Refeeding the Starved Horse: Metabolic Responses to Three Isoenergetic Diets

Christine L. Witham, DVM, MPVM and Carolyn L. Stull, MS, PhD

Careful consideration of dietary programs for chronically starved horses should include selecting diets with low soluble carbohydrate sources, feeding small frequent meals, and monitoring of selected electrolytes during the initial 10 days of refeeding. Authors’ address: Veterinary Medicine Extension, School of Veterinary Medicine, University of California at Davis, Davis, CA 95616. © 1997 AAEP.

1. Introduction
During the catabolic state of starvation, the body metabolizes stored fat, followed by muscle tissue, to provide for the essential energy requirements; this eventually leads to a total body depletion of fat, protein, and electrolytes. The refeeding syndrome described in emaciated humans is associated with the introduction of concentrated calories, primarily glucose, which stimulates the release of insulin and subsequently the influx of glucose and selected electrolytes into the cells. The result is severe hypophosphatemia, hypokalemia, and depletion of other phosphorylated metabolites, especially adenosine triphosphate and 2,3-diphosphoglycerate, causing red blood cell dysfunction.1,2 In both humans and horses, abrupt refeeding can lead to death as a result of cardiac and respiratory failure in 3–5 days.1,3

The objective of this study was to examine the metabolic responses to three isoenergetic diets fed to chronically starved horses and provide practical nutritional guidelines for successful refeeding programs.

2. Materials and Methods
Emaciated but overtly healthy horses (n = 22) were purchased in Mexicali, Mexico and transported to Davis, California for utilization in a 10-day refeeding trial. The horses (12 mares, 10 geldings) ranged in age from 3 to 24 years (10 ± 6 years), weighed 242 to 399 kg (307 ± 44 kg), and were assigned body condition scores of 1 to 4 (1.8 ± 0.9).4

Daily digestible energy (DE) was calculated at 125% of their body weight on arrival, and horses were randomly assigned to isoenergetic diets of 100% alfalfa hay (AH), 100% oat hay (OH), or 50% oat hay/50% Equine Senior (OH/ES).a On days 1–3, 50% of the DE was offered in six equal feedings at 4-h intervals. On days 4–5, the DE was increased to 75% at the same feeding schedule. On days 6–10, 100% of the DE was fed at 8-h intervals. Water was available ad libitum.

On the day of the horses’ arrival, indwelling venous catheters were placed in the left jugular of each horse and maintained throughout the study. Daily, a prefeeding blood sample was drawn at 08:45 h, the
horses were fed at 09:00 h, and hourly postprandial samples were collected between 10:00 and 13:00 h. These samples were quantified for serum concentrations of glucose, insulin, free fatty acids (FFA's), total bilirubin, electrolytes, and 2,3-diphosphoglycerate (2,3-DPG). Body weight, fecal output, and feed and water intake were recorded daily. Fecal samples were collected on day 5 and submitted to the University of California at Davis Veterinary Medicine Teaching Hospital for parasite identification and quantification by using flotation and McMaster's tests.

The daily response of each animal to its 09:00 meal was examined by analyzing the postprandial change relative to the observation taken immediately prior to feeding. A repeated measures analysis of variance was used to examine the effects of day and diet on these responses. Student's two-sample t tests assuming equal variances were performed by using MICROSOFT EXCEL. Statistical significance was claimed whenever p < 0.05.

3. Results
For surviving horses (n = 19), mean body weight declined during the first 5 days of refeeding but made gains during days 6–10. There was no difference (p > 0.05) in mean weight gain or loss during the 10-day study among diets AH (2.6 ± 4.3 kg), OH (14.7 ± 20.6 kg), and OH/ES (3.1 ± 17.0 kg). Throughout the study, all horses exhibited below normal levels of red blood cells, hematocrit, and hemoglobin and within normal levels of total bilirubin. The number of strongyle spp. eggs/g ranged from 50 to 3550 with a mean of 742 ± 811 eggs/g. Six horses had ≤100 eggs/g, three horses were positive for parasarcis, and one had Dictyocaulus filaria seen on flotation.

A daily glucose peak was reached 2–3 h after meal ingestion, followed by an insulin peak approximately 1 h later. The OH/ES diet exhibited larger postprandial glucose and insulin peaks (p < 0.05) than either the AH or OH diets. This was especially prominent on days 6–10, when the horses received 100% DE. For all three diets, there was a rapid decrease in FFA during the first 5 days and a steady decline (p = 0.03) of serum phosphorous, which reached below normal concentrations between days 4–7. There were no diet effects (p > 0.05) of 2,3-DPG, which was below normal levels of 2.1 mol/dl and declined during the study. Magnesium concentrations were below normal levels and did not increase during the study with the exception of those horses on AH.

Three horses died during this trial. One mare was euthanized because of fulminant salmonellosis, which developed early on day 2. Horse 16 was euthanized because of a left large colon torsion on day 8. On day 6, horse 6 developed acute neurologic signs of tonic-donic rigidity, head banging, and inability to rise. No gross or histopathologic lesions were found at necropsy. However, both horse 6 and horse 16 developed severe hypophosphatemia, hypocalcemia, and hypomagnesemia during the trial. These two horses had been on the OH/ES and AH diets, respectively.

4. Discussion
In this study, there were several metabolic response similarities between the refeeding syndrome of humans and nutritional rehabilitation of chronically starved horses. In both, there was a rapid decrease in FFA and an increase in glucose and insulin followed by a decrease in phosphorous and 2,3-DPG. The AH diet appeared to be more physiologically supportive than either the OH diet or the OH/ES diet because of its low postprandial glucose and insulin response. It may be important to start the horse on small, frequent meals and gradually increase the caloric intake. Further investigation of other diet combinations or nutrients, and vitamin and electrolyte supplementation, should be pursued to determine the optimal nutritional protocol for the chronically starved horse.

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References and Footnotes

*Equine Senior, Purina Mills, Inc., St. Louis, MO 63164.