RECENT DEVELOPMENTS IN EQUINE NUTRITION RESEARCH

JOE D. PAGAN
Kentucky Equine Research, Inc., Versailles, Kentucky, USA

Introduction

Several important equine nutrition meetings were held during 1992 and 1993. The first European Horse Nutrition Conference was held in Hannover, Germany and the Equine Nutrition and Physiology Society (ENPS) held its scientific meeting in Gainesville, Florida. At each of these meetings, new information of relevance to feed manufacturers was presented. This paper will review papers from each of these meetings as well as present results of research that until now has not been published.

Blood flow

At the Hannover meeting, Dr. Steve Duren presented interesting results from his Ph.D. dissertation from the University of Kentucky (Duren *et al.*, 1992). This experiment was conducted to compare hemodynamics and blood flow distribution in fasted and fed ponies at rest and during treadmill exercise. In the first portion of the experiment, hemodynamics and blood flow distribution were measured in fasted ponies at rest. The 24 hour fast imposed prior to data collection resulted in a 3.5% decrease in body weight.

From this experiment, Dr. Duren concluded that digestive tissue blood flow is the lowest in the esophagus and rectum, two tissues devoid of absorption capabilities. Digestive tissue blood flow was the highest in the glandular region of the stomach followed by the duodenum of the small intestine, two tissues with large secretory capacity. Blood flow to the pancreas was twofold greater than any digestive tissue, again attributed to secretory potential. Finally, it was concluded that fasted ponies divert 20.4% of their cardiac output to the digestive system.

In the second portion of this experiment, postprandial hemodynamics and blood flow distribution were determined in resting ponies. The ponies consumed 0.71% of body weight of a pelleted grain concentrate plus free-choice alfalfa hay, 1.2 hours preceding data collection. Feeding resulted in an elevated stroke volume, which led to a trend for elevated cardiac output. It was concluded that feeding resulted in mesenteric hyperemia, evident by increased blood flow to the small intestine, cecum, ventral colon, dorsal colon and small colon in fed ponies. This is the first known report of mesenteric hyperemia in the pony. This hyperemic effect was not present in the stomach, indicating that, contrary to popular belief, the continued presence of food in the stomach does not stimulate an increase in gastric blood flow. Feeding resulted in pancreatic hyperemia, which was attributed to increased pancreatic secretion during digestion. Kidney blood flow also increased following feeding. It was speculated that increased intravascular volume associated with water absorption, or increased kidney function associated with nitrogen excretion, caused renal hyperemia. Despite the increased blood flow to the digestive system, muscle blood flow was not different between fasted and fed ponies. Thus, it is hypothesized that increased blood flow to the digestive system was accomplished by slight increases in cardiovascular performance, coupled with small, hard to detect, changes in blood flow distribution in other vascular beds. Finally, it was concluded that fed ponies divert 27.4% of their cardiac output to the digestive tract, compared to 20.4% in fasted ponies.

The final phase of this experiment compared hemodynamics and blood flow distribution in fasted and fed ponies during exercise. Hemodynamic and blood flow determinations were made at rest and during 30 minutes of treadmill exercise. Exercise began 24 hours postprandial in fasted ponies and 1.4 hours postprandial in fed ponies. Heart rate, cardiac output, stroke volume and arterial blood pressure all increased during exercise, and each displayed a treatment x time interaction. This interaction indicated the magnitude of difference in response between fasted and fed ponies was dependent on exercise time. However, heart rate, cardiac output, stroke volume and arterial pressure were consistently higher in fed than in fasted ponies. Blood flow to the digestive tract decreased during exercise in both fasted and fed ponies; however, blood flow was higher throughout exercise in the fed ponies. It is speculated that fed ponies had an elevated blood flow at rest, associated with increased digestive tissue oxygen demand, and the increased sympathetic tone produced during exercise was not large enough to totally reverse this hyperemia. Blood flow to the locomotor and respiratory muscles increased during exercise and each displayed a treatment x time interaction. Again, this interaction indicated the magnitude of difference in response between fasted and fed ponies was dependent on exercise time. However, blood flow in each locomotor and respiratory muscle was higher in fed than in fasted ponies. It is surmised that fed ponies work harder during exercise, as evidenced by increased muscle blood flow, due to increased gut fill associated with feeding. Blood flow to the non-exercising masseter muscle did not differ during exercise and was not different between treatment groups.

BOTTOM LINE

The results of this experiment indicate that during exercise, both hemodynamics and blood flow distribution are affected by feeding. Since the fed ponies exercised at approximately 75% of heart rate maximum, they were able to increase heart rate, cardiac output and stroke volume to deliver an increased amount of blood to both the digestive tract and working muscles. This invites the next question: What would happen during maximal exercise? Would blood be completely shunted away from the digestive tract regardless of digestive status, or would exercise tolerance be hindered by digestive hyperemia? More research is needed to answer this question.

Biotin and hoof condition

At the ENPS meeting, Swiss researchers reported the results of an experiment conducted at the Spanish Riding School in Vienna (Linden, *et al.*, 1993). Forty-two Lipizzaner stallions were used in a double-blind trial over two and a half years to study the efficacy of dietary biotin on hoof condition. The horses were divided into two groups: 26 animals (group B) received 20 mg d-biotin daily and 16 horses (group C) were fed a placebo. Assessments were made of overall hoof condition, horn histology and the white line using a scoring system which ranged from 0 (= no irregularities) to 3 (= severe defects).

Initial overall hoof scores were 1.73 and 1.66 for groups B and C, respectively. After 9 months, the score for group B was 1.27, compared to 1.47 for group C ($P<0.01$). The improvement in group B continued subsequently. Average horn histological scores at the start were 1.81 and 1.75 for groups B and C, respectively. After 19 months, the score for group B was 1.52, significantly better ($P<0.05$) than group C which was unchanged. White line condition improved ($P<0.05$) from 2.01 initially to 1.67 after 19 months for group B. The white line score of group C was unchanged. Horn tensile strength averaged 4.0 kp/mm^2 at the start. After 30 months, the tensile strength of group B increased to 4.5 kp/mm^2, compared to 3.7 kp/mm^2 for group C ($P<0.05$). Biotin had no significant effect on horn growth rate.

BOTTOM LINE

The results demonstrate the beneficial effects of d-biotin supplementation on hoof condition of Lipizzaner horses, by reducing the incidence and severity of horn defects, increasing tensile strength and improving the condition of the white line. However, contrary to popular belief, biotin did not improve hoof growth rate. Also, it takes a long time before all of the beneficial effects of feeding biotin become apparent.

Feeding fat for performance

Kentucky Equine Research, in conjunction with the Waltham Centre for Equine Nutrition and Care, presented results of a study evaluating the effects of feeding fat to racehorses at the ENPS meeting (Pagan *et al.*, 1993). Nine thoroughbred racehorses were used in a six month long exercise study to evaluate the effect that different types of energy sources have upon metabolic response during a series of standardized exercise tests. The horses were fed diets containing either high carbohydrate, soybean oil (10%), coconut oil (10%) or a mixture of soybean oil (5%) and coconut oil (5%). Each horse was fed the high carbohydrate (control) diet for a four week period at the beginning of the experiment. The horses then performed a five day standardized exercise test (SET-5) to determine baseline fitness and ability. Using data from the SET-5, the horses were divided into four groups and fed one of the four diets for a three week period followed by two weeks of standardized exercise tests. The first test (SET-5) consisted of 1600 m gallops on five consecutive days at speeds from 7 to 11 m/s on an inclined (6°) high speed treadmill. Blood samples were taken five minutes post exercise for determination of lactate, glucose, ammonia, FFA and triglycerides. Heart rate was measured throughout exercise. A second test (SET-1) consisted of two minutes walking, four minutes trotting, and eight minutes galloping at speeds between 8 and 9 m/s on the inclined treadmill. These speeds produced heart rates of between 180 and 220 beats/minute (ave. 200). Blood samples were taken at rest, after the trotting warm up, at four minutes and eight minutes of the gallop as well as at five and ten minutes after the gallop. After the first period, the horses were switched to another diet according to a Latin square arrangement and the trial was repeated. V_{LA4} measured during the Set-5 was significantly lower (10.15 m/s) in the control diet than when either the soy (10.52 m/s), coconut (10.46 m/s) or mixed (10.69 m/s) oils were fed ($P<0.05$). V_{200} measured during the SET-5 averaged 9.58, 9.71, 9.49, and 9.51 m/s in the control, soy, coconut, and mixed diets, respectively. V_{200} was significantly higher in the soy diet than in either the coconut or mixed diets. During the SET-1 there was no difference in average HR, while lactate was lower in the coconut diet than in the control throughout the test. Blood glucose was not significantly different during or after exercise during SET-1.

BOTTOM LINE

Addition of fat to the diets of Thoroughbred racehorses affected metabolic response to exercise by reducing lactic acid production. This is certainly an important effect since high lactic acid production is associated with fatigue in racehorses. The long term effects of feeding high fat diets to performance horses remains to be determined.

Fat digestibility

Our laboratory just completed a series of digestion trials to compare the digestibility of three different fat sources in mature horses. Four horses were used in a 4 X 4 Latin square design trial to evaluate the effect of feeding a sweet feed along with either soybean oil, a 4-80 spray dried animal fat (4% protein, 80% fat, Milk Specialties Company, Dundee, Illinois) or a new 100% dry fat product (Start to Finish Energy Pak, Milk Specialties Company, Dundee, Illinois).

During each one month period, each horse was fed one of the four rations which consisted of 20% grass hay, 47% high fiber pellets, and 33% sweet feed with or without added fat. The various fats were supplemented at a rate equal to 5% of the grain intake as added fat. The nutrient compositions of the hay, pellets and grain are shown in table 1.

Table 1. NUTRIENT COMPOSITION OF FEEDS (DRY BASIS)

	Grass hay	*Sweet feed*	*Fiber pellet*
Dry matter	91.25 %	86.5 %	86.4 %
Protein	14.2 %	16.0 %	14.1 %
ADF	33.8 %	11.2 %	38.2 %
NDF	56.9%	21.8 %	57.2 %
Crude fiber	27.5 %	8.6 %	30.6 %
Fat	3.4 %	5.0 %	2.7 %
Calcium	0.72 %	0.91 %	1.16 %
Phosphorus	0.31 %	0.76 %	0.24 %
Magnesium	0.19 %	0.24 %	0.25 %
Potassium	2.22 %	1.02 %	1.57 %
Zinc	23 ppm	134 ppm	46 ppm
Copper	9 ppm	39 ppm	10 ppm
Manganese	45 ppm	94 ppm	43 ppm
Ash	7.34 %	6.99 %	7.27 %

During each 4 week period, the horses were fed their experimental rations for a three week acclimation period followed by a five day complete collection digestion trial. During the collection period, daily feed intake and total fecal output was measured. Subsamples of daily feed and feces were taken and frozen. These subsamples were dried and composited for chemical analysis. Both feed and feces were analyzed for dry matter, crude protein, ADF, NDF, fat, calcium, phosphorus, magnesium, potassium, zinc, copper, manganese, and ash. Digestibilities were calculated for each nutrient measured.

The apparent digestibility of the various nutrients are shown in table 2.

The addition of these various fats did not adversely affect the digestibility of any of the other nutrients measured. In fact, it appears that the 4-80 fat actually improved the digestibility of several of the minerals. The 4-80 fat was also highly digestible, equaling the digestibility of the soybean oil. The ration containing Energy Pak had an apparent fat digestibility equal to 80% of the soybean oil or 4-80 diets.

Of the three fats tested, the Energy Pak dry fat seemed most palatable followed by the soybean oil. The 4-80 was least palatable and it took the horses several days to become accustomed to the taste. Every horse accepted the Energy Pak at first offering.

Table 2. APPARENT NUTRIENT DIGESTIBILITIES (%)

	Control	*Soy oil*	*4-80*	*Energy Pak*
DM	64.34	63.87	64.66	62.43
CP	71.98	69.27	72.05	70.06
ADF	49.78	48.15	48.33	46.23
NDF	53.59	50.53	51.19	52.61
CF	54.12	52.46	51.49	52.56
fat	53.72	68.26	69.62	54.61
Ca	42.74	42.51	46.74	41.01
P	11.28	14.49	18.22	11.63
Mg	30.49	30.69	36.49	30.36
K	80.03	78.11	79.31	77.57
Zn	6.77	8.78	15.94	5.87
Cu	25.53	24.17	31.09	18.63
Mn	0.75	3.43	7.09	1.06
ASH	46.81	44.57	47.87	45.19

BOTTOM LINE

Adding fat to a sweet feed, hay, fiber pellet ration at a level equal to 5% of the grain intake did not adversely affect digestibility of any nutrients. Diets containing soybean oil and 4-80 dry fat had similar fat digestibilities while the fat digestibility of the diet containing Energy Pak was about 80% of these values. The Energy Pak, however, was the most palatable of the three fats and it was also easy to feed since it was in a dry form.

Do fat babies become good athletes?

The detrimental effects of rapid growth on skeletal soundness have been well established in horses, but what effect does excessive fatting have on subsequent performance in the equine athlete? Cecil Seamen of Thoroughbred Analyst in Lexington may just have the answer. Thoroughbred Analyst is a consulting company that advises Thoroughbred racehorse buyers of a horse's athletic potential based on its biomechanical conformation. A series of 15 measurements of body dimensions are taken of yearlings and these measurements are used to rate the horse's mechanical probability of success on a scale of A+ down to C.

From 1980 until 1988, 10,190 Thoroughbred yearlings have been measured at major sales in Kentucky, New York and England. In addition to the rating described above, the yearling's body condition was also evaluated. Each yearling's height, length and girth measurements were extrapolated to 40 months of age using computer generated growth curves. These measurements were compared to measurements taken from winners of Classic and Graded Stakes which were taken at the time of their stakes victories. This group included such elite racehorses as Riva Ridge, Spectacular Bid and A.P. Indy. Body weights were estimated for each group based on the relationship between heart girth, length and height.

The yearlings were divided into 3 categories based on estimated weight:

1) Ideal (less than 60 lbs overweight)
2) Overweight (>60 lbs and <120 lbs overweight)
3) Obese (>120 lbs overweight)

The race records of these 10,190 yearlings were purchased from Bloodstock research and the horses' racetrack performances were compared to both their mechanical probability scores and their body condition at sale time. As expected, the high probability horses (A+,A, A-,B+) performed much better than the low probability horses (B, B-, C). High probability horses earned an average of $48,775 per starter compared to only $26,206 for the low probability horses. Over 10% of the high probability horses won stakes races compared with only 5% of the low probability horses.

Among the low probability horses, body condition as a yearling didn't have much of an affect on racing performance. Apparently, other factors such as conformation limited these horses' ability to compete in quality races. The high probability horses, however, were greatly affected by body condition as yearlings. Yearlings with ideal body weights went on to earn an average of $62,732 per starter while yearlings which were obese earned an average of only $36,198 per starter! 12.41 % of the yearlings with ideal body weights won stakes (7.41% graded) while only 7.85 % of those yearlings that were obese managed to win in stakes company (3.44 % graded). Yearlings which were in between in body condition were also intermediate in both earnings and stakes victories.

It should be emphasized that body weight was estimated when the horses were yearlings. Therefore, body weight may have changed greatly by the time the horses began racing depending on their diet and training regime.

Why the obese yearlings performed poorly is open to debate. Perhaps the fat yearlings never lost the extra pounds and therefore were forced to carry excess weight into their races. Or maybe obesity in young animals changes their metabolism so that they are less efficient at generating energy during a race. Research in rats suggests that this may be the case. Regardless of the reason, the bottom line is that excessive fatness in young horses not only increases the risk of skeletal damage, but it also diminishes their subsequent racing ability, at least in good individuals.

References

Duren, S.E., M. Manohar, B. Sikkes, S. Jackson, and J. Baker. 1992. Influence of Feeding and Exercise on the Distribution of Intestinal and Muscle Blood Flow in Ponies. Europäische Konferenz über die Ernährung des Pferdes. Tierärztliche Hochschule Hannover.

Linden, J., H. Josseck, W. Zenker, H. Geyer and J. Schulze. 1993. The Effect of D-biotin Supplementation on Hoof Condition in Lipizzaner Horses. In: Proc. 13th ENPS, Gainesville, FL.

Pagan, J.D., W. Tiegs, S.G. Jackson and H.Q. Murphy. 1993. The Effect of Different Fat Sources on Exercise Performance in Thoroughbred Racehorses. In: Proc. 13th ENPS, Gainesville, FL.