Assessing Energy Balance

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INTRODUCTION

"The eye of the master fattens the ox." Anyone who has heard this adage may have wondered how the master knew how much to fatten the ox. Many horse owners have a similar question about their horses. How fat is too fat? How thin is too thin?

In the last 25 years, the use of portable scales has allowed us to gain a lot of information on body weights in horses. But, knowing a horse's body weight doesn't tell us if that is the best body weight for that horse. Henneke and coworkers (1983) developed a body condition scoring system that has been widely used in the horse industry. Their system applies a score of 1 to an emaciated horse and a score of 9 to an extremely obese horse. A score of 5 is given to a horse with "moderate" condition. A horse in moderate condition has enough fat cover to make the withers feel rounded and to make the back appear flat. The ribs are easily felt but cannot be visually distinguished. The neck and shoulders blend smoothly into the body. Henneke et al. (1984) reported that broodmares had higher reproductive efficiency if they entered the breeding season with a condition score of at least 5. There was no benefit to much higher condition scores, but there was also no negative effect on reproductive performance. Because it is a subjective system, there is always some variation from one user to another. However, researchers have reported that performance horses usually have condition scores between 4 and 6.

Few feeding guidelines for mature horses give recommendations on how to manipulate the diet to alter condition score. However, there are many horses that are deemed to be either too thin or too fat. Mares entering the broodmare herd from a performance career may have a condition score that is too low for optimum reproductive efficiency. Conversely, horses going back to work after a period of rest may have a condition score that is too high. These horses must be fed diets that permit a change in body condition through weight gain or weight loss. The most recent NRC (2007) provides a small amount of information on feeding mature horses for weight gain, but there is little information on feeding horses for weight loss.

My Horse is Too Skinny!

When a horse is in less-than-desirable body condition, it will need to gain weight to improve condition. There seems to be a lot of variation in how much weight gain is needed to produce a noticeable change in condition. The NRC (2007) suggests that weight gain of 16 to 20 kg will increase the body condition of a 500-kg horse from a 4 to a 5. However, Quinn et al. (2007) have reported that the condition score of Thoroughbred geldings that gained 93 kg increased from 4.3 to 7.0. Their results suggest that about 34 kg of gain were associated with each unit increase in condition score. The NRC (2007) has suggested that each kilogram of gain in a mature horse will require about 20 to 25 Mcal of digestible energy

(above maintenance). The results of Quinn and coworkers (2007) suggest that this value may be too low, so the exact value is not known. The amount of digestible energy needed to achieve a kilogram of gain may be affected by the composition of the gain. Weight gain will consist of some protein, some fat, and some water. A pound of gain in a fat individual will probably contain less protein and water and more fat than a pound of gain in a lean individual. Therefore, the calories stored in a kilogram of weight gained by a lean horse will be less than in a kilogram gained by a fat horse. The percentage of protein in the whole body is relatively constant at about 18-21%, but the percentages of body fat and body water are more variable. In a study conducted at the University of Illinois, carcass fat ranged from 8 to 21%, and body water ranged from 56 to 64% (Lawrence, unpublished data). Ultrasound measurement of rump fat thickness has been used to estimate total body fat in horses. Cavinder et al. (2005) reported that broodmares with a condition score of 5 had about 12% body fat, whereas mares with a condition score of 7 had about 15% body fat. Other researchers have reported that horses with a condition score of about 4 had approximately 7 to 11% body fat (Henneke et al., 1984; Lawrence et al., 1992). If the calories stored in each kilogram of gain are approximated from the change in body weight and the change in body composition, a kilogram of gain should contain 5 to 6 Mcal. The NRC (2007) estimates that 20 to 25 Mcal of digestible energy are needed for a kilogram of gain, so the efficiency of digestible energy use for gain would be about 20-30%. Pagan et al. (2005) suggested that the efficiency of digestible energy use for gain was at least 28% in horses.

Daily energy balance is the first factor to consider when developing a dietary plan for a thin horse. It will be important to provide additional amounts of other nutrients (weight gain is not just fat) but energy intake will be the focus of this discussion. The first step is to determine the animal's current energy intake. In true energy balance (sometimes called "zero energy balance"), an individual consumes enough energy to exactly replace the energy that is expended. If a horse is in thin condition but has a stable weight, then the current diet is meeting the horse's current energy expenditures and the horse is in zero energy balance. However, if a horse is in thin condition and is progressively losing weight, then energy expenditure exceeds energy intake and the horse is in negative energy balance. So, before this horse can start to gain weight, it must be fed enough to attain a daily energy balance of zero. The NRC (2007) provides three levels of maintenance for adult horses. The elevated level is suggested for horses with above average voluntary activity, but it could be a starting point for horses that are in negative energy balance as well. On a body weight basis, maintenance requirements are higher for lean animals than for fat animals, and therefore it is suggested that the elevated maintenance level be used for horses on a weight-gaining diet. Actual daily maintenance requirements of horses may be much higher than levels proposed by the NRC (2007). The NRC values apply to maintenance in nonstressful, thermoneutral environments. Horses kept outside in challenging climates may have maintenance needs as much as 50% above the NRC levels.

If evaluation of the diet and the horse's environment suggests that the horse is being fed a diet that should provide adequate energy and the horse is still losing weight, then the possibility of underlying disease should be considered and a veterinarian consulted. A veterinarian should also be consulted if the horse's feed intake is unusually low, if weight loss is severe, or if there are any other indications of poor health. If the diet evaluation indicates that the horse is receiving inadequate amounts of dietary energy,

then a new diet should be formulated. Inadequate energy intakes may result from low feed intake, poor-quality feed (particularly the forage component), or both.

Using the information above, it is possible to develop diets that will result in weight gain for most clinically normal horses. The first step is to determine how much digestible energy the horse should receive each day to meet its maintenance requirements. The second step is to estimate the amount of weight the horse should gain to achieve the desired condition score. The third step is to determine the number of days available to accomplish this weight gain. For example, if you would like a mare to gain enough weight to increase her condition score from a 4 to a 5 before the onset of the breeding season (February 1), you will have 120 days if you start on October 1, but only 60 days if you wait until December 1. Finally you will have to calculate the amount of digestible energy needed to achieve the desired daily weight gain. The estimated daily digestible energy intakes that would be needed to change the condition score of a 500-kg mare from a 4 to a 5 are shown in Table 1. The shorter the available time to change body weight, the higher the amount of digestible energy that must be fed. Some horses in poor body condition may already have suboptimal gastrointestinal health (racehorses on layup), so diets that promote normal gastrointestinal function should be used. The higher the quality of the forage, the higher the expected forage intakes and the lower the amount of concentrate that will be needed.When 90 days are available, the diet could consist of about 10 kg of good-quality forage and 2 to 3 kg of concentrate. When only 30 days are available, a very high level of concentrate (6 to 8 kg) will be needed even if high-quality forage is available. This level of concentrate may not be ideal for gastrointestinal health. Management programs should allow for longer periods of time to adjust body weights so that it is not necessary to feed extremely high levels of concentrate.

The estimates in Table 1 are based on a horse that is not receiving regular exercise. If a horse is being exercised, then additional energy must be fed to meet the needs for exercise. The 500-kg mare in Table 1 would have to consume about 26 Mcal of digestible energy a day just to maintain her body weight if she is being exercised at a moderate level. She would need an additional 10 Mcal/d to gain 25 kg in a 60-day

Table 1: Daily digestible energy (Mcal) intakes needed for weight gain in a mature idle mare with an initial body condition score of 4.

Initial Condition Score = 4 **Target Condition Score = 5** **Initial Weight = 500 kg** **Target Weight = 525 kg**

Days to Target Weight	ADG (kg/d)	DE to Maintain Current Wt (Mcal)*	DE for Gain (Mcal)	Total Daily DE (Mcal)
120 d	0.2	18.6	5.0	23.6
90 d	0.3	18.6	7.5	6.1
60 d	0.4	18.6	10.0	28.6
30 d	0.8	18.6	20.0	38.6**

* Based on an average BW of 512.5 kg.

** Not recommended

period, so her total digestible energy intake would have to be about 36 Mcal/d. It is almost impossible to achieve this digestible energy intake without feeding very high levels of concentrate. An alternative is to reduce daily energy expenditure (exercise) to make it easier to achieve a positive energy balance.

Although increases in weight gain and condition score are positively correlated, many people observe that a change in body weight can occur without a change in body condition. It is likely that this occurs because of changes in gut fill and/or gastrointestinal tissue mass. A relatively small increase in dry matter intake of 2 kg/d could increase body weight by 6-8 kg due to the water that is associated with the food. As feed intake increases there may also be an increase in gastrointestinal tissue mass. Ironically, as gastrointestinal weight increases, so does an animal's maintenance requirement. Therefore, as an animal is adapted to a diet with increased feed intake, there may be a fairly immediate increase in body weight due to changes in the gastrointestinal tract, followed by a period of slower body weight change. The change in condition score will frequently lag behind a change in body weight.

My Horse is Too Fat!

It seems that every month there is an article about obesity in horses. However, there is hardly any good scientific information that allows us to define "obese" in terms of physical characteristics. Hoffman et al. (2003) suggested that horses with a condition score of 6 should be characterized as moderately obese. The NRC (2007) did not adopt a definition of obesity in relation to condition score. It is tempting to recommend that all horses should be kept at a condition score of 5, but there may be situations where higher condition scores are desirable. In nature, many animals will gain weight when food is readily available in order to prepare for periods when food is scarce. So perhaps, in some situations, brief periods of "obesity" can be a good thing. If a broodmare is expected to live outside in a harsh winter climate without good-quality food available, it might be prudent to allow her to increase her condition score in the summer and fall to a 6 or higher so that she will have adequate body reserves to use during the winter. There is concern that excess body fat will produce insulin resistance in horses. However, Quinn and coworkers (2007) did not find a difference in glucose or insulin dynamics when condition score increased from 4.3 to 7 in mature geldings fed to gain weight.

From a practical standpoint, there are probably at least two categories of "fat" horses: those that have become fat temporarily because of a change in management or food availability, and those that have been very fat for a long time. Changing the condition score of the first group is usually relatively easy. In many cases these horses put on weight because diet was not adjusted when exercise was reduced or because concentrate intake was not adjusted when forage quality increased. Resumption of exercise and moderate dietary changes can produce a noticeable change in condition score for these horses in a relatively short period of time.

Adjusting condition score in the second group of horses is much more difficult. To produce weight loss, horses must be in negative energy balance (energy expenditure must exceed energy intake). The easiest way to increase energy expenditure is to increase the amount of regular exercise that the horse receives. Horses that have been very fat for a long period of time are often older and may have some degree of lameness; consequently it may not be possible to impose a significant exercise program. Dietary management will be the only way to create a negative energy balance for these horses. These horses may be

quite inactive, often due to lameness but also perhaps as an adaptation to carrying excessive weight. Because they are inactive, their daily maintenance requirements are fairly low. The dietary changes that are necessary to produce significant weight loss in this group of horses are relatively dramatic and may be difficult to impose.

The first step in developing a weight-loss plan for the perpetually fat horse is to determine its daily maintenance requirement. The NRC (2007) suggests that "easy keepers" have a digestible energy requirement of about 30.3 kcal per kilogram of body weight. For a 600-kg horse, this would be a daily digestible energy intake of 18.2 Mcal/d. This requirement would be met by about 10 kg of average-quality grass hay. The 10 kg of grass hay contains about 9 kg of dry matter, so the maintenance dry matter intake for this horse is only 1.5% of body weight. It is easy to see why horse owners with perpetually fat horses claim that their horses are "air ferns" that stay fat with hardly any food! It is also easy to understand how these horses become fat. If this horse received just 1 kg of concentrate a day (1 pound in the morning and 1 pound at night) in addition to its hay, it would consume enough extra calories in a year to gain about 40 kg.

The second step in developing a weight-loss plan is to decide how much weight the horse should lose. If the 600-kg horse above has a condition score of 7, a target weight loss might be 50 kg. If each kilogram of weight loss contains 6 Mcal, then the dietary plan will have to produce a total negative energy balance of at least 300 Mcal (50 kg x 6 Mcal/kg). However, the total negative *dietary* energy balance will have to be more than 300 Mcal, because the energy stored in the body is used with a higher efficiency than the digestible energy in the feed. If the digestible energy in the feed is used with 85% efficiency in comparison to body stores, then the estimated total negative dietary energy balance will be approximately 350 Mcal.

The final step is to determine a reasonable period of time to accomplish the desired weight loss and then calculate the amount of digestible energy the horse should be fed each day. If the target period is 60 days then the negative energy balance should be about 5.8 Mcal/d. If the maintenance requirement is 18.2 Mcal/d, the weight-loss diet should contain about 12.4 Mcal of digestible energy (about 6.9 kg of hay). This will provide dry matter at a rate of about 1% of body weight. Because the horse is consuming less food, it is likely that there will be an immediate reduction in body weight, due to reduced gut fill. However, the weight loss that occurs in the following weeks will often be much less than predicted from the calculations above.When horses lose less weight than expected, it suggests that the degree of negative energy balance has been overestimated. One source of error in this scenario is that the low feed intakes may affect the digestibility of the energy in the hay. In addition, several of the components of the maintenance requirement relate to ingestive and digestive activity. When feed intake is low, the maintenance components associated with chewing, nutrient digestion, nutrient absorption, and waste excretion are reduced, so reducing feed intake may actually lower the maintenance requirement. Also, as the horse loses weight, the total daily maintenance requirement will decrease. Ideally, as the horse loses weight he will become more active, but this does not always happen.

The NRC (2007) "minimum"maintenance level is a relatively conservative estimate of the digestible energy requirement of confined, quiet, sedentary animals. The mean digestible energy requirement for maintenance in several studies as reported in the NRC (2007) was below 30 kcal/kg body weight, so some individuals may have a requirement as low a 25 kcal/kg body weight (or lower). These estimates of

very low requirements may be related to the docile temperament of animals selected for nutrition trials requiring significant confinement. However, it is possible that they are better estimates of the maintenance requirement of some perpetually fat horses than the minimum maintenance level suggested by the NRC (2007).

If the maintenance requirement of the 600-kg horse is recalculated using a value of 26 kcal/kg of body weight, the new daily digestible energy requirement would be about 15.6 Mcal/d. The weight-loss diet suggested above (12.4 Mcal/d; 6.9 kg of hay) results in a true daily negative energy balance of about 3.2 Mcal/d. At this rate it will take more than 100 days for the perpetually fat horse to lose 50 kg!

It has been relatively simple to make the calculations above. Actually imposing the weight-loss diet is much more difficult. The suggested feed intake is very low. This level of feed intake might not be optimal for the digestive tract or for the horse's behavior. Rather than restrict the amount of average-quality hay that is fed, hay with higher fiber and lower caloric density could be fed. The owner could feed slightly more of this hay, which might be better for the horse's behavior and digestive tract. In addition, hay that is higher in fiber will increase chewing and other components of the maintenance requirement. Even if lower calorie hay is fed, it will be difficult to impose a negative energy balance of 3 or 4 Mcal/d and keep the horse and the owner happy. Developing a diet that imposes a smaller negative energy balance (perhaps 2 Mcal/d) will be more realistic, but it will lengthen the time to achieve the desired weight loss. It is important to point out that the weight-loss diet for a perpetually fat horse is not usually appropriate for a horse that has become "temporarily" fat. This type of diet could result in rapid and dramatic weight loss in the horse that has become "temporarily"fat. Also, weight loss requires restriction of calories but other nutrients are still required in normal amounts. The use of high-fiber, low-calorie hay is desirable because it provides more dry matter and chewing activity, but it will not provide adequate amounts of protein, vitamins, or minerals. When horses are fed a low-calorie hay to induce weight loss, a small amount of a protein, mineral, and vitamin supplement should also be provided.

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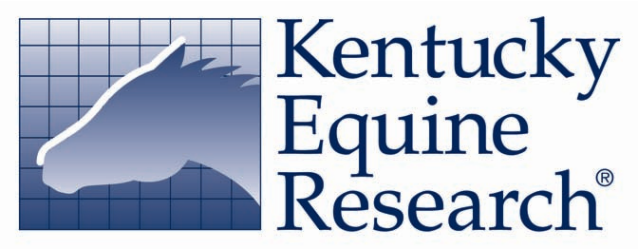

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