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NUTRITION OF THE YOUNG EQUINE ATHLETE

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Introduction

Many horses begin their athletic careers long before they have reached maturity. Thoroughbreds enter race training as young as 18 months of age and may race before they have reached two years of age. Feeding this type of young horse is challenging because nutrients must be supplied for both growth and exercise. Additionally, little research has been done to quantify the nutrient requirements of horses this age, particularly during the transition period from untrained yearling to intensely exercised two-year-old.

The energy, protein, and lysine requirements of long yearlings, two-year-olds, and adult racehorses are listed in Table 1. The requirements for two-year-olds are derived largely from combining information about requirements for growth and performance, as few studies have been conducted with two-year-olds to quantify their requirements. Below is a brief explanation of how each requirement was calculated.

Table 1. Digestible energy (DE), crude protein (CP), and lysine requirements of long yearlings, two-year-olds, and adult racehorses.

	Long yearling	*Two-year-old*				*Adult racehorse*
Training	No	No	Light	Moderate	Heavy	Heavy
Age (months)	18	24	24	24	24	Mature
BW (kg)	425	485	485	485	485	500
ADG (kg/d)	0.40	0.25	0.25	0.25	0.25	0
DE (Mcal/d)	20.6	21	24.9	28.9	36.9	32.8
CP (g/d)	925	890	980	1070	1160	906
Lysine (g/d)	39	36	39	47	61	32

DIGESTIBLE ENERGY

The energy requirements of horses are generally expressed in terms of digestible energy (DE) as either Mcal/day or MJ/day. For growing horses, the DE requirement is the sum of the maintenance energy requirement (DE Mcal/d) = 1.4 x (.03 x BW) plus a

DE requirement for growth, where the efficiency of utilization of DE for growth equals 18.4 Mcal/kg gain in yearlings and 19.6 Mcal/kg gain in two-year-olds. Therefore, a long yearling that weighs 425 kg with an average daily gain of 0.4 kg/d would have a DE requirement of 14.1 Mcal (maintenance) + 7.4 Mcal (growth) = 21.5 Mcal DE/day. The two-year-old that weighs 485 kg and has an ADG of 0.25 kg/d would have a higher maintenance requirement because it is heavier (16 Mcal/d) but would have a smaller requirement for growth since its average daily gain (ADG) is slower (4.9 Mcal/d). Its daily DE requirement with no exercise would equal 21 Mcal/d.

The DE requirement for exercise is defined as a multiple of maintenance. Light, moderate, and heavy work are assumed to increase a horse's DE requirement to levels equal to 1.25, 1.50, and 2.0 times maintenance, respectively. For a two-year- old, this would equal 20, 24, and 32 Mcal/d. Adding the DE for growth (4.9 Mcal/d) to the requirement for maintenance and exercise yields requirements of 24.9, 28.9, and 36.9 Mcal DE/day for two-year-olds in light, moderate, and heavy work, respectively.

CRUDE PROTEIN

The crude protein (CP) requirements for growth and maintenance are based on a CP:DE ratio. The maintenance CP requirement equals 40 g CP/Mcal DE. The CP requirement for yearlings equals 45 g CP/Mcal DE, and the CP requirement for two-year-olds equals 42.5 g CP/Mcal DE. The NRC (1989) suggests that the maintenance CP:DE ratio is appropriate for exercise as well, but I believe that this overestimates the CP requirement at higher work intensities. Instead, I recommend that CP intakes increase to 110%, 120%, and 130% at light, moderate, and high work intensities in both two-year-olds and adult performance horses.

LYSINE

The first limiting amino acid for growth in horses is lysine. The lysine requirement of long yearlings is equal to (1.9)(Mcal DE/day). For idle two-year-olds, the requirement equals (1.7)(Mcal DE/day), and for mature horses, the requirement equals 3.5% of daily CP intake. Lysine requirements for exercise increase at a similar rate as CP requirements.

Skeletal Adaptations with the Onset of Training

As yearlings leave a breeding farm environment and enter training, major changes occur in their skeletons. Much of this change is due to alterations in housing and exercise, but nutrition may also play a role. A Texas A&M 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 study, 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. A follow-up study suggested that the NRC calcium recommendation was too low for young horses entering intense training (Nielsen et al., 1998b).

Kentucky Equine Research tracked bone density and morphology in a group of 15 Thoroughbred yearlings as they entered race training. Dorsopalmar radiographs of the third metacarpal bone (McIII) were taken on a monthly basis. An aluminum step wedge exposed simultaneously with the McIII was used as a reference standard. The radiographs were scanned into an image software program and a calibration curve was developed using the 11-step aluminum step wedge exposed with each film. Radiographic bone aluminum equivalencies (RBAE) were recorded at three sites: lateral and medial sites with peak densities and a central site of least density in the medullary cavity. Total RBAE was also calculated as the RBAE area under the curve for the entire bone cross section. The bone mineral content in grams per 2-cm cross section of bone was estimated using regression equations derived by Ott et al. (1987). Bone morphological measurements (bone width, medullary width, lateral, medial, dorsal, and palmar cortical width) were also measured from radiographs. Additionally, plasma concentrations of calcium, phosphorus, and calcitonin were measured monthly.

The yearlings entered training (day 0) in late November on a central Kentucky farm where regular turnout paddocks were available. The horses were confined in stalls for approximately 6 hours per day. The training intensity at this time was low, consisting of 15-20 minutes per day jogging in a paddock.

In late December (day 28) the horses were moved to a training center in central Kentucky where little or no turnout was available. For the remainder of the study the horses were confined in stalls for approximately 23 hours per day. In January and February (day 28-84), the horses (now 2-year-olds) were lightly exercised, mostly in an indoor arena since weather conditions prohibited training on the outside track. In March (day 84-112), weather conditions improved and training intensity increased. From this time period onwards, horses were kept at an intense level of training.

Bone mineral content (BMC) dropped from day 28 until day 84 when the horses were confined to stalls with only light exercise (Table 2 and Figure 1). By day 84, BMC was significantly lower than day 0. When training intensity increased in the spring, BMC increased to levels that were not different from pre-training.

Osteocalcin is a protein produced by the osteoblasts in bone and is an accepted marker of bone formation (McIlwraith, 2005). Plasma osteocalcin levels dropped slightly from day 0-84 when the horses were confined and in light training (Table 3 and Figure 2). Levels increased from day 84-112 when the horses began intense exercise, suggesting an increase in bone formation.

Table 2. Cannon bone density and morphology during early training.

Day	*BMC (g/2-cm)*	*Bone Width (mm)*	*Medullary Width (mm)*	*Medial Cortical Width (mm)*	*Lateral Cortical Width (mm)*
0	20.6 ± 0.7	40.5 ± 1.2	20.9 ± 1.8	11.0 ± 1.0	8.6 ± 0.7
28	21.0 ± 0.2	38.6 ± 0.7	18.2 ± 0.5*	11.2 ± 0.5	9.1 ± 0.4
56	20.5 ± 0.4	37.4 ± 0.7*	18.4 ± 0.5*	9.7 ± 0.4	9.3 ± 0.3
84	19.3 ± 0.3*	37.3 ± 0.8*	17.9 ± 0.5*	11.0 ± 0.7	8.4 ± 0.5
112	19.7 ± 0.3	37.1 ± 0.7*	18.0 ± 0.6*	10.7 ± 0.6	8.4 ± 0.3
140	21.1 ± 0.4	39.3 ± 0.8	18.1 ± 0.5*	12.0 ± 0.7	9.2 ± 0.5
168	21.5 ± 0.8	37.0 ± 1.3*	17.4 ± 0.5*	11.4 ± 0.8	8.2 ± 0.4
196	19.8 ± 0.2	38.6 ± 0.8	18.9 ± 0.4	10.7 ± 0.4	9.0 ± 0.5

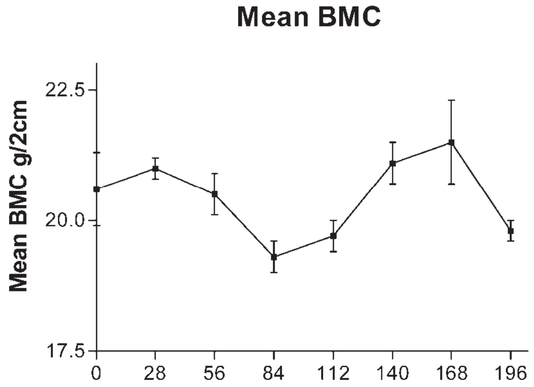

Figure 1. Bone mineral content (BMC) of the third metacarpal bone of young horses entering training.

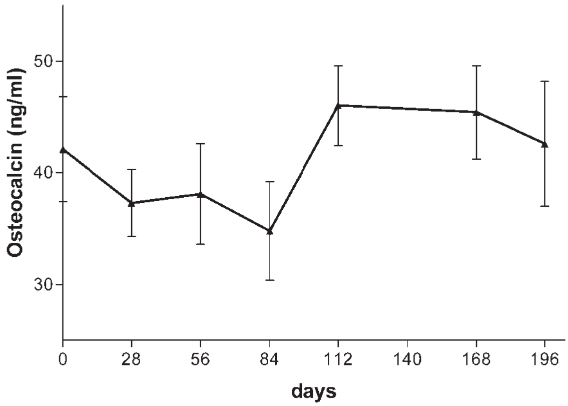

Figure 2. Plasma osteocalcin (ng/ml) in young horses entering training.

Plasma calcium also dropped significantly from day 28 to 84 (Table 3 and Figure 3). There was a large increase in plasma calcium levels when training intensity increased. Plasma phosphorus followed a similar pattern of change with exercise (Table 3 and Figure 4). These data illustrate how confinement and changes in exercise intensity can affect bone mineralization. These horses were consuming a commercial fortified feed and grass throughout the study. It is not known if additional nutrient supplementation could alter the pattern of skeletal changes that occurred. More research is needed in this area.

Table 3. Plasma osteocalcin, calcium and phosphorus during early training.

Day	*Osteocalcin (ng/ml)*	*Calcium (mg/dl)*	*Phosphorus (mg/dl)*
0	42.1 ± 4.7	12.7 ± 0.1	5.5 ± 0.1
28	37.3 ± 3.0	12.9 ± 0.1	5.3 ± 0.2
56	38.1 ± 4.5	12.3 ± 0.1*	4.6 ± 0.1*
84	34.8 ± 4.4	12.2 ± 0.1*	3.8 ± 0.1*
112	46.0 ± 3.6	13.6 ± 0.2*	5.1 ± 0.2
168	45.4 ± 4.2	12.9 ± 0.2	4.9 ± 0.3*
196	42.6 ± 5.6	12.5 ± 0.1	4.6 ± 0.2*

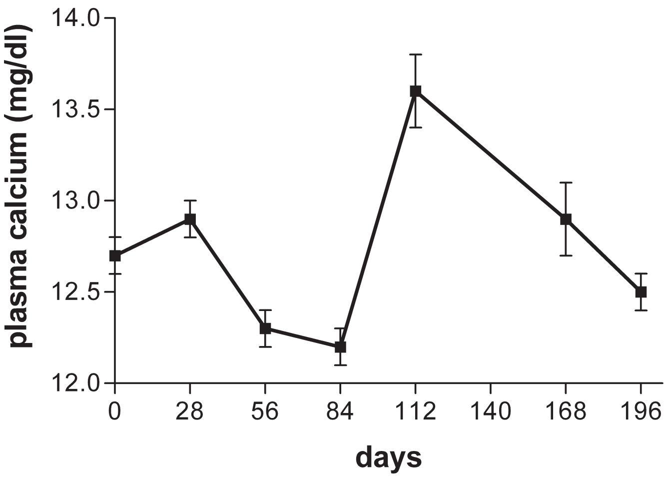

Figure 3. Plasma calcium (mg/dl) in young horses entering training.

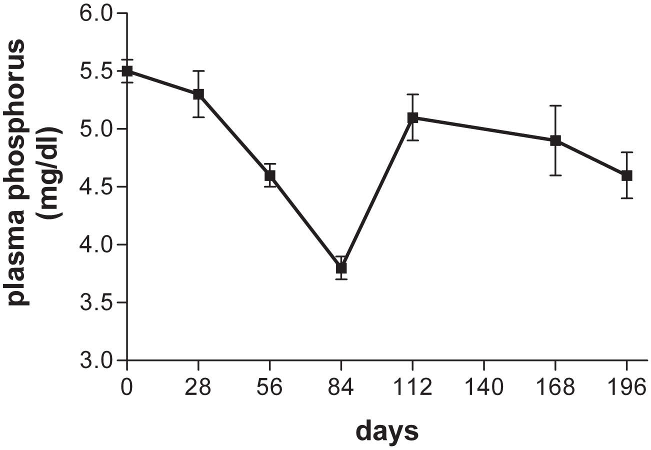

Figure 4. Plasma phosphorus (mg/dl) in young horses entering training.

BUCKED SHINS

Bucked shins and dorsal metacarpal disease are terms used to describe a condition of the third metacarpal bone which is related to bone fatigue and/or stress fractures. Bucked shins is a very common condition in young racehorses, normally occuring during the first year of training. The initial signs of the problem are heat and swelling over the dorsal aspect of the cannon bone. If work continues, horses can become extremely lame, resulting in long periods of inactivity (Nunamaker et al., 1990). A survey of veterinarians and trainers estimated that 80% of two-year-olds in Australia (Buckingham and Jeffcott, 1990) and 70% in the United States (Norwood, 1978) were affected by bucked shins. In a survey conducted by the Japanese Racing Association (JRA), a 66% incidence of bucked shin complex was recorded in horses during their first 8 months of training (Japan Racing Association, 1999).

In humans, inadequate calcium intake has been reported to play a significant role in skeletal injuries. In a study examining factors associated with shin soreness in human athletes (Myburgh et al., 1998), only 3 out of 25 athletes that developed shin soreness consumed the recommended dietary allowance of calcium in contrast to 15 of 25 control athletes who met their daily Ca requirement. Furthermore, only 2 of the control athletes consumed under half the recommended daily allowance compared to 10 of the injured athletes. No research has been conducted in horses to investigate the relationship between mineral intake and bucked shins.

Kentucky Equine Research studied the relationship between bucked shins, blood parameters, and cannon bone measurements in 30 two-year-olds as they were prepared for two-year-old in training (breeze-up) sales which took place in late winter or early spring. The horses were all trained by the same individual, but were housed at 3 different training facilities which were within a 2-mile radius of each other in South

Carolina. The study began in late December when the horses were already in moderate to intense training and lasted 56 days. Typically, each horse galloped four days, breezed once, and either lightly jogged or rested two days each week. Dorsopalmar and lateral radiographs of the third metacarpal bone (McIII) were taken on a monthly basis. An aluminum step wedge exposed simultaneously with the McIII was used as a reference standard. Bone density and morphology measurements were made using the same methods described earlier in this paper. Plasma concentrations of calcium, phosphorus, and calcitonin were also measured.

During the study, 5 of the 30 two-years-displayed clinical signs of shin bucking following breezing. These signs included swelling, heat, and soreness of the dorsal aspect of the cannon bone. Table 4 compares bone density and morphological measurements calculated from the dorsopalmar view radiograph in the bucked shin group (bucked) and the horses that did not buck their shins (normal). At the beginning of the study, the two groups' BMC, mean RBAE, total RBAE, and bone width were not significantly different. There was a trend towards greater medial and lateral cortical thickness in the normal group (p<.10). There was a significant increase in all dorsopalmar measurements in the normal horses over the 56-day training period (p<.05). In the bucked group BMC, mean RBAE, total RBAE, and bone width did not change significantly over the 56-day period (p>.05). In this group, lateral and medial cortical thickness increased (p<.05). At 56 days, there was a trend (p<.10) towards greater BMC and mean RBAE in the normal horses and normal horses had significantly greater lateral cortical width, bone width, and total RBAE (p<.05).

Table 4. Bone optical density and morphology of the third metacarpal bone (dorsopalmar view).

		Mean BMC (8/2-cm)	*Mean RBAE (mm AI)*	*Total RBAE (mm AI)*	*Medial Cortical Width (mm)*	*Lateral Cortical Width (mm)*	*Dorsopalmar Bone Width (mm)*
0 days	Bucked n =5	19.0 ± 0.5	23.0 ± 0.6	7870.4 ± 189.5	7.0 ± 0.4	5.3 ± 0.3	29.7 ± 1.2
	Normal n =25	18.5 ± 0.2	22.4 ± 0.2	8020.2 ± 211.0	8.6 ± 0.5	6.1±0.3	31.1 ± 0.8
56 days	Bucked n =5	18.60 ± 0.9	22.6 ± 1.0	8275.8 ± 456.7	9.7 ± 0.3	6.2 ± 0.2	31.8 ± 0.8
	Normal n =25	19.70 ± 0.3	23.7 ± 0.3	9411.5 ± 266.5	10.7 ± 0.4	7.5 ± 0.2	34.7 ± 0.6

There were no differences in the 0-day measurements taken from the lateral view with the exception of palmar cortical thickness which was significantly greater (p<.05) in the normal horses (Table 5). At 56 days, dorsal cortical width, total bone width, and mean and total RBAE had significantly increased (p<.05) in both groups. Palmar cortical width was unchanged in both groups, but remained greater in the normal group of horses (p<.05). There was a trend (p<.10) towards dorsal cortical thickness being greater in the bucked group.

Table 5. Bone optical density and morphology of the third metacarpal bone (lateral view).

		Mean RBAE (mm AI)	*Total RBAE (mm AI)*	*Dorsal Cortical Width (mm)*	*Palmar Cortical Width (mm)*	*Bone Width (mm)*
0 days	Bucked n =5	17.3 ± 0.4	5206.4 ± 193.3	9.1 ± 0.5	5.1 ± 0.4	26.3 ± 0.6
	Normal n =25	17.3 ± 0.2	5361.2 ± 130.9	9.5 ± 0.2	6.5 ± 0.3	27.3 ± 0.5
56 days	Bucked n =5	17.8 ± 0.4	6029.5 ± 209.0	11.8 ± 0.3	5.4 ± 0.3	29.2 ± 0.7
	Normal n =25	17.7 ± 0.2	5833.3 ± 102.6	11.1 ± 0.2	6.2 ± 0.2	29.0 ± 0.3

Plasma calcium, phosphorus and osteocalcin dropped significantly in both groups from 0 to 56 days (p<.05)(Table 6). Calcium and phosphorus were not different between groups at either 0 or 56 days, but osteocalcin was significantly higher in the bucked group during both times (p<.05).

Table 6. Plasma calcium, phosphorus and osteocalcin.

	Sample Time (days)	*0*	*56*
Calcium (mg/dl)	Bucked n = 5	13.7 ± 0.1	13.1 ± 0.2
	Normal n = 25	13.5 ± 0.1	13.2 ± 0.1
Phosphorus (mg/dl)	Bucked n = 5	5.3 ± 0.2	4.5 ± 0.2
	Normal n = 25	5.0 ± 0.1	4.7 ± 0.1
Osteocalcin (ng/ml)	Bucked n = 5	42.1 ± 4.7	33.1 ± 2.4
	Normal n = 25	31.5 ± 1.3	28.0 ± 1.0

These data suggest that two-years-olds that buck shins do not produce as much McIII bone as unaffected horses. In spite of increased osteocalcin, bone width and total bone mineral deposition are reduced. The reason for this difference is not apparent since all the horses in the study were managed similarly.

Feeding Programs for Two-Year-Olds

A real concern for trainers is how differently to feed two-year-olds compared to older horses in the stable. Table 7 contains a typical feeding program for an adult

Thoroughbred in race training along with a feeding program for a two-year-old in moderate work using the same hay and grain mix. Both horses are fed 6 kg of timothy hay and a 12.0% protein grain mix that supplies 3.1 Mcal DE/kg. The adult racehorse would require 6.5 kg of grain to meet its energy requirement, while the two-year-old requires 5.25 kg/day.

Table 7. Feeding programs for adult racehorses and two-year-olds in training.

			Adult racehorse		*Two-year-old*	
	Timothy Hay	*Grain Mix*	*Timothy Hay*	*Grain Mix*	*Timothy Hay*	*Grain Mix*
	Composition		*Daily Intake*		*Daily Intake*	
DM	93.8 %	88.0%	6.0 kg	6.5 kg	6.0 kg	5.25 kg
DE	2.1 Mcal/kg	3.1 Mcal/kg	12.5 Mcal	20.3 Mcal	12.5 Mcal	16.4 Mcal
CP	8.0%	12.0%	480 g	785 g	480 g	634 g
Lysine	0.24%	0.65%	14.4 g	42.2 g	14.4 g	34.1 g
Calcium	0.34%	0.60%	20.4 g	39.0 g	20.4 g	31.7 g
Phosphorus	0.21%	0.52%	12.6 g	33.8 g	12.6 g	27.5 g

Figures 5 and 6 show how well these rations meet the nutrient requirements of the two types of horses. Although the hay and grain are not excessively high in protein or minerals, the adult racehorse's ration supplies more protein, lysine, calcium, and phosphorus than needed because of the high level of intake required to meet the racehorse's energy requirement. A ration using the same hay and grain mix also meets the nutrient requirements of the two-year-old in moderate work. Again, a fairly high level of intake provides adequate nutrients from feedstuffs containing fairly low concentrations of protein and minerals. The bottom line from this comparison is that most rations fed to adult racehorses contain adequate protein, calcium, and phosphorus for two-year-olds. If caloric intake must be restricted in a two-year-old, higher levels of fortification may be needed.

In conclusion, the nutrient requirements of the two-year-old are intermediate between the growing foal and the adult performance horse. If the two-year-old is in training, it can be fed feeds that are typically formulated for adult performance horses because the elevated level of feed intake required to meet the energy required for exercise will provide the extra protein and minerals needed for growth. More research is needed to determine if nutrition can play a role in attenuating the loss in bone density that yearlings experience as they enter training or if nutritional manipulation can affect bone deposition in two-year-olds that are susceptible to bucked shins.

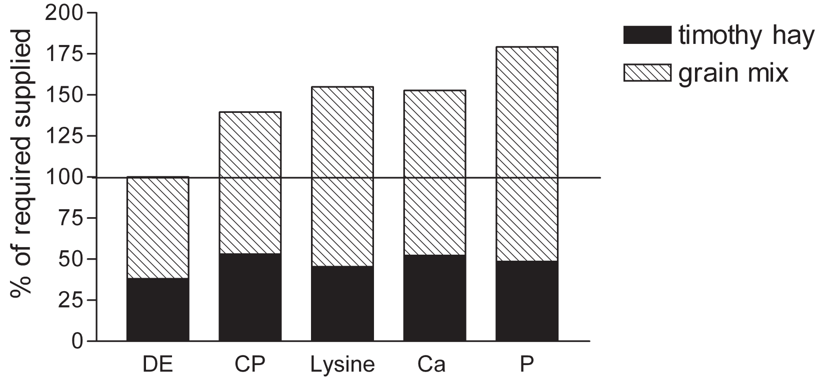

Figure 5. Nutrients supplied from a ration consisting of timothy hay and grain mix for an adult racehorse.

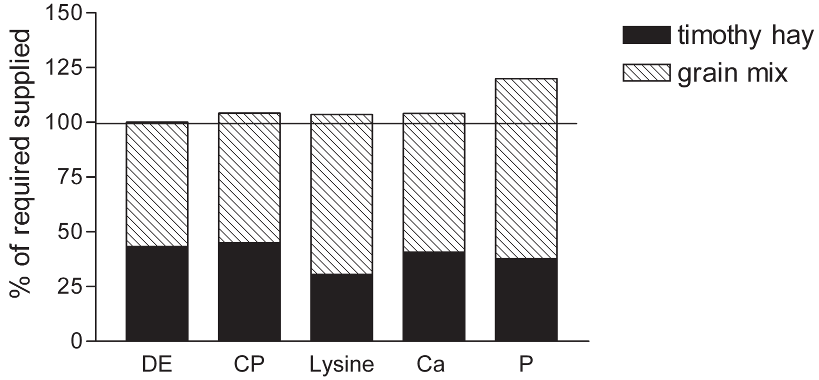

Figure 6. Nutrients supplied from a ration consisting of timothy hay and grain mix for a two-year-old in moderate work.

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