Advances in Equine Nutrition IV

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CONTEXT

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GENERAL NUTRITION

their body weight per day of good-quality roughage or be given access to pasture for sufficient time to consume at least 1% of body weight as dry matter per day. The 1989 NRC discusses different sources of energy for the horse but does not provide recommendations for either safe or optimal levels of each source in the horse's ration. This is an area of prime importance for all classes of horses and should be a major focus of research in the future.

Acceptable Ranges

Only under very artificial experimental conditions will the intake of every nutrient exactly match the recommendation. Some nutrients will exceed recommendations by a large margin, while others might be slightly below. In truth, horses can tolerate and thrive on a range of nutrient intakes. That range, however, can vary tremendously depending on the nutrient and class of horse being fed. For example, potassium intakes are often much higher than required because forages are rich sources of potassium and high forage intakes are desirable for most horses. Energy intakes, on the other hand, must closely match the horse's requirement or the horse will gain or lose weight.

Kronfeld (2001) endorsed setting goals for intakes of energy and nutrients. These goals were not specified as single numbers or requirements, but rather as optimal or target ranges, with upper and lower limits as well as middle values (Figure 1).

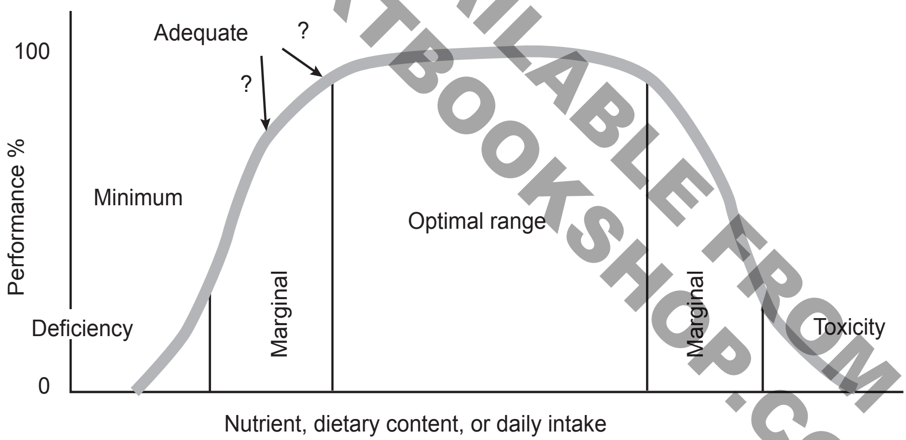
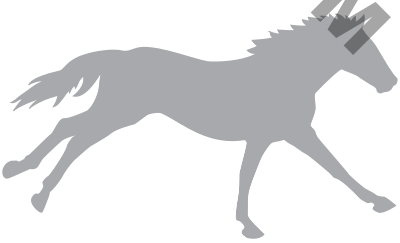


Figure 1. Optimal ranges for nutrient intakes.

KER has adopted this philosophy of assessing nutrient adequacy and has divided levels of nutrient intake into seven ranges as follows:

- *Deficient*: Nutrient intakes in this range will likely result in either the clinical expression of disease or a marked reduction in performance. Additional fortification is absolutely necessary.

NUTRITION AND MANAGEMENT OF THE PERFORMANCE HORSE



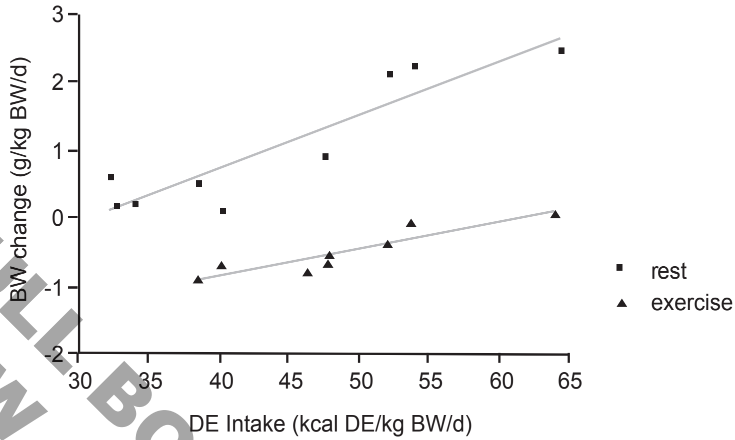


Figure 1. Body weight changes and DE intake.

Table 3 illustrates the quantity of oxygen consumed and NE expended by a horse during one day of treadmill exercise and one day of exercise on the walker. Average daily NE expenditure was calculated by multiplying these values by 3 (the number of days of each type of exercise) and dividing by 7 (number of days in a week). Table 4 contains the average daily NE expended by each horse during each exercise period. The horses expended an average of 7.87 ± .26 kcal NE/kg BW/d above maintenance during exercise. This equals 3.94 Mcal NE/d for a 500-kg horse.

Table 3. Oxygen consumed and NE expended by one horse during one day of treadmill exercise and one day of exercise on the walker.

	Type of exercise	*Speed (m/s)*	*VO_2 ml/kg/ min*	*Extra O_2 consumed ml/kg/min*	*BW*	*Extra O_2 consumed l/min*	*NE Kcals/ min*	*Exercise duration (min)*	*NE expended per exercise period (Kcals)*
Treadmill day	walk (flat)	1.5	16.25	13.25	510	6.76	32.87	5	164.33
	trot (3°)	4.0	45.87	42.87	510	21.86	106.32	5	531.58
	trot (3°)	4.0	40.16	37.16	510	8.95	92.15	5	460.75
	trot (3°)	4.0	44.41	41.41	510	21.12	102.70	5	513.48
	trot (3°)	4.0	46.65	43.65	510	22.26	108.27	5	541.34
	canter (3°)	7.0	71.41	68.41	510	34.89	169.67	6	1018.02
	trot (3°)	4.0	44.39	41.39	510	21.11	102.65	5	513.27
	trot (3°)	4.0	43.62	40.62	510	20.71	100.73	5	503.67
	trot (3°)	4.0	40.16	37.16	510	18.95	92.15	5	460.75
	trot (3°)	4.0	43.73	40.73	510	20.77	101.02	5	505.08
	canter (3°)	7.0	72.79	69.79	510	35.59	173.09	6	1038.57
	walk (flat)	1.5	17.06	14.06	510	7.17	34.87	5	174.34
	walk (walker)	1.5	16.66	13.66	510	6.96	33.87	15	508.00
Walker day	walk	1.5	16.66	13.66	510	6.96	33.87	60	2032.01

NUTRITION AND MANAGEMENT OF THE BROODMARE

to calculate weight at a specific age. Once body weight is estimated, average daily gain can be calculated.

A number of researchers have studied growth characteristics of Thoroughbred horses including Green (1969), Hintz et al. (1979), Jelan et al. (1996), Pagan et al. (1996), and Kavazis and Ott (2003). Fewer or less comprehensive studies are available for other breeds. Therefore, to obtain a continuous growth curve that would apply to all horses, the committee to revise *Nutrient Requirements of Horses* took an approach of expressing growth as a function of mature weight. This is not a new concept and has been described by others including Austbo (2004) and Coenen (2000). To obtain an equation to predict body weight at any age from mature weight, growth data from the following breeds or types of horses were summarized: Thoroughbred, Morgan, Quarter Horse, pony, Arabian, Belgian, Hanoverian, and Swedish Standardbred. Once data for each breed were summarized by age, body weights were expressed as a percentage of mature body weight. Mature body weights were obtained from values given in the reviewed papers or from a search of the literature. The data from all breeds/types were combined, and a single growth curve was developed. The resulting growth curve can be applied to any breed or type of horse, if an estimate of expected mature weight is available. There were insufficient data to generate separate curves for colts, fillies, and geldings. However, different estimates of body weight at any age will be obtained if users estimate different mature weights for stallions, geldings, and mares. There were also insufficient data to generate separate curves for ponies, light horses, and draft horses. Although representatives of each type of horse were included in the data used to generate the final equation, the data set for Belgian horses included only foals/weanlings.

The committee recognizes that there are some limitations to the method developed to predict equine growth in the sixth revised edition of *Nutrient Requirements of Horses*. First, the method that was developed was based on body weight data and did not incorporate any factor for optimal skeletal growth. The committee did not find sufficient data to quantify an optimal growth rate. Therefore, the method that was developed provides information only about the average rate of gain and does not account for growth rates that might be preferred in order to meet specific production goals of an individual horse owner. Second, the equation developed to predict body weight suggests that rate of gain continuously decreases with age, a situation which may not occur in practice. Real-world data sets suggest that average daily gain varies with environment and that the rate of gain of yearlings on high-quality pasture in the spring may exceed the rate of gain of weanlings/yearlings during the prior winter (Pagan et al., 1996; Asai, 2000; Staniar et al., 2004). Therefore the method suggested in the sixth revised edition of *Nutrient Requirements of Horses* probably overestimates average daily gain of weanlings/yearlings in the winter and underestimates their growth rate the following spring. Finally, the method to estimate growth rate in the sixth revised edition of *Nutrient Requirements of Horses* was developed primarily with data from horses with mature body weights of 400 to 600 kg. Therefore it is not known how well this method will apply to miniature horses, small ponies, or draft lighter than all other foals until 4 months of age (Table 2). By 150 days of age, there was no difference in body weight between birth months.

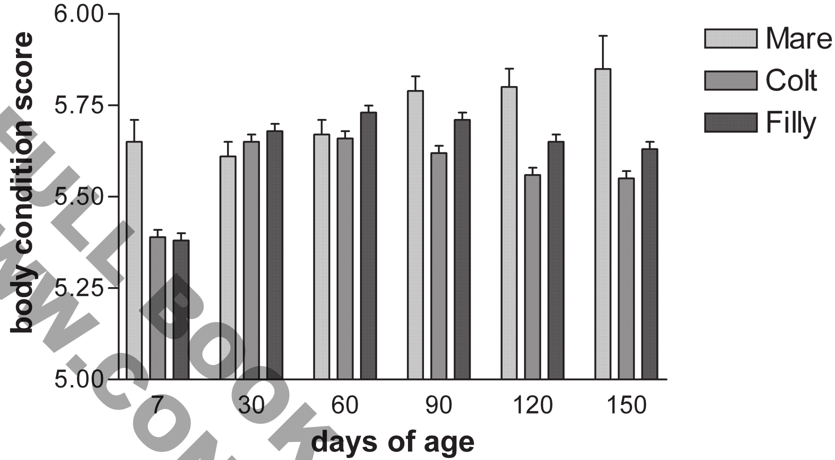


Figure 1. Body condition score ± 95% confidence intervals of Kentucky mares, fillies and colts.

Table 2. Foal body weight (kg) ± 95% confidence interval. Differing superscripts within rows indicate significant differences ($p < 0.05$).

Days	*January*	*February*	*March*	*April*	*May*
1	53.69 ± 3.67^{a}	54.86 ± 1.57^{a}	55.21 ± 1.91^{a}	57.76 ± 2.11^{ab}	60.17 ± 2.60^{b}
7	62.86 ± 1.99^{a}	64.36 ± 0.88^{a}	65.71 ± 0.84^{a}	68.18 ± 1.16^{b}	69.96 ± 1.43^{b}
30	93.50 ± 1.37^{a}	96.27 ± 0.80^{b}	100.80 ± 0.78^{c}	102.74 ± 0.84^{d}	102.11 ± 1.18^{d}
60	128.48 ± 1.75^{a}	133.72 ± 1.05^{b}	138.90 ± 0.96^{c}	138.82 ± 0.99^{c}	137.31 ± 1.62^{c}
90	163.85 ± 2.24^{a}	169.03 ± 1.18^{b}	172.61 ± 1.12^{c}	171.26 ± 1.28^{bc}	170.92 ± 1.70^{bc}
120	195.66 ± 2.53^{a}	199.46 ± 1.31^{ab}	201.98 ± 1.47^{b}	202.24 ± 1.50^{b}	202.55 ± 2.32^{b}
150	226.00 ± 3.07^{a}	228.74 ± 1.83^{a}	230.63 ± 2.24^{a}	230.92 ± 3.31^{a}	227.11 ± 4.18^{a}

January and February foals had lower ADG than March, April, and May foals at 7 days and 1 month of age. January foals had greater ADG than all foals at 3 months of age coinciding with rapid spring pasture growth beginning in April. May foals had the lowest ADG of all foals at 2, 3, and 4 months, which coincides with July, August, and September when late summer pasture is losing its quality, suggesting a seasonal effect on foal ADG (Figure 2).

NUTRITION AND MANAGEMENT OF THE GROWING HORSE

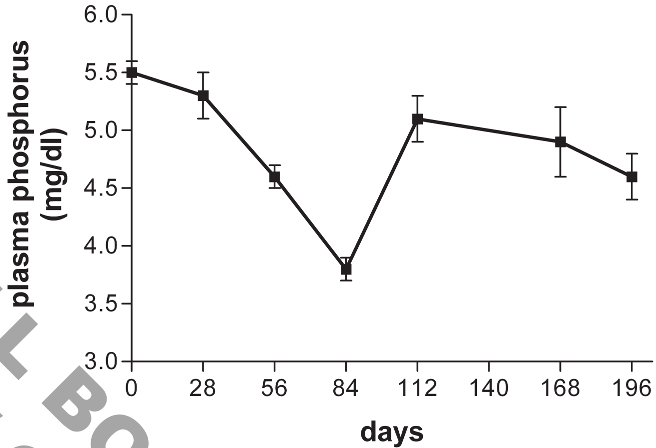


Figure 4. Plasma phosphorus (mg/dl) in young horses entering training.

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

PATHOLOGICAL CONDITIONS

Data from human and animal studies have demonstrated severe trauma increases energy expenditure by a factor of 1.3 to 1.4, and expenditure in animals with sepsis or a major burn can be up to 1.4 to 1.7 times higher when compared to resting healthy humans (Geor, 2000). Pagan and Hintz (1986) reported that the resting energy expenditure (REE) of horses could be estimated from the formula: REE=21 kcal (BW kg)+975 kcal. Thus, for a 500-kg horse, REE would be approximately11.5 Mcal/d, 30% lower than the requirement for maintenance under normal conditions (16.4 Mcal/d for a 500-kg horse). No data are available on energy requirements of sick horses. However, if regression equations for human medicine are applied, a stalled 500-kg horse with an infection or postsurgical condition would have energy requirements of 16 to 20 Mcal/d (1.5 to 1.8 x 11.5 Mcal/d).

Increased protein requirements in sick, debilitated, or injured horses due to protein catabolism should be taken into consideration. Rooney (1998) suggested that 5 g of protein be provided per 100 kcal (i.e., 800 g) of crude protein for a diet containing 16 Mcal digestible energy. This is a 25% increase over the NRC (1989) maintenance protein requirement. There are probably increased requirements for essential vitamins and minerals due to debilitation. However, without knowing specifics, meeting maintenance requirements is a reasonable goal. The main concern is to limit tissue breakdown and weight loss. Realistic goals of providing 60 to 70% of maintenance requirements should help the sick or injured horse.

Recent research in human medicine points to the therapeutic effects of certain nutrients. Arginine, glutamine, omega-3 fatty acids, and ribonucleic acid are reported to upregulate immune function in critically ill humans (Beale et al., 1999). Glutamine is a nonessential amino acid that is important in the growth and repair of the small intestinal mucosa. Glutamine also helps maintain intestinal immune function (Nappert et al., 1997). Routledge et al. (1999) reported plasma glutamine concentrations decrease following viral infection. Further research is needed on glutamine and the immune system of horses. Omega-3 fatty acids have also received a great deal of attention because of their effects on the immune system.

Determining body condition scores and evaluating horses for potential disease or injury are important in identifying those horses in need of nutritional support (Doneghue, 1992). Well-fed adult horses that are not pregnant (last trimester) or lactating can withstand up to four days of partial or complete starvation without long-term effects. However, thin horses with condition scores between 1 to 3 that have experienced a dramatic loss in weight (10% or more) need emergency nutritional support. Rapid weight loss is commonly observed in horses with sepsis, endotoxemia, pulmonary abscess, pleuropneumonia, abdominal abscesses, diarrhea, severe trauma, surgery, or intestinal disorders. Overweight horses, those with condition scores of 7 to 9, quickly develop hypertriglyceridemia (7,500 mg/dl) after even short periods of anorexia.

Foals, particularly during the first weeks of life, have limited energy stores. Conditions compromising nutritional support of foals can quickly result in hypoglycemia, weakness, and death.

COMPUTED TOMOGRAPHY

Computed tomography (CT) has had increasing use in the horse, both as a research tool and a clinical tool. Benefits of CT are visualization of the area of interest in three dimensions (which alleviates superimposition) and the ability to determine density patterns.

Density patterns of bone can be determined by three-dimensional modeling of CT images (computed tomography osteoabsorptiometry or CTO). CTO allows three-dimensional evaluation of the joint in any plane. Hounsfield units, which are the CT measure of bone density, are determined and coordinated into ranges and then the ranges of density are represented by colors. This color map is then superimposed over a three-dimensional image of the joint surface to show a representation of the relative subchondral density (Figure 1).

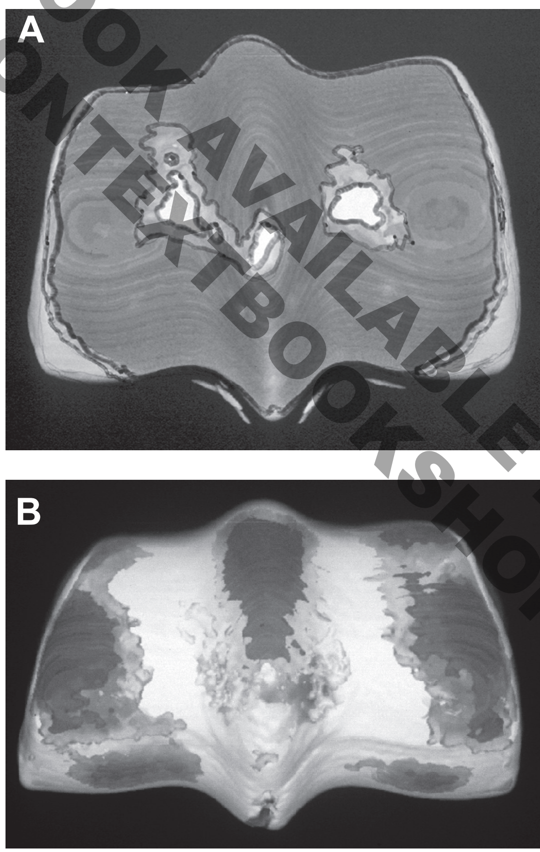


Figure 1. Computed tomography osteoabsorptiometry (CTO), a three-dimensional evaluation of the surface of the third metacarpal condyles of a horse exercised on a treadmill (A) and a hand-walked horse (B). Notice the increased density of subchondral bone (black areas) in the treadmill-exercised horse compared with the hand-walked horse (reprinted from Kawcak et al., 2000. Amer. J. Vet. Res.).

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