal parameters were measured every 7-d and blood was taken every 14-d for determination of serum ICTP and PICP concentrations. Although no differences between treatments were found in RBAE within periods, changes in RBAE across periods demonstrated a tendency for decreased bone density in both the EX and NEX horses between periods II and III. Furthermore, the significant decrease in bone density observed in the NEX horses throughout the duration of the trial would indicate that stalling and lack of exercise may result in a greater loss of BMC as compared to the forced exercise horses. Consequently, EX horses may be better prepared for the future mechanical stress placed upon them.

Key Words: Bone Density, Exercise, Yearling Horses

Introduction

The development of an adequate skeletal support system is among the most important requirement of a potential racing, working, or competition horse. Subsequent entry into training and competition exposes the bones of the lower limb to severe mechanical stress (Glade et al., 1986). The practice of moving young, growing horses from pasture to box stalls prior to yearling sales or training may indeed predispose them to skeletal complications. Research has observed a decrease in bone mineral content (BMC) of the third metacarpal in young horses soon after the onset of race training and when moved from pasture to stalls (Nielsen et al., 1997, Hoekstra et al., 1999). Transferring young horses from pasture to stalls results in a slowdown in the rate of bone formation due to a decrease in physical activity (Maenpaa et al., 1988). It has been shown that housing in stalls and reducing exercise has a negative impact upon BMC, however, a proper exercise regimen has not been determined to prevent loss of BMC while housed in stalls. Thus, yearling horses housed in stalls with limited free exercise may have a skeletal structure less prepared for forces applied upon them during training than those horses forced to exercise on a daily basis. Therefore, the objective of this study was to determine the effect of different exercise regimens on bone metabolism and growth.

Materials and Methods

Sixteen Quarter Horse yearlings were utilized in a 90-d experiment to evaluate the effects of different exercise regimens on bone density, parameters of growth and serum markers of bone metabolism. Horses had a mean age of 14 mo with a range of 13 to 15 mo. Horses were paired by age and weight and randomly allotted to either the exercised (EX) or non-exercised (NEX) treatment. Both groups were housed in 3.6 X 3.6m box stalls throughout the experimental period. Horses were fed at 2.5% of body weight (BW) per day, which was divided into two equal feedings (7am and 7pm). Each pair's daily feed intake was adjusted according to the highest body weight. The diet consisted of 50% concentrate, 30% prairie grass hay, and 20% alfalfa cubes. Prior to starting the trial, horses were allowed a 45-d acclimation period on native pasture and received the concentrate portion of the experimental diet along with free-choice prairie grass hay.

During the 45-d acclimation period, all horses were introduced to the 18m diameter round pens and taught to longe. During this stage, horses were asked to walk, trot, and canter in both directions for approximately 10-15 min depending upon the progress of the horse. Following the acclimation period, horses were paired by weight and age and then randomly allotted to either the EX or NEX treatment (8 horses per treatment).

During the first 45 days of the trial, horses in the EX group were longed in round pens for 15 min prior to the morning feeding, six days per week. Horses were exercised at the trot and canter in both directions for an equal amount of time. The NEX group was turned out into 30.5 X 30.5m dry lots after the morning feeding for 3 hr/d, six days per week. During the second 45 days of the trial, horses in the EX group were increased from 15 min of longeing to 20 min/d as horses became increasingly fit. Horses continued to be exercised at the trot and canter in both directions for an equal amount of time.

A radiographic photometric technique for estimating bone mineral content (BMC) of the third metacarpal (MCIII) was utilized in this study (Meakim et al., 1981). Dorsal-palmar and lateral-medial radiographs of each horse's left front leg were taken to determine radiographic bone aluminum equivalence (RBAE) of the lateral, medial, dorsal, and palmar cortices of MCIII. Venous blood samples were taken every 14-d to determine serum ICTP and PICP concentrations. Concentrations of PICP in the blood should increase during bone formation while concentrations of ICTP should detect changes in bone resorption (Hiney et al., 2000). Three 72-h fecal collections were taken on d 0, 45 and 90 of the trial. Body weight (BW), wither, shoulder, hip, hock and knee height and heartgirth circumference were recorded for each horse every 7-d. Data were analyzed as multiple comparisons using the mixed model procedure of SAS (SAS Inst. Inc., Cary, NC) with horse, treatment and period as main effects. Differences between treatments were detected using least significant differences. Significance was declared at $P<.05$.

Table 1. Composition of diet, as fed basis

Ingredient (%)	
Cracked Corn	14.15
Wheat Midds	14.15
Alfalfa Meal	12.50
Soybean Meal	8.45
Limestone	0.12
Trace Mineral Salt	0.25

Dicalcium Phosphate	0.38
Prairie Grass Hay	30.00
Alfalfa Cubes	20.00
Nutrient	
DE, Mcal/ kg	2.60
CP, %	16.40
Ca, %	0.84
P, %	0.32

Results & Discussion

Changes in growth parameters of yearling horses in response to exercise are reported in table 2. During the trial, there were no significant differences in average daily gain (ADG). However, horses in the EX group gained significantly less body weight compared to NEX horses. This may be explained by the fact that the NEX horses were simply becoming fatter due to the lack of exercise at an equal energy intake.

Table 2. Changes in growth parameters in response to exercise[a]

Body Weight (kg)	Exercised	Non-exercised	SEM[d]
Initial	352.39	348.46	12.36
Final	410.23	426.99	11.92
Change	57.84[b]	78.52[c]	7.10
Average Daily Gain (kg)	0.73	0.86	0.09

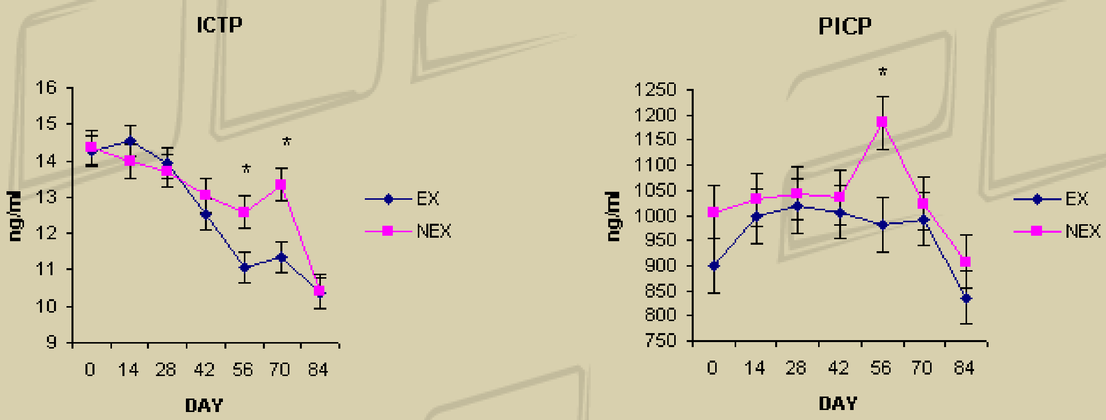
[a]Values are least squares means

[bc]Means within a row with different superscripts differ (P<.05)

[d]Values are average standard errors

Data for changes in serum PICP and ICTP in response to exercise are shown in figure 1. Concentrations of ICTP for the NEX horses were higher (P<.05) on d 56 and d 70 as compared to the EX group. The higher ICTP concentration in the NEX horses would indicate a higher rate of bone resorption and a decreased BMC. Furthermore, a corresponding increase (P<.05) in PICP concentration was observed for the NEX horses on d 56. This increase may be in response to an increased bone resorption as indicated by the levels of ICTP. Previous work has indicated that stalling horses may be associated with a loss of BMC in comparison with horses maintained on pasture (Hoekstra et al., 1999; Bell et al., 1999).

Figure 1. Changes in ICTP and PICP in response to exercise



*Means within a day differ (P<.05) between treatments

Data for changes in RBAE in response to exercise are shown in table 3. Within periods I, II, and III there were no significant differences in the lateral, medial, dorsal, and palmar cortices. These data do not agree with previous research, which has demonstrated an increase in RBAE following 90 d of exercise (Nielsen et al., 1997). The lack of difference in the current study may be due to the lower intensity and duration of exercise as compared to horses in the previous trial which were galloped and sprinted up to 1555 m/d and 229 m/d, respectively.

Table 3. Changes in radiographic bone aluminum equivalence (RBAE mm^2 Al) in response to exercise[a]

Period I	Exercised	Non-exercised	SEM[b]
Lateral	23.01	21.97	0.88
Medial	22.22	20.21	0.93
Dorsal	20.80	21.15	1.03
Palmar	20.13	20.49	1.09
Period II			
Lateral	24.34	23.46	0.88
Medial	22.35	21.27	0.93
Dorsal	22.15	20.00	1.03
Palmar	21.61	19.24	1.09
Period III			
Lateral	23.18	21.09	0.88
Medial	20.99	20.08	0.93
Dorsal	19.66	17.53	1.03
Palmar	18.89	16.82	1.09

[a]Values are least squares means

[b]Values are average standard errors

Data for changes in RBAE across periods are shown in table 4. The RBAE's for the lateral and medial cortices of both groups remained unchanged (P>.05) across periods I (d 0), II (d 45), and III (d 90). A numerical increase (P>.05) in RBAE for the dorsal and palmar cortices was observed in the EX group between periods I and II, while RBAE tended (P<.10) to decrease between periods II and III. Horses in the NEX group experienced a significant decrease in RBAE between periods I and III. Additionally, a similar decrease (P<.10) in RBAE was found between periods II and III as that observed in the EX group. Bone mineral content has been shown to decrease significantly following approximately 60 d of training (Nielsen et al., 1997; Nielsen et al., 1998). Also, significant decreases in BMC have been observed in horses following 28-56 d of stalling when compared to pasture reared horses (Hoekstra et al., 1999).

Table 4. Changes in RBAE across periods in response to exercise[a]

Lateral	Period I	Period II	Period III	SEM[f]
Exercised	23.01	24.34	23.18	0.87
Non-exercised	21.97	23.46	21.09	0.87
Medial				
Exercised	22.22	22.35	20.99	0.93
Non-exercised	20.21	21.27	20.08	0.93
Dorsal				
Exercised	20.80[de]	22.15[d]	19.66[e]	1.03
Non-exercised	21.15[b]	20.00[bcd]	17.53[ce]	1.03
Palmar				
Exercised	20.13[de]	21.61[d]	18.89[e]	1.09
Non-exercised	20.49[b]	19.24[bcd]	16.82[ce]	1.09

[a]Values are least squares means

[bc]Means within a row without a common superscript differ (P<.05)

[de]Means within a row without a common superscript differ (P<.10)

[f]Values are average standard errors

Conclusion

Although no differences between treatments were found in RBAE within periods, changes in RBAE across periods demonstrated a tendency for decreased bone density in both the EX and NEX horses between periods II and III. This decrease may indicate that stalling horses for 90 d results in a decrease in BMC, which could predispose horses to subsequent injury. Furthermore, the significant decrease in bone density observed in the NEX horses throughout the duration of the trial would indicate that stalling and lack of exercise may result in a greater loss of BMC as compared to the forced exercise horses. Consequently, EX horses may be better prepared for the future mechanical stress placed upon them.

Literature Cited

Glade, M.J. et al. 1986. J. Anim. Sci. 63:1432-1444.

Hiney, K.M. et al. 2000. J. Equine Vet. Sci. 20(12):851-857.

Hoekstra, K.E. et al. 1999. Equine Vet. J. Supp. 30. 601-604

Maenpaa, P.H. et al. 1988. Am. J. Vet. Res. 9(11)1990-1992.

Meakim, D.W. et al. 1981. J. Anim. Sci. 53(4):1019-1026.

Nielsen, B.D. et al. 1997. J. Equine Vet. Sci. 17(10):541-549.

Nielsen, B.D. et al. 1998. J. Equine Vet. Sci. 18(3):190-200.

Nunamaker, D.M. 1986. Proc. 32nd Am. Assoc. Equine Pract. 457-460.
